The rise and extension of submarine telegraphy

Willoughby Smith

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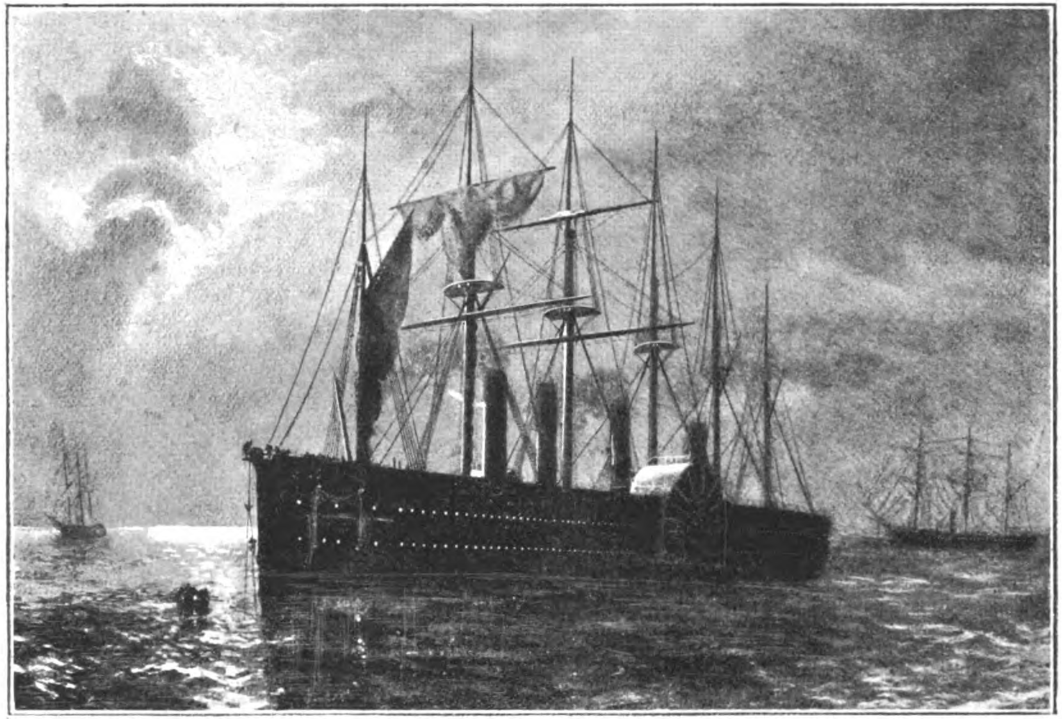

S.S. "GREAT EASTERN" ON THE MORNING OF SEPTEMBER 2ND, 1866.

THE
RISE AND EXTENSION
OF
SUBMARINE TELEGRAPHY

BY

WILLOUGHBY SMITH

With Illustrations

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PREFACE.

For fear my hands should be considered idle, and the proverbial employment attributed to them, I have thought it advisable to be doing something. It has occurred to me that to note down some of the facts I have learned by experience in the electrical world would be employment, congenial to myself and at the same time serviceable to others. In this hope I submit to my readers the following pages.

When I commenced these jottings, it was with the intention of saying something of gutta percha, subterranean and submarine telegraphy, and electric lighting, and also of republishing (what I have already distributed in pamphlet form) my papers touching upon electrical matters. All these subjects could, I thought, be contained in one book of convenient dimensions, but how false were my deductions.

I began with submarine telegraphy, and on that subject alone, have found more than sufficient matter to fill a good sized book; so this I publish by itself.

I think it probable that the other subjects I have enumerated can be contained between two covers, if only I have time and opportunity to put them there.

It was not my intention to write an amplified history of submarine telegraphy, nor have I done so; I do not consider myself sufficiently acquainted with many of the facts

concerning its rise and progress, a knowledge of which is, without doubt, essential for the production of a comprehensive treatise of the subject.

I have therefore contented myself with merely setting down, in chronological order where possible, many of the incidents which have come within my personal experience, or have been derived from sources for the accuracy of which I can vouch; leaving it to the historian to give to the world a full account of so important a science.

The correct history of submarine telegraphy has never yet been written; the sooner it is compiled and circulated the better, for I notice that counterfeit statements are frequently allowed to pass as current coin, to the detriment of those interested in tracing the various stages of growth through which this branch of science has passed before attaining to its present state of fruition.

A generation has passed away and time has thinned the ranks of those who took a prominent part in the scenes I describe; if therefore my jottings should attract the attention of a serious enquirer, he may find in them reliable information on some points, which would otherwise have been passed over and forgotten.

If what I have gleaned and garnered should be thought not only interesting but instructive, it will add to the enjoyment which I have experienced in calling up old scenes and old familiar faces.

WILLOUGHBY SMITH.

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APPENDICES.

THE RISE AND EXTENSION

OF

SUBMARINE TELEGRAPHY.

CHAPTER I.

Large Order for Gutta Percha Company in 1850—Covered Wire to be laid from Dover to France—Wire Drawers—Joints—Battery—Galvanometer—Mr. W. Reid—Financial Difficulties—*Goliath*—Testing Coils—Rejected Coils on Quay—Public Criticism—Shore End Laid—Cape Grisnez—Captain Beer—Trial Trip off Dover—Eventful Day, August 23rd, 1850—H.M.S. *Widgeon*—Spectators on Board—Leaden Weights—Soundings—Mr. F. C. Webb—Unforeseen Difficulties—Allotted Task Accomplished—Something Wrong with the Operator—Destroying Messages—Final Splice—Puzzling Messages—Induction—Line Abandoned—Pioneers and Settlers—First Claimants—" Telegraph Cable "—Engraving of Joint and Weight.

Early in 1850 the Gutta Percha Company received what they then considered a very large order. It was for twenty-five knots or nautical miles (2,029 yards representing a knot) of copper wire, No. 14 Birmingham wire gauge, to be covered with gutta percha to half an inch in diameter. Great care was to be exercised in the covering of this wire, which was required for laying across the Channel from Dover to France, to prove, if possible, the practicability of submarine telegraphy, and universal interest was taken in what was characterized as a bold and daring experiment. Unfortunately, many things were at that time thought perfect which would not now pass muster; for example, the wire-drawers of those days, strangers

to long lengths and proper annealing, appeared to take it for granted that the Birmingham wire gauge was any size they chose to make it; the result being that the diameter of the wire varied considerably, even when supplied by one firm. To its electrical conditions and quality no attention was given, for the simple reason that all copper wire was credited with the possession of equal value in these respects.

The Gutta Percha Company could only cover short lengths of the wire at one time, and even then were not able to insure its being kept in the centre. The method of cleansing the gutta percha, too, was very defective, and also there were, to contend with, many air holes and other imperfections, caused by the application of the gutta percha so thickly in one covering. The wire was supplied in short and variable lengths, which, to suit the requirements of the covering machine, had to be joined by overlapping scarves soldered together with hard solder by the aid of powdered resin and blow-pipe, the whole being filed to the size of the wire.

With the covered wire this process did not answer, as, owing to the amount of heat required to melt the solder, the wire became so hot as to soften the gutta percha for a considerable distance on either side of the joint; other methods for making the joints were therefore discussed, and the plan eventually adopted was as follows:—

The gutta percha was removed for about two inches from either end of the wires, which were then well cleaned with emery paper, crossed and twisted several times one over the other, bell hanger fashion, and the whole covered with soft solder applied with an ordinary soldering iron, common powdered resin being used as a flux. A suitable slice of plastic gutta percha was then placed on either side of the

joint, the whole pressed in a wooden mould, where it was kept under pressure until the gutta percha was quite hard. The joint thus made resembled, when removed from the mould, a magnified cigar, some two inches in diameter and nine in length; it tapered at either end to the size of the covered wire over which it lapped. Each coil of wire was immersed in water as soon as covered, and, if thought sufficiently insulated, passed. The electrical arrangements were not elaborate, and although the battery generally used looked formidable, it was totally unsuited to much of the work for which it was required. This battery consisted of a long and narrow wooden box, divided by wooden partitions into twelve cells; at either end of the box was a fixed wing-head terminal, the one firmly secured to a zinc, the other to a copper plate; similar plates of zinc and copper were riveted together by bands of copper, and so bent over the wooden partition that each cell contained two plates of dissimilar metal immersed in a mixture of water and sulphuric acid; for better insulation, each cell was lined with an insulating compound. The box was covered with a hinged lid, the two ends of the terminals being left easy of access for the desired connections. The galvanometer used was of the vertical needle form and not very sensitive, the record being given as the number of degrees to which the needle was deflected with one cell; if under these conditions there was unsteadiness of the needle or too many degrees deflection, the coil was again examined and re-tested until it passed. Mr. William Reid, engaged as engineer and electrician on this occasion, and responsible for the electrical condition and the laying of the line, was a celebrity in his time, and held responsible positions from the commencement of electric telegraphy until his death.

When the Gutta Percha Company had completed the

covering of the 25 knots of wire, reports were circulated to the effect that the enterprise was hampered by financial difficulties. Whether report in this case told the truth or not, the fact remains that the many coils which constituted the entire length were for weeks stacked in the yard of the Gutta Percha Company's Works without adequate protection either from the depredations of the curious or the uncertainties of the weather. Eventually the coils were carted to a wharf on the Thames, whence they were shipped on board the small steam tug *Goliath*, and taken to Dover harbour. Just abaft the funnel of this tug a large iron reel was mounted on suitable bearings; its ends nearly reached the bulwarks on either side. Upon this reel the twenty-five knots of covered wire were to be wound as evenly as possible. As the coils had been so long out of water, it was thought advisable to re-test before joining them into one length; for this purpose, a batch of coils was suspended daily over the side of the tug in the water, the ends of each coil being secured just above the side of the vessel and made ready for testing.

The testing was done by Mr. Reid, who, seated astride a beam of timber on deck with his vertical galvanometer before him, shouted "Right" or "Chalk" as the case might be; "Right" denoting that the coil was passed, "Chalk" that the line-man was thus to mark the coil, to show that its electrical condition was such as to require re-examination. While this was going on, men were employed in joining the perfect coils and winding them on the iron reel, a very slow process, as the wire had to be wound as evenly as possible—a difficult task, owing to the size of the joints and other causes. Cotton waste was used, where possible, to fill up the inequalities; wooden laths also, when necessary, were placed lengthwise at equal

intervals round the reel, the wire being wound over them. From lack of room on the tug, the rejected coils had to be re-examined on the quay, a proceeding attended with much annoyance, because crowds of people daily assembled to watch the process and freely criticise what they saw, in no very flattering terms; of course they imagined they understood all about it, and talked at the operators. "What a mad scheme! why a sailor, or anyone who knew anything about seafaring matters, would declare it was impossible to pull such a line 25 yards, let alone that number of miles, over such a rough and uneven surface as the bottom of the channel had." These wise persons were clearly of opinion that the signals were to be made with France by pulling the wire after the fashion of mechanical house bells! However, one quiet-looking old gentleman seemed to take a more optimistic view of the case, for he remarked, "Why when they said that the railway was coming to Dover through Shakespeare's Cliff, there were many with a knowing shake of the head and laugh of derision; but it was accomplished for all that, and these men will be equally successful, mad though some people think them." Some of the spectators had the impertinence to cut through the gutta percha to show their friends that there was copper wire inside, while others still less scrupulous purloined a piece of the line when they thought there was a chance of doing so without detection.

The tug went several times over the course to Cape Grisnez, as though an attempt were being made to get her used to the route on which she would eventually play such an important part. On one of these visits, the shore end of the cable was laid from the lighthouse at Cape Grisnez in a prepared trench to the edge of the cliff; here it hung over; from the foot of the cliff it was laid among the rocks

and taken for some distance out to sea, where the end was buoyed. The shore end consisted of a copper wire doubly covered with cotton, overlaid with a coating of india-rubber, the whole being enclosed in a very thick lead tube; the india-rubber, at the time of laying, was in a semi-fluid state from partial decomposition.

Cape Grisnez is high and rocky, with huge boulders at its base; at high water these rocks are in many cases hidden, the rise and fall of the tide from maximum to minimum being very great. Between the rocks there are several sandy bays in which a boat can be landed, but it requires an intimate knowledge of the coast to find the way to them, especially at certain states of tide.

All communication between the shore and the tug had to be made in the steamer's boat. When the shore end was to be landed, the boat, being heavily laden with the reels containing it besides several passengers, took the bottom sooner than was expected. The sea at the time was very rough, and the majestic billows breaking on the beach seized the little boat as their plaything. The young and agile jumped at once into the water, so as to lighten the boat, and at last, after much difficulty, all reached the beach in safety without further mishap than a thorough wetting.

A shore end, precisely similar to the one at Cape Grisnez, was laid from a horse-box in the yard of the railway station at Dover, across the road, along the wooden stage erected to assist in the building of the Admiralty Pier, then just commenced, and into the sea, where it was buoyed. The correspondent of the local paper must have grown tired of reporting the very slow proceedings, as at last he simply gave us a note, such as "The *Goliath* took her usual preliminary trip over the course between Dover

and Cape Grisnez. Among the scientific men on board we noticed Captain Beer." The gentleman referred to happened to be the captain of the tug. When everything was considered ready for the "extravagant project," a trial trip was made in a rather rough sea off Dover, by laying about three miles of the line. This was satisfactorily recovered, the tug returning to make final arrangements before commencing to lay the whole length to Cape Grisnez.

At last the eventful day arrived when this was to be, if possible, achieved, and at about 10 A.M. on August 23rd, 1850, the weather proving so propitious that one might imagine all Nature approved of the undertaking, the joint was made from a boat between the sea end of Dover shore terminus and the wire on the reel on board the tug. This accomplished, H.M. surveying paddle-ship *Widgeon* led the way, followed by the *Goliath*, from which the line was being paid out. The deck between the reel and the taffrail was kept clear, so that the line had a free passage from the reel into the sea. While Messrs. Reid, sen. and jun., Wollaston, jun., and myself were busy with the work in hand, on the deck might be observed a small group of spectators, Messrs. T. R. Crampton, John and Jacob Brett, Wollaston, sen., and Edwards. Whilst the cable slowly unwound the onlookers passed the time in discussing the topics of the day; they spoke of H.R.H. Prince Albert, his extraordinary scientific attainments, and the great interest he was taking in our proceedings; of the death of Louis Philippe, and the effect his demise would exercise upon the destinies of France.

The specific gravity of the line was so little below that of the sea water that it was thought advisable to attach leaden weights, a sixteenth of a knot apart, to ensure the line being taken to the bottom. These weights varied

from 8 to 16 lbs.; they were flat square shaped blocks cast in two halves; on one half were two projecting studs, and through the other two holes to receive the studs; along the centre of each half was a semi-circular groove corresponding to the diameter of the line. To attach these weights, strips of plastic gutta percha were laid in each groove and the halves pressed together; the two studs which projected through the two holes were hammered flat by two men, one on either side of the line. It was at first thought that the men could attach the weights while the line was passing from the reel to the taffrail, but experience proved otherwise, as in their hurry to do so they more often struck each other than the studs; it was therefore deemed expedient to stop the paying out while this operation was being performed. The line must in consequence have been very taut in those places, and it is a wonder how the gutta percha stood the tension and knocking about it received. The *Widgeon* took soundings, communicating the result to the tug by means of large chalk figures on a black board placed on the paddle-box, and the large or small weights were used according to the soundings given. Mr. F. C. Webb, an officer of the *Widgeon*, was on board the *Goliath* to interpret the signals from the pilot ship. Unforeseen difficulties now presented themselves; not only did the cotton waste used in the reeling of the line fly in all directions, but the partially released wooden laths behaved after the fashion of flails in the hands of infuriated threshers, making it extremely dangerous for anyone to approach the reel until the laths became totally released.

During the laying no messages were sent or received, only electrical signals on galvanometers were exchanged as opportunity offered.

At about 5 P.M. on that memorable day the tug had

accomplished her allotted task, and anchored in the vicinity of the shore end buoy off Cape Grisnez. The sea end of the line was then passed into the cabin of the tug, where it was connected with one of Brett and Little's modifications of the "House Roman" type-printing instrument. But what had gone wrong with the operator at Dover? True, *letters* came, but they were so mixed that it was in many cases impossible to make any sense out of them. The man in charge of the instrument was justly rebuked for destroying them; they were the first messages received by submarine telegraphy, and as such ought to have been preserved, no matter how illegible. The more the operator tried to control the letters the more erratic they became. At last it was suggested that the success attending the laying of the wire had caused the champagne to circulate so freely that the persons in the shore station at Dover did not know what they were doing. This solution of the mystery really did appear to be a feasible one, more especially as the man in charge of the type-printer showed how correctly he could work it on short circuit.

To save daylight for making the final splice and getting to the shore, the end of the line was passed into the boat, where it was joined to the shore end: thus was submarine telegraphy presumably established between England and France. The steamer then left, and those interested ascended to the lighthouse, where an ordinary single needle instrument was attached to the line; but although messages appeared to be sent correctly, and Dover gave what was thought to be the signal of acknowledgment, no other message came. This merely confirmed the champagne theory. The only thing to be done, therefore, was to wait until morning, when all would doubtless be explained. As it was now 12 P.M. the company separated; some walked to

Calais, while others preferred to forego their supper and seek what rest a lighthouse could afford.

In the morning all were astonished to find the results on the single needle instrument the same as before; the type-printer was not tried. It was now decided to await patiently the arrival of the mail from England. In due course letters reached us containing the astounding statement that at Dover the signals received had been very similar and in the same chaotic order as those complained of at Cape Grisnez. To add insult to injury, came the suggestion that success had proved too much for the workers at our end, and caused carelessness and neglect; it was hoped, however, that business would now be attended to.

Had the phenomenon of induction been generally recognised in those days, and the true state of the line with regard to its electrical condition understood, what an amount of misunderstanding and mutual recrimination would have been avoided. There can be no doubt that the continuity of the copper wire between Dover and the tug anchored off Cape Grisnez was perfect, and that it was owing to the retardation caused by induction that the letters were not received in the order sent; but when the Cape Grisnez shore end formed part of the circuit it is quite certain that continuity no longer existed, the supposed signal of acknowledgment being nothing more than the return current caused by the effect of induction.

It was evident to all concerned that something was wrong, and they had to grope about in the thick fog of ignorance in their endeavours to find the remedy, without even one ray from the important light of experience to illumine their path. It would be, therefore, not only unfair, but unjust, to criticise these endeavours by the light of the present day. Every device known and thought of was tried, but to no purpose; the line had at length to be abandoned. It

is, however, a true axiom that failures are the best teachers, and this line had proved the practicability of submarine telegraphy, if only more perfect means could be obtained.

Doubtless science, like a human community, has its pioneers and settlers; there are many records in history proving that, as a rule in either case, pioneers do not make good settlers, nor good settlers good pioneers Settlers have in many instances cause to revere and perpetuate the names of the pioneers as men who have sacrificed much to benefit their fellows. I will instance one or two of the many cases which have occurred in that branch of science with which I am more intimately acquainted. It had long been suggested that lightning and electricity were one and the same thing, but it remained for Franklin to prove this by actual experiment, and also to show how such a knowledge could be made to benefit the whole world; therefore, whenever the subject of lightning conductors is discussed, Franklin's name must of necessity be remembered with honour.

Even long before the discovery of voltaic electricity it was known by actual experiment that electricity could be sent for miles through insulated wire, the earth being used as half of the circuit, and that the signals so produced were sent and received simultaneously; but notwithstanding this knowledge, the names of Cooke and Wheatstone are always associated with our telegraphic system, for to them we are indebted for its practical application.

Submarine telegraphy has now grown so important that there are many claimants to the merit of having been the first to suggest it. I must admit that if every person who, on the introduction of gutta percha into this country tried its insulating properties, even in a basin of water, be admitted as one of these claimants, their name would be legion.

While on this point I might mention, as a curious coincidence, that in 1836 there was a stage coach running called the "Telegraph," driven by a man named John Cable. He was a celebrity in his way, and was always known by the nickname of "Telegraph Cable." It seems to me that this man might with more reason have laid claim to starting the idea of submarine cables than many of those who have since put forth such demands.

Whatever experiments may have gone before, I maintain that, in spite of its too brief working, the laying of the gutta percha covered wire from Dover to France in 1850 was the true pioneer of submarine telegraphy; therefore all honour is due to those engaged in it.

Below are shown illustrations of the joint and weight I have described, taken from originals still in my possession. It will be observed that they have somewhat deteriorated through age, more especially the joint.

Joint.

Lead Weight.

CHAPTER II.

Cable for another Attempt—Copper Wire—Yarns—Wire Rope Works—Messrs Wilkinson & Weatherly—Mr. Fenwick—Messrs. Newall & Co.'s Patent—Works Closed — Cable Completed — *Blazer* — Cable Coiled on Board—End Landed—Messages between Ship and Shore—Expedition Started Sept. 25th, 1851—Brake—Insufficient Cable—Subterranean Wire substituted—Sangette—Congratulatory Messages—Knot of New Cable—*Red Rover*—Splice made—Cable open to Public—No Signals Received—Set of Joints Omitted—Horsemen Employed.

After mature consideration it was decided that the next attempt, planned for the summer of the following year, should be made with a cable having four copper wires, each of No. 16 Birmingham wire gauge in diameter, covered separately with two coverings of gutta percha to No. 1 diameter of the same gauge, and twisted together in a similar way to the strands of an ordinary hemp rope. The interstices were to be filled up by tarred hemp strings, the whole being covered with similar strings wound round at right angles. This core, as it was termed, had ten galvanised iron wires, each of which was No. 1 Birmingham gauge, laid helically around it, so that it resembled in appearance a huge wire rope.

Those who supplied the copper wire were anxious to do their best, but still their wire was irregular in gauge and annealing, and in the same length would be found parts hard, brittle, soft, and rotten.

Insulating the copper wire with two instead of one covering of gutta percha and other improvements were no doubt steps in the right direction, but still the Gutta Percha Com-

pany had much to learn. The covering was very irregular, the lumps had to be spokeshaved before the wire would pass through the gauge which corresponded with the holes in the lay plate of the twisting or, as it was called, the core machine, and in some places the copper wire was more or less eccentric. Want of adhesion between the two coverings was also frequent, while "air-holes" and "gutters" caused much trouble.

The joints in the copper wire were made by scarfing the ends and holding them face to face by two small fixed upright vices, while hard solder by aid of the blow-pipe joined them, when cold the whole was filed to the diameter of the wire. Here again it was found that the heat required to melt the hard solder was too great for the covered wires, as it melted the gutta percha too far on both sides; very soft solder, which melted at a comparatively low temperature from a soldering iron, was therefore used. Two plastic bands of gutta percha, one after the other, were applied over the copper joint and manipulated by hand to the required diameter, a warm iron "tool" being used along the seam and at each end to amalgamate the whole.

The yarns used, both for covering and serving, were hard layed, and the composition of hot coal-tar and pitch with which they were saturated made them harder when cold; the knots in the yarns caused trouble, as they were hard lumps which pressed more or less into the gutta percha at the lay plate of the iron wire covering machine. The tension at the serving machine was not always uniform, as could be seen from the deep indentations made in the gutta percha by the hemp which was supposed to protect it. The iron wires were galvanised, but the process was badly done, large and dangerously sharp lumps of the metal adhering to the wire, and, in some places, cutting through the gutta

percha, forming contact with the copper conductor. The welds were numerous and continually breaking while being reeled, or at the lay plate of the machine.

On one side of a somewhat narrow yard or court leading out of High Street, Wapping, in the direction farthest from the river Thames, were situated the Wire Rope Works of Messrs. Wilkinson and Weatherly; they may have been all that was required for their legitimate work, but for the manufacture of submarine telegraph cables a more inconvenient place as regards size and position could not have been selected. The core and covering machines were made and erected under the superintendence of Mr. Fenwick, an engineer of Gateshead, who also for a time had charge of their working.

The core was kept taut upon the drawing-off drum by manual labour, and, by the same means, was coiled in a number of small sections on the floor of an upper room, the completed cable being hauled to an open yard, where it was coiled and left exposed to the changes of an English climate.

Several miles of the core and a few knots of the cable had been manufactured when everything was suddenly stopped. "A silence that might be felt" held sway. Reports circulated that Messrs. Newall & Co., wire rope makers of Gateshead, had a patent for inserting a core of some soft material into wire ropes with a view to making them more pliable and more manageable; they therefore considered that this submarine telegraph cable was an infringement of their patent, and obtained an injunction to stop its manufacture. It did appear strange, especially to the initiated, that a submarine telegraph cable should be considered as belonging to the same category as a wire rope; true, in make and appearance they are the same, but for what different

purposes are they required! By the same course of reasoning it would not be difficult to prove that a lightning conductor is a wire rope, and must therefore be a submarine cable; absurd logic doubtless, although in courts of law it might not be considered so. Whether the reports were correct or otherwise the Works were closed, and the gate of the yard guarded to prevent the entrance of strangers, more especially of Mr. Newall or any of his party; thus much valuable time was wasted on the road to success. At length Mr. Newall took possession and completed the cable with his own staff from Gateshead; as regards its electrical condition, more attention was given to the continuity of the conductor than to its insulation. The Government lent the hulk *Blazer* to carry the cable, but how to get it on board was the question, especially as the tenant of the property opposite had refused to endanger his fire insurance by allowing such a "Thunder and Lightning" thing to pass through his premises unless what was considered an exorbitant price was paid. Fortunately his neighbour was more reasonable, and the cable was, by manual labour, hauled from the yard of the manufactory to the *Blazer*, which was moored in the Thames. This was a long and tedious operation, the hauling having to be frequently stopped so that canvas and fine iron wire might be wrapped at right angles round the cable where a broken wire was detected. When at last the 25 knots of cable in one length were coiled into the *Blazer*, she was towed as close as possible to the beach beneath the South Foreland Lighthouse, where the end was landed and wires connected with the end, laid into a room in the lighthouse. In the hands of skilful operators messages passed through the cable between ship and shore by "double needle."

On the morning of the 25th September, 1851, all appearing promising for the success of the expedition, it started,

the *Blazer* being towed by two tugs, while a steamer lent by the Government led the way. The only means provided for retarding the egress of the cable was what was called a "Brake," but it consisted of a simple wooden lever compresser worked by hand. As the day advanced the weather became what would be termed in sailor parlance "dirty," the elements having to all appearance combined with the cable to try the strength of man's endurance. What with the totally inadequate "brake" power, cable entangles caused by foul flakes, broken wires and tow ropes, the roaring wind and much agitated sea, a desperate struggle between mind and matter lasted nearly the whole of that memorable day. Want of sufficient cable caused the hulk to be stopped about one knot short of the desired landing-place, and so far matter had gained the day; but mind had not been conquered, only checked, for a knot more cable was at once ordered, and a makeshift arranged. Bare gutta percha covered copper wires twisted together had been laid in the ground from Sangette, where it was intended to land the cable, to the telegraph office in Calais, so a length of this subterranean line was joined to the cable and landed at Sangette, thus establishing electrical communication between the telegraph office in Calais and the South Foreland Lighthouse, and congratulatory messages freely passed to and fro between England and France.

The knot of new cable when completed was coiled on the after deck of the steam tug *Red Rover*, and she started in the following month for Sangette, but encountering very bad weather she eventually put into Ramsgate in a disabled condition. On re-starting all appeared to be going well until it was discovered that no person on board knew where Sangette was, consequently it was late in the day before the tug anchored off that place. The following day at high

water the cable was laid as near to the shore as possible, and then parallel with it, and at low water horses were employed to haul it into position. The splice between the two cables was made on board H.M.S. *Widgeon*, which had been waiting for some days in Calais harbour for the tug, but owing to the erratic movements of that vessel had missed her.

The cable completed, subterranean wires were laid across the fields from the South Foreland to an ordinary dwelling-house in Dover, and it was decided to open for public service. On the morning of October 15th, however, to the general consternation, from some unknown cause the cable refused to work. It was at length discovered that one set of joints had been omitted in the subterranean line from the South Foreland, and this was the last link in the rather long chain of accidents and misfortunes which had obstructed the road to scientific success. Horsemen were employed to convey the messages to and from the telegraph office in Dover, and by the aid of the newly invented long distance electric fuse, a cannon at Calais was discharged by merely touching together two copper wires at Dover; Calais replying to Dover Castle in the same way. In fact, the day was one of rejoicing and congratulation, for a new branch had been successfully engrafted on the tree of knowledge.

The Institution of Civil Engineers has it recorded in its charter that the profession of an engineer is "The art of directing the great sources of power in nature for the use and convenience of man."

The powers of nature have indeed been developed, and the engineers of the present day have a much larger field for their operations than was ever dreamed of when that institution was first established. Electric telegraphy is one of these powers, and it illustrates how persistently mind

fights with matter until the latter's final subjection. The fight may be fierce and long, and veterans may succumb, but there are always recruits ready to fill their places, and although failures are the necessary stepping-stones to success, mind must eventually triumph, to the advancement of science and the benefit of the human race.

It may be said with apparent truth that these "jottings" are long and tedious, as they enter into detail too deeply and unnecessarily; but be it remembered they are given to enable the historian to select what he may consider sufficient for his purpose.

CHAPTER III.

Fresh Competitors—Submarine Cable Works, Sunderland—Cable from Portpatrick to Donaghadee—Magnetic Telegraph Company—Covered Wire from Holyhead to Howth—Want of Insulation—Line Abandoned—India-rubber and Gutta Percha—Chemical Action—Subterranean Wire to Portpatrick—Similar Wire to Donaghadee—Cable for Magnetic Company—Mishaps attending Manufacture—Cable coiled in *Britannia*—Paying-out—Various Mischances—Attempt Abandoned—Cables for two different Companies commenced—Cable for Electric Telegraph Company—Orford Ness to the Hague—Special Drying-room—Serving—Heavy Multiple Cable from Dover to Ostend—Objectionable Methods of Testing—Year 1853 propitious.

When the practicability of submarine telegraphy was established many schemes and devices were introduced with a view to its further development, and men who had viewed from afar and criticised loudly the doings of those who were struggling to connect England and France electrically, now at the first sign of success eagerly entered the newly-discovered field. These fresh competitors, being somewhat erratic in their movements, made what might have been considered a good long distance race with a clear course, degenerate into an obstacle race of unlooked-for dimensions.

Naturally the very next thing to be attempted was the connection of England and Ireland. Messrs. Newall & Co. erected at Sunderland what they called "Submarine Cable Works." What a noisy dirty inconvenient shop this was! Imagine a low wooden structure lighted from the roof, in front of it a boarded-in space, called by courtesy a yard,

and bounded by the North Dock, North Pier and open beach; within the building was far too crowded. It contained a portable traction engine, with all the heat, steam, noise, and dirt, in those days inseparable from such engines; then there were stacks of coils of iron wire, and gutta percha covered wire; these were employed to fill the machine bobbins, by the aid of large flanged swifts on which the coil in use was placed; the core and closing machines were much too large for the building; smoke and sparks flew in all directions from the welders' forges, and sprays of tar from the worming and serving issued from each twirling machine. Such were the "Submarine Cable Works," Sunderland, of that day.

Here to the order of the newly-formed Magnetic Telegraph Company, was commenced a cable similar to that laid between Dover and Calais, to connect Portpatrick and Donaghadee. Whilst this was in hand, Messrs. Newall & Co. secretly ordered from the Gutta Percha Company, 100 knots of 16 gauge copper wire covered with gutta percha to No. 2 gauge, to be sent to their "Wire Rope Works" at Gateshead. This wire they merely covered partially with six No. 12 galvanised iron wires bird-cage fashion; it was then coiled upon railway trucks and taken to a suitable seaport to be shipped to Holyhead. I use the word suitable, because, at the first seaport selected, the steamer owing to its size was unable to enter; so the line had to be re-coiled into the trucks of another railway company and taken to another port, where it was coiled into the hold of the paddle steamer *Britannia*, well known in the cattle trade between Dublin and Liverpool. A fine day having been selected, the cable was laid from Holyhead to Howth, and there joined to a subterranean conductor similar to

that in the cable, and which had been previously laid along the railway from Dublin.

Had the insulation of this submarine line been tested, it would not have been laid in so faulty a condition as it undoubtedly was, for as it became submerged the signals grew less and less distinct, and at the completion of the laying it gave several spasmodic but intelligent signals, and then died. Much time and labour were wasted in endeavours to resuscitate it, but without more effect than would be gained by "whipping a dead horse" or "slaying the slain," and ultimately it was abandoned. Great must have been the awakening for those who believed that such a line would prove all sufficient for the extension of submarine telegraphy.

Another company tried lapping a copper wire with strips of india-rubber and covering the whole with gutta percha, but it required a very short time to show that a chemical action was going on between the india-rubber and the copper, as the former became semi-fluid, bursting through the outer covering just as some gums burst through the bark of trees.

A subterranean wire of this description was laid in Scotland to Portpatrick, and a similar wire placed in the centre of an ordinary three strand hemp rope about 1½ inch in diameter was attempted from that place to Donaghadee, but owing to its light specific gravity it floated, and became so much affected by the strong currents that it had to be abandoned for want of sufficient length to reach the shore.

To return to the cable Messrs. Newall & Co. were manufacturing for the "Magnetic Company." The coils of the gutta percha covered wire were all suspended over the side of the North Dock, and after so hanging in the water for a

certain time were tested for insulation. A suggestion was made but unheeded at the time that it would be much better to dispense with this system of testing, as the operation injured the gutta percha to such an extent that it destroyed the insulation of the coils.

Gutta percha moulded battery cells had superseded the wooden ones, and saturated sand been substituted for the liquid; this contrivance, known as the "sand-battery" was very complete, and although somewhat heavier than the others, it was certainly much more portable, and therefore more suitable for ship or boat work.

The recognised test for insulation was to connect twelve such batteries so as to make 144 cells in series, the copper plate of the battery was put to earth and the zinc plate at the other end attached to one terminal of a vertical galvanometer of which the standard of the sensibility was a deflection of 45 degrees with one cell; all the cells were not equal, they could, in fact, be made to suit the occasion; consequently the battery power employed was an unknown quantity. If the deflections were steady and fairly uniform the insulation was considered satisfactory.

A great many mishaps attended the manufacture of this cable, which I think it unnecessary to mention; suffice it to say that on its completion the insulation of the conductors was not uniform. When the cable was coiled in a yard with every precaution taken to keep it dry, the deflection varied between 36 degrees and 5. To remedy this the iron wires were forced open in three different places by means of a "Spanish windlass" and the core cut and rejoined according to the deflections, thus making the insulation sufficiently uniform to pass. The cable was then coiled into the hold of the *Britannia* and taken to Portpatrick, where, after waiting a long time for suitable weather and

favourable tides, the end was landed, and paying out towards Donaghadee commenced. The arrangements on board were similar to those on board the *Blazer* the previous year. At starting, the cable, being kept too taut, was dragged from the beach bringing with it instruments, etc. This accident naturally caused considerable delay, and the morning was far advanced before a fair start was made. As the day advanced the weather became very stormy, and all the troubles which attended the laying of the Dover and Calais cable were repeated, intensified by the strong currents which prevail in this Channel; but all on board did their duty manfully, and the cable was at one time laid to within five miles of its destination. Owing, however, to the frequent recurrence of broken wires and foul flakes, the ship drifted in a wrong direction until it was at least 12 knots from Donaghadee, when, all the cable being expended, the attempt was abandoned.

Thus the year 1852 came to an end without seeing an extension of submarine telegraphy. The fault lay not so much in lack of experience as in the bad policy of hurry ever attending the manufacture and laying of cables, a policy which has done much to retard the progress of this most important branch of science, by too often wrecking what would otherwise have proved a good and efficient cable. The manufacturer is not always to blame in this; there are times when the company for whom the cable is to be manufactured stipulates that it is to be laid and handed over to them in perfect condition by a certain date. The time specified has often proved totally inadequate for the work to be really well done. "Perfect condition" can only mean that it shall be impossible to detect any flaw either in insulation or conductivity of conductor, but cables frequently contain faults in the gutta percha which remain

undetected because time is necessary for their development.

On the shipment of the last mentioned cable Messrs. Newall commenced the manufacture of others for two separate companies, and as they differed considerably both in design and make, a description of them will illustrate how opinions varied even in well balanced minds as to the best methods of securing success.

The Electric Telegraph Company wanted seven conductors from Orford Ness to The Hague, and with a view to not putting all their eggs into one basket, so far as the deep water was concerned, they had seven separate cables, but for the shore ends all these were twisted together, resembling in appearance one big wire rope.

Mr. F. C. Webb superintended the manufacture of these cables on behalf of the Electric Telegraph Company. The sand at the back of the works was excavated and a wood-lined water tank built in. This was sufficiently large to admit of two cables being coiled at one time; also proved a suitable place in which to test the coils as they were received from the Gutta Percha Company.

For testing these coils and cables, a sensitive horizontal galvanometer replaced the less sensitive vertical one, and records were kept of the results. Some persons ridiculed all this as unnecessary precaution and trouble; therefore the more credit is due to Mr. Webb for the way in which he persevered in what proved to be the right direction.

The coils, after being tested, were spread out to dry along poles supported on trestles in close proximity to either side of the boiler of the traction engine, each line was then separately covered helically with cotton tape, and then passed through a long trough filled with a "preservative mixture," the principal ingredient of which was coal tar.

The wire as it left this mixture was drawn through sand and, as before, suspended in a shed to dry. Coal tar is a solvent of gutta percha; so after this process the gutta percha on the coils became yellow in colour, and cut as though it were soap.

Drying the coils beside the boiler was only a temporary arrangement, as a special room was being built for this purpose. This new drying room had no windows, and was approached by means of wooden steps leading from the yard; it was built of brick and kept heated by flues beneath the floor. It frequently happened that while taking the coils in or out of this room, they were allowed to rest upon the floor; the gutta percha became from this cause more or less soft, and in some cases the whole coil was totally destroyed.

These cables were served with tarred yarns in the usual way, and then covered with ten No. 9 galvanised iron wires. The welds of this wire made in the works were also dipped in a bath of molten zinc by two men sent from Messrs. Tupper & Carr's for the purpose. The closing machines were of a light and fast horizontal type; the drawing off was done by means of turns round a large grooved wheel, and not by iron rollers as in use with the large machines. Seven three-mile lengths of this cable were sent to Gateshead to be twisted six round one for the shore ends.

Whilst these cables were being made, a heavy multiple cable to be laid from Dover to Ostend was also in hand. Its core consisted of seven No. 16 solid copper wires doubly covered with gutta percha; six to No. 2, and one to No. 4 size. The No. 2 were laid helically round the No. 4, the whole being wormed and served with tarred yarns in the usual way. Over these were twisted spirally twelve No. 1 ungalvanised iron wires.

The manufacture of this cable was in the hands of the contractors, Mr. Reid superintending the electrical tests. The Gutta Percha Company supplied the insulated conductors, and it would have been better if the coils had been used as they were instead of being subjected to the following objectionable methods of testing.

At first they were tested in the North Dock, but that not being considered satisfactory, batches of the coils were taken in a steam tug to sea, and anchored in 20 fathoms. It was intended to test their insulation at that depth, but, owing to their light specific gravity and the strong tide, they might be seen floating that distance astern like huge animals endowed with life and struggling to be free. From this and other causes so many of the coils became injured that the plan had to be abandoned.

On a piece of ground close to the works was a large horizontal boiler, which had been used for ejecting a preservative liquid into railway sleepers. In this boiler about 70 coils were placed at one time; one end of each coil was sealed and the other projected through a contrivance at the man-hole for testing purposes, but, owing to the great leakage there, it is doubtful at what pressure, if any, the insulation was tested. The gutta percha covered wire of the Gutta Percha Company was in those days irregular in gauge; the core was in places eccentric; there was also want of adhesion between the coverings, besides spongy parts, air-holes, and gutters. The cause of each of these mechanical defects was well known, and energetic endeavours were being made to remedy it. Close inspection was used to find such defects, as no electrical test would reveal them. After long immersion, sometimes a " mended " place would develop into an electrical fault, showing that the cure had been worse than the disease. Certainly the

system of testing the coils at Sunderland only added to the defects of the core, and did little if any good. Unfortunately the important part which temperature, age, and electrification were playing in the conductivity of gutta percha was not recognised at the time; if it had been much dissatisfaction and uncharitableness might have been averted, and peace and concord reigned in their stead.

The "draw-off" at the closing machine of this cable consisted of two small grooved iron rollers which, by means of springs, could be made to grip the cable at any pressure, the pressure too often used being sufficient to squeeze the core and put the gutta percha out of shape. The cable, as it left the rollers, was coiled in the yard, and apparently every means was adopted to keep it dry, but it was found impossible to maintain insulation in the No. 4 or centre conductor, and, on the completion of the cable, it was beyond redemption.

To give in detail all the incidents which occurred during the manufacturing and laying of these cables, would only be to repeat what has gone before, and would be as tedious to the reader as to the narrator; suffice it, therefore, to record that these and other shorter cables were laid, and that the year 1853 appeared as propitious as the previous year had been disastrous to the advancement of submarine telegraphy.

However, to those who knew exactly how these cables had been manufactured and laid, it was no surprise that repairing ships were so soon at work upon some of them.

CHAPTER IV.

Cable from Spezzia to Corsica—Corsica to Sardinia—Sardinia to Bona—Messrs. Tupper & Carr—Messrs. Kuper & Co.'s Wire Rope Works—First Consignment of Covered Wire—"Core Machine"—Gutta Percha Damaged—Morden Wharf—Messrs. Elliot, Glass & Co.—Mishaps during Manufacture—Constant Continuity Test—Mr. H. V. Physick—First Section Finished—Insulation of each Conductor—*Persian*—Shoring—Mr. John Thompson—Great Rejoicings—*Persian* leaves Greenhithe for Genoa—Storm Encountered—Falmouth—Keyham Dock—Cable in Kinks—*Persian* leaves Plymouth—Reaches Genoa safely—Laying Commenced—Taffrail Damaged—Cape Corso—Messages—End Landed—Insulation Deflection—Favourable Weather—Twelve Knots laid from Bonifacio to Longo Sardo—Third Section—Vertical Galvanometers—Cable left in Tank—*Result*—Captain Kell—*Star*—*Whitley Park*—Laying Commenced—Mishaps—Cable Cut—Expedition Abandoned—Remarks.

WHILE the last-mentioned cables were being laid, Mr. Brett had undertaken to construct lines across the Mediterranean, from Spezzia to Corsica, from Corsica to Sardinia, and from Sardinia to Bona; all these were to be precisely similar to the Dover and Ostend cable, except that they were to have a centre of soft tarred string in lieu of a No. 4 wire. The first section was laid between Spezzia and Corsica. Early in January, 1854, the Gutta Percha Company to the order of Messrs. Tupper & Carr, who, I believe, were the contractors, sent to Messrs. Kuper & Co.'s Wire Rope Works, on the Surrey Canal at Camberwell, the first consignment of gutta percha covered wire for this cable. An altered wire-rope stranding machine, known as the "Core machine," twisted these wires, the tarred hemp worming, and the serving together. In this process the gutta percha became more or less damaged; it was liable to get over the side of

the bobbins, especially when revolving quickly; friction straps would become too slack, or cog wheels break, or knots too large to pass the lay plate would occur in the yarns; and, lastly, inexperienced men and boys handled the core as they would have done an ordinary wire rope.

A barge filled with water proved a very good place in which to keep and test the coils of gutta percha covered wire; a similar arrangement also answered admirably for the coiling and the testing of the core as it was made.

On February 25th, twenty-five knots of the core were so tested, and then taken in the barge to Morden Wharf, East Greenwich, where the length was coiled on the upper floor of a building then in course of erection for the manufacture of the cable. Mr. Kuper was now replaced by Mr. Glass, the name of the firm being altered to Glass, Elliot & Co.

Mr. Fenwick was engaged to make and superintend the working of a machine similar to the one he had used at Wapping for the Dover and Calais cable. Although the iron wire was ungalvanised, it was supplied through Messrs. Tupper & Carr, a firm of galvanisers; the senior partner of this firm took great interest in everything connected with the manufacture of this cable, his representative being always present. Mr. Glass lived in an adjoining house and passed most of his time both night and day in the Works.

This line was not constructed without a repetition of those mishaps which had befallen its predecessors. As the cable was made it was coiled in an open yard, into what was intended to be a water-tight tank, but, owing to the nature of the soil, it was found impossible to keep water in it during low tide in the Thames. Experience had taught that the insulation of the conductors was always better when the cable was covered with water or in a cool atmosphere, so the tests were generally taken at high tide or in

the evening. A constant continuity test was applied to all the wires, by what might be described as six galvanometers in one long horizontal case. A current kept the needle of each deflected, but should a want of continuity occur in any conductor, the needle, in assuming a vertical position, would come into contact with a pin, thus closing a bell circuit which gave the alarm.

Mr. H. V. Physick frequently tested the electrical condition of this cable for Mr. Brett during its manufacture. On May 9th the first section, 110 knots, was finished, the end being brought from the machine and laid upon the coil in the yard, amidst the cheers of the workmen and the mutual congratulations of all concerned.

With the coil under water, 144 new cells and a vertical galvanometer with one cell, which stood at 60 degrees, the insulation of each conductor was as follows :—

No.	1	2	3	4	5	6
Degrees	5	4	3	3	4	3

a condition of affairs considered highly satisfactory.

The 110 knots were coiled dry in the hold of a long narrow screw steamer, called the *Persian*, and secured with beams of timber in the usual way. This mode of "shoring" is for many reasons very objectionable and ought to be discontinued; so ought the "lash," which is really the tying together of the turns of the coil to keep them in position; as the cable is paid out the ties are cut, but should the men omit to do this at the proper time, the cable becomes entangled, and much trouble and anxiety ensues.

Mr. Fenwick was under the impression that he would have charge of the laying of this cable, but Mr. Brett engaged instead Mr. John Thompson, an engineer who had superintended the manufacture and laying of cables for Messrs. Newall and Co. The coiling of the cable on board

was no easy task; not only had it to be hauled by many hands from the tank to the ship, but that laborious work was hindered by frequent stoppages to repair broken wires; so the completion of the job was celebrated by much rejoicing. The ship was dressed with flags from stem to stern, invited guests, both male and female, promenaded the deck, and the inhabitants of Greenwich made holiday in honour of the occasion. All the conductors were joined so as to make a length of 660 knots; through this, by means of the long-distance fuse, the ladies fired electrically cannon or small quantities of gunpowder placed in cases of gutta percha at the bottom of the Thames close to the ship.

Early in the morning of June 24th, with every prospect of a fine passage, the *Persian* left Greenhithe for Genoa, there to embark Mr. Brett and friends, and then to proceed to Spezzia, but at noon on the 26th she encountered what was to her a storm in the "Bay." In the main hold the shoring gave way, and the cable thus set free formed itself into an entangled mass. The sea swept the deck and invaded every available place below; the vessel being much knocked about by the violence of the storm, it was deemed advisable to put back, and, if possible, reach Falmouth. On gaining that port the extent of the damage done was more fully realised; the shifting of the cable had given her a "list" which caused inconvenience even in smooth water.

The cable in the main hold had to be taken out, examined and recoiled, and as Falmouth afforded no accommodation for such work the ship was taken into Keyham Dock, Plymouth, where with much difficulty the work was done. The cable had formed itself into very bad kinks and bends and in some cases heavy purchases had to be employed to disentangle it. When the recoiling was finished, car-

penters, unfortunately inexperienced, were employed to securely shore it, and knowing from previous observation how liable they were during this operation to drive nails into the cable, all the conductors were joined in series and a well-watched test kept. It was fortunate that this plan was adopted, for insulation was destroyed by a nail entering between the iron wires and perforating the gutta percha down to the copper wire; this accident occurred in the eye of the coil, and as it was found impossible to repair the damage without removing a large portion of the cable, it was thought better to mark the place and stop to examine it during the laying. When the nail was withdrawn the insulation returned to its normal condition and so allowed the test to be continued. The *Persian* left Plymouth on the evening of July 8th, arriving at Genoa on the 18th, and on the 21st the laying of the cable was commenced from Spezzia. It had not proceeded far when a broken wire caught in the guide of the "paying-out drum" (why so designated it would be difficult to say as it was here used to retard the cable), and destroyed the insulation of all the wires in a sharp bend on the taffrail. Advantage was taken of the opportunity afforded by this stoppage to put another turn round the drum. The following day it was found necessary to repair the taffrail and add an additional paying-out drum, but, during the stoppage for these purposes, the cable started paying itself out at full speed and it was some minutes before it could be stopped; then it was found that a sharp bend on the taffrail had again destroyed all insulation. With all the appliances available, it was but just possible to lift the cable sufficiently clear of the rail to apply a Spanish windlass. The gutta percha was much crushed by this untoward accident, and six new pieces of wire had to be

inserted, necessitating twelve joints in close proximity. All this occupied from the morning of Saturday, July 22nd, until the morning of the following Monday; at 5 p.m. on that day the damage done to the cable by the insertion of the nail at Plymouth was repaired, and the ship remained anchored by the cable until 4 a.m. the next morning. At 6.30 p.m. of the same day the *Persian* anchored off Cape Corso, when cannon were fired by the long distance fuse, and congratulatory messages sent and received; the accompanying steamer *Tripoli* then left for Genoa. By noon the next day the end was landed, and with 72 cells and a fairly sensitive vertical galvanometer, the insulation deflection of each wire was

No.	1	2	3	4	5	6
Degrees	4	4	6	5	5	4½

With 12 cells the signals were very good on a single needle instrument.

The laying of this 90 knots occupied from 4 a.m. of the 21st until noon of the 26th; fortunately during this time there was no wind to ruffle the sea, and no clouds to tell of coming storm; had this been reversed the cable would have been numbered with the slain, instead of being quoted as an example of engineering skill in the annals of submarine telegraphy. After waiting two days for favourable weather the length of 12 knots was laid from Bonifacio to Longo Sardo. Three broken wires occurred during the laying, and, owing to a miscalculation, the cable was too short to reach the shore, so a piece had to be spliced on at low water mark; these delays made it 10.30 p.m. before the work was accomplished. On the completion of the cable taken out by the *Persian* the contractors commenced the third section, intended to be laid from Cagliaria to Bona. On the 24th of August,

after the usual number of mishaps, seemingly inseparable from the manufacture of submarine telegraph cables, 125 knots were completed.

Rival makers constructed and supplied vertical galvanometers, some of which gave the following results on this cable.

Conductors	1	2	3	4	5	6	
Mr. Glass's Galvanometer	4	4	4	4	3	4	Degrees Deflection.
Mr. Physick's „	25	25	23	22	24	20	
Mr. Willoughby Smith's Galvanometer	40	36	38	39	37	39	

The instrument from which the last mentioned results were obtained, was manufactured for me at the Works of Mr. W. T. Henley, under his personal superintendence.

This cable was left for nearly twelve months in the tank in the yard of the Works; it was sometimes kept wet, but more often dry, and exposed to all the changeable conditions of the weather. It was at length coiled into the holds of the *Result*, one of Green's large sailing vessels, and taken to Cagliaria. It arrived there on September 8th, 1855, and on the 17th Mr. Brett joined the ship. Captain Kell, who had accompanied the *Persian*, and was employed on board that vessel in many capacities, was thought by Mr. Brett fully competent to take charge of the laying of this cable.

Two small steamers had been engaged in London to attend the *Result*, and at noon on the 22nd, one of them, the *Star*, arrived at Cagliaria reporting the other, *The Whitley Park*, as broken down and gone to Gibraltar for repairs. At 3 p.m. on the 25th the end of the cable was landed at Cape Spartivento and the laying commenced, the *Result* being towed by a French steamer, the *Tartare*. The expedition had not proceeded many miles before the ship was stopped to alter

the leading on gear, as the cable was riding upon the fore drum, owing to its having too much play. At 11 p.m. a kink stopped the paying out, and the ship hung to the cable all night.

At 9.30 next morning, soon after starting, the cable surged over both the paying out drums and paid itself out at a terrific speed for about two knots when, fortunately, one of the turns in the hold got entangled with one of the shoring planks and stopped it.

The insulation of all the conductors in this portion was destroyed, and no power being found sufficient to lift the cable at the stern, it was cut and passed through the hawser to the windlass and there secured for the night. All this took place on Wednesday, September 26th, and on the morning of the following Wednesday a broken end was hove in.

During the week a little over one knot was regained, and as it was not thought advisable to hove in at night, the ship rode by the cable during the dark hours.

The portion recovered contained many kinks each of which was deficient in insulation, or continuity, or both, and perhaps it was as well the cable broke, for the windlass was worn out and fast becoming useless.

The length of cable in the sea was abandoned, and the *Result* was taken to within a knot of Cape Spartivento, where the *Whitley Park* lifted the cable and passed it to her, but owing to unfavourable weather it was three days before laying was recommenced, and then it was thought advisable not to proceed at night, but to hang to the cable until daylight; especially as the ship was rolling to an alarming extent. When the laying was recommenced the *Whitley Park* assisted the *Tartare* to tow, as the *Result* was making slow progress and

the cable was leaving her at its own speed; thus 25½ knots of cable passed into the sea for only 15 knots of distance, so at noon on the following day, Monday, October 8th, the cable was cut close to the stern wheel and the expedition abandoned.

During the laying of this cable it was curious to note how it would at times leave the ship at an ungovernable speed, and then, as suddenly, stop of its own accord, no power at command being sufficient to move it from the perpendicular position it would assume, until the ship had proceeded a certain distance, when the balance would be disturbed and another run would occur to regain it.

In those days most of the cable layers considered it correct to lay them taut, in fact to stretch them as much as possible, slack being considered as so much cable wasted. Assuming this rule to be a good one, surely on board the *Result*, in this second attempt it was unreasonable to expect that so heavy a cable could be laid in unknown depths, not only without any slack, but stretched to reach the desired land.

It was a pitiable sight to see the *Result* in the face of a strong wind and turbulent sea pulled by the two steamers. Owing to the want of pre-arranged signals, they often dragged her in opposite directions while the cable was leaving the ship at its own speed, and men, whose tongues appeared as uncontrollable as the cable, were indulging in angry expletives and mutual recriminations. If the experience gained on board the *Persian* during the laying of the first section had been properly utilised, it is certain that many of the mishaps which befel the *Result* could have been avoided.

CHAPTER. V.

Lighter Three Multiple Cable—Lost in Endeavour to Lay—Cable between Cape Spartivento and Bona—1857—Cable Laid—French Law Court—Cable Useless—Mr. J. R. France—Efforts to Repair—Strand Conductors—Professor Faraday—Experiments on "Electric Induction"—Professor Wheatstone—Experiments—Dr. Whitehouse—Electrical Conditions for an Atlantic Cable—"Black Sea Cable"—S.S. *Elba*—Rough Weather—"Cone and Rings"—Line Laid Successfully—Shore End Cut Through—Opinion of Lord Lyons—Competition—Gutta Percha Company—Difficult Position to Maintain.

To give in detail the particulars of the expedition of the following year is quite unnecessary, the main events being similar to those previously experienced. It is, therefore, enough to note that the contractors made a much lighter three multiple cable, and that Mr. Brett lost the whole of it in his endeavour to lay it from the S.S. *Dutchman*, which was employed to carry it. Mr. Brett no longer employed Messrs. Glass, Elliot & Co. as his manufacturers, but went to Messrs. Newall & Co., who, in consideration of a lump sum to be paid to them when electrical communication should be established between Cape Spartivento and Bona, agreed to design, manufacture, and lay a multiple cable between those places the following year (1857); Mr. Brett and his party to have no part in the proceedings of the contractors.

This cable contained four 16 gauge, No. 4 wire copper *strand*, covered with two coverings of gutta percha to No. 5 gauge; this was by far the thinnest covering of gutta percha ever used for submarine cables.

The cable was laid after much trouble and many accidents; on one occasion *unprotected* gutta percha covered wire did good service in establishing communication while more cable was fetched from home, there being about twelve knots short.

Upon its completion opposing electricians differed as to the electrical condition of each conductor, and while a French law court was considering the matter, the cable became useless and was eventually abandoned.

Mr. J. R. France was the electrician appointed by Mr. Brett to test this cable when laid, but finding that the contractors would only allow one current to be used, and that one in their favour, he was perfectly justified in his indignant refusal to have anything more to do with it.

Subsequent efforts to repair this cable showed that in places the gutta percha had been sliced, apparently with a knife, along one side of the conductor and tightly bound in its place again by well-tarred yarn. Thus ended an episode that will not redound to the credit of progress in submarine telegraphy.

In the description of this cable I have for the first time mentioned the word *strand;* short lengths of wire made pliable by twisting them into a strand and plaiting and braiding them together had often been covered with gutta percha for electrical purposes, but not for submarine cables, until the frequent failures of solid conductors suggested their adoption. The first time a strand conductor was used was in 85 knots of cable made in 1856, by Messrs. Glass, Elliot & Co., and laid by them from the S.S. *Pontas*, from Newfoundland to Cape Breton. It is true that weight for weight, a strand, when covered to the same thickness as a solid, with any insulating material and surrounded by a conductor, has the disadvantage of a slightly higher induc-

tive capacity, which in those days was considered by many fatal to its use. As to its mechanical advantage there could be no doubt, and it is a source of gratification to know that this soon outweighed the supposed electrical difficulty.

Fortunately, the advancement of submarine telegraphy did not depend upon the successful completion of the section just described. It was with some of the gutta percha covered wire which formed part of the cable laid from the *Persian* that Professor Faraday made the experiments on "Electric Induction," experiments so well described at page 508, vol. III. of his "Experimental Researches."

Upon the completion of this section, while it was coiled at Greenwich, Professor Wheatstone experimented with a view to verifying some of Professor Faraday's statements; fortunately it was demonstrated to him that the results obtained with a coiled cable, especially if a multiple one, were delusive, and in no way proved Faraday to be wrong. Professor Wheatstone has published some of the experiments, but they must be received with caution, as they will be found to differ from those made with long straight cables.

Dr. Whitehouse experimented upon the next section while it lay coiled at Greenwich, in order it find out the most suitable electrical conditions to be used in an Atlantic cable. It is to be feared that the results obtained were misleading as to the proportions of a conductor, the thickness of the gutta percha and the nature of the electrical energy necessary to give the desired speed for a cable 2,000 knots in length.

In 1855, during the Crimean War, Messrs. Newall & Co. were employed by the British Government to make and lay a line, which became known as the "Black Sea Cable." The contractors bound the Gutta Percha Company

to supply to them, within far too short a time, 400 knots of 16 copper wire doubly covered with gutta percha to No. 1 gauge. As Messrs. Newall & Co. shipped the cable immediately on its delivery to them, the proceeding was considered very mysterious, and in proportion to the mystery were the efforts of rival contractors to unravel it.

Unfortunately for Messrs. Newall & Co., the S.S. *Elba*, employed by them to carry the cable, experienced rough weather in the North Sea and had to put in to the Thames for repairs; here the curiosity with regard to the rapid shipment culminated in the employment of every device for gaining the much coveted information.

It had always been a common practice, both at the Gutta Percha Works and at the Cable Works, to wind the coils of wire upon a swift; this swift consisted of a circular wooden base, on the centre of which was fixed a perpendicular wooden cone, going through the eye of the coil while the disc supported it. Each hold of the *Elba* was fitted on a much larger scale, with a similar contrivance, round which was wound the gutta percha covered wire, just as it was received from the Gutta Percha Company, except that it had been joined in one continuous length, and twelve knots at either end of the line had been covered with iron wires to act as shore ends. Metallic rings were suspended round the top of the cone and in the rigging of the ship through which the wire passed when being laid. Mr. Newall eventually patented this contrivance, when it became known as the "Cone and Rings," and was the cause of much litigation and recrimination. Whether the patent could be evaded by using a cylinder, telescopic or not, in lieu of a cone, and other contrivances instead of the rings, opinions differed, but certainly with the use of the cone and rings commenced the desirable system of securing coiled cables on ship board,

instead of the objectionable practice of using wooden planks and nails.

This line was successfully laid from Balaklava to Varna, and Mr. Newall has placed it on record that the cable had been in use for ten months, when just before the conclusion of the war one of the shore ends was cut through designedly by a sharp instrument. This mischief was quickly repaired, and Lord Lyons has given it as his opinion, that the duration of the war was lessened considerably by the facilities for rapid communication which this line gave. This is another instance in which *unprotected* gutta percha covered wire has rendered good service and proved itself fully trustworthy.

Cable makers, contractors, and concessionaires were but a small body at that time, but they seem to have been possessed with a large proportion of envy, hatred, malice, and all uncharitableness with regard to one another; that is, if we may judge from the way they spoke of their rivals while watching their doings with "Paul Pry" tenacity. Competition, fair and honest, is healthy and legitimate; it does good in many ways, but when it condescends to the despicable device of injuring the work of the successful, it deserves all possible condemnation. One is loth to believe that such a thing did occur in connection with submarine telegraphy, although an English jury arrived at that conclusion, as I shall hereafter relate.

The Gutta Percha Company had a most difficult position to maintain, as their different customers were clamouring to be supplied. If the Company were behind time, they were accused of favouritism, reminded of the "failure" of many cables through the unsuitability of gutta percha, and the many endeavours that were being made to find a substitute which would certainly be used in preference, etc., etc. It

must be admitted that the Gutta Percha Company to satisfy their customers frequently supplied wire, which under ordinary circumstances they would not have sent out; the mechanical flaws thus passed were as defects in their armour, of which their adversaries were not slow to take advantage.

CHAPTER VI.

Works at Birkenhead—Hemp Rope Walks of Mr. Enderby—Mr. W. T. Henley—Works at North Woolwich—Ireland and Newfoundland—To be Connected—Samples of Cable—Made and Tested—Messrs. Brown, Lenox & Co.—Cable Selected—Atlantic Telegraph Company—Coils of Cable Tested—Core Covered—*Niagara*—*Agamemnon*—Laying Commenced—Valentia—Cable Broken—Professor Thomson—Breaking Strain—Mr. Cyrus Field—Temperature and Pressure—Conductivity of Copper Wires—Insulation—Paying-out Machinery—Covering of Conductor—Cable Re-shipped—Laying from Mid-Atlantic—Cable Broken—Breaking Strain—Another Attempt—England and America Connected—Hopes Delusive—Impracticable Schemes—Detecting Faults—Examination of Core—High Temperature—Valuable Knowledge Gained—Conductivity of Wire Resistance—Mr. C. T. Bright.

To provide more room, and for greater convenience in shipping their cables, Messrs. Newall & Co. turned some of the warehouses at the side of the Birkenhead Docks into a cable factory, and here they did most of their work.

Not far from the works of Messrs. Glass, Elliot & Co. stood what had at one time been the Hemp Rope Walks of Mr. Enderby, and part of these they rented to meet the extension of their business.

Mr. W. T. Henley, who had hitherto confined himself to instrument making and the laying of subterranean lines, now commenced manufacturing submarine cables, and for this purpose rented the other part of Enderby's. But time soon proved that two rival manufacturers could not work under one roof, so Mr. Henley, much to his annoyance, had to leave, and Messrs. Glass, Elliot & Co. rented the premises he vacated. When turned out of Enderby's, Mr. Henley built

works beside the Thames at North Woolwich which confounded his enemies and astonished his friends.

Even those persons most competent to judge differed in opinion as to whether sufficient experience had been gained to warrant an attempt to connect Ireland and Newfoundland with a view to bringing England and America into electrical communication. It was certainly a laudable desire, but those who were in favour of the proposed scheme differed as to the best means of accomplishing the task.

Many sample-lengths of cable were made and their mechanical properties tested at the works of Messrs. Brown, Lenox & Co., the one ultimately selected consisting of a seven copper wire strand, weighing 107 lbs. per statute mile, trebly covered with gutta percha to $\frac{3}{8}$-inch diameter, and weighing 237 lbs. per statute mile. This was helically covered with tarred yarn, and then with 18 seven iron wire strand of the same size as the conductor. The total weight per statute mile of the cable was one ton. Prepared yard-length specimens of this, not only showed its flexibility but looked very pretty, and were used as decoys to obtain the capital required, a purpose which seems to have been more thought of than the suitability of the cable.

In 1856 the Atlantic Telegraph Company was formed. Their proceedings do not compare favourably with even the first attempt to connect England and Ireland by electricity. Hare-like and careless was the rapidity of their performances as contrasted with the tortoise-like caution of their predecessors. The Gutta-Percha Company manufactured the core, and from December 19th, 1856, to July 6th the following year, Dr. Whitehouse had at their works "tested" 2,717 knots.

The coils varied in length—the maximum being 3,091, the minimum 1,623 yards—and each coil was tested

separately in batches varying from 15 to 136 coils each time. After the coil had been "passed" it was wound on to a wooden reel and sent to be covered with hemp and iron wire strands, either to the works of Messrs. Glass, Elliot & Co., or to those of Messrs. Newall & Co. at Birkenhead, between whom the 2,717 knots were equally divided.

Thirty half-knot lengths of this core were covered up to three-fourths of an inch with common gutta percha, mixed with mahogany wood dust. These were part of the 30 knots to be covered for the shore ends, but, from some then unknown cause, the insulation was far below that of the ordinary core; that is to say, all the coils were tested with forty-two 12 cell sand batteries and a fairly sensitive large horizontal galvanometer, and the number of degrees of deflection regulated the passing or rejecting of the coil; but, as neither time nor temperature was taken into account, such tests were not always just, and consequently the verdict was frequently disputed. Ultimately the $\frac{3}{4}$-inch was abandoned and the ordinary core used instead.

The half of the core made at Birkenhead was coiled as best it could be on board the *Niagara*, a war steamer lent by the American Government. The *Agamemnon*, a war steamer lent by the English Government, received under similar circumstances the half made at Greenwich. On Friday evening, August 7, 1857, the laying of the cable was commenced from Valentia, Ireland, in the direction of Newfoundland, but on the Friday following the ships put in to Plymouth, as the cable had broken at the stern of the *Niagara* when nearly 400 knots had been laid.

Professor Thomson (now Sir William Thomson) and one of the directors of the Atlantic Telegraph Company, tried, at the works of the Gutta Percha Company, the breaking strain of a piece of the cable (Newall's make) close to where

it broke, with 85·75 cwt. A new length made by Glass, Elliot & Co., to compare with it, carried 75 cwt., and broke while sustaining 75·75 cwt.

The secretary of the Atlantic Telegraph Company and Mr. Cyrus Field experimented at the same works as to the mechanical effects of temperature combined with pressure on their core. At 110° F. it remained firm with a pressure of 56 lbs., but when that temperature was exceeded it was not to be depended upon. The cable was passed through a hot "preservative compound" and coiled on shore at Plymouth during the winter, and in the meantime 400 knots more cable were made to replace the portion lost.

The conductivity of the copper wires used in the strand conductor, and the insulation of the completed lengths were tested by Mr. Phillips at the Gutta Percha Company's Works, and they were then sent to Glass, Elliot & Co.'s works at Greenwich to be covered with tarred hemp serving and strands of iron wire.

The newly devised paying out machinery made by Messrs. Easton & Amos was put together at the Gutta Percha Works, where Mr. Bright and most of his staff experimented with it.

Mr. Hearder, a blind gentleman, of Plymouth, had suggested to the Atlantic Telegraph Company that if they covered the conductor with cotton or similar material before putting on the gutta percha it would considerably lessen induction. This idea suggested itself to Mr. Hearder while he was experimenting with the induction coil, and he experimentally investigated the subject further with static electricity, Leyden jars and pieces of flannel.

The words *less induction* appear to have been good bait for the Atlantic Telegraph Company, as they immediately had six knots of their core covered as suggested, half with

cotton and half with worsted of varying thickness, but in each case Mr. Whitehouse and Mr. C. F. Walker found the induction higher than that of the ordinary core. Even assuming that it had been less, there were many other reasons against the adoption of such a core.

In the summer of the following year the cable was re-shipped, and, from the numerous experiments made in the deep water of the Bay of Biscay on the way out, it was thought that sufficient knowledge had been gained to justify the splicing of the cable in mid-Atlantic, and for the ships to proceed in opposite directions to lay it, one going east the other west. But owing to the breaking of the cable beyond the prescribed distance, arranged for a return to mid-Atlantic in case of failure, each ship steamed to Cork for consultation.

Professor Thomson, Mr. Glass, and one of the directors of the Atlantic Telegraph Company, tried, at the Gutta Percha Works, the breaking strain of the cable, which was close to the last break in the Atlantic (Messrs. Glass, Elliot & Co.'s make); it carried 63 and broke with 65 cwt. On the previous day Messrs. Bright, Whitehouse, and Elliot were also present, but on that occasion the cable slipped in the clamps with a strain of 10 cwt., and it was arranged for them to meet again at 10 o'clock the following morning.

Summer being not far advanced, and a sufficient length of cable still left, it was decided to make another attempt. The expedition therefore started for mid-Atlantic, where the splice was once more effected.

After another series of mishaps and much agonising suspense, the joyful tidings were at length proclaimed that the cable was successfully laid and electrical connection between England and America at last established. But,

alas, the pleasure was of short duration. Very soon grave doubts arose that the communication was not what it ought to be, and those upon the spot who were competent to form an opinion, of course knew that the insulation was very bad and daily getting worse; therefore it was with the greatest difficulty, even during the most favourable intervals, that intelligible signals could be interpreted. When at last it was no longer possible to signal at all, and the many devices tried to restore the insulation proved unavailing, the "I told you so" class came prominently to the front, with numerous suggestions and models; each individual asserting his method to be the only way to ensure success. How multitudinous were these doubtful sympathisers, and how devoutly it was wished that most of them possessed more reason and less imagination; as then, perhaps, their tongues would not have been so voluble in advocating impracticable schemes. Well has it been said

"Beware of a tongue
That's loosely hung."

Of course it was thought that gutta percha had proved wanting, and many substances were suggested to supersede it.

Much has been said and much written concerning this cable and how it was manipulated. During its manufacture, want of continuity frequently occurred in the conductor while being served or sheathed at joints or mended places. With a view to detecting such faults, the electrician of the Atlantic Telegraph Company ordered all the coils to be wound under sufficient strain for this purpose. In this way the core was stretched, and, owing to the dead set of the copper and the resilient character of the gutta percha, the core was more susceptible of being affected by an abnormal temperature. About two knots, recovered during

one of the attempted repairs, was examined by me at the works of the Gutta Percha Company in the presence of Mr. G. Saward, secretary to the Atlantic Telegraph Company. Even in this short length there were many parts where, for a considerable distance, owing to the cable having been subjected to a high temperature, the conductor was to be seen on the surface of the gutta percha, and was only prevented by the serving from coming into contact with the outer iron strands. In such places it was difficult to separate the hemp and gutta percha, so closely had heat and pressure united them. The cable having been manufactured dry and never put into water until it was laid, it is possible, and highly probable, that the tarred hemp serving had sufficient insulation to conceal its real condition until it was too late to remedy it. Much valuable knowledge was gained while this line was in hand.

Professor Thomson demonstrated the important fact that electrically all copper had not the same conductivity, and in this respect the wire being used for the Atlantic cable varied as much as 40 per cent. Unfortunately this discovery was made too late to be utilised, excepting in the 400 additional knots. What had been long suspected was proved beyond a doubt, namely, that a decrease of temperature increases the electrical resistance of gutta percha, and that the amount of the resistance depends upon the time it is under electrical charge, or, as it is now termed, polarisation or electrification. Age, too, has a marked effect in increasing its resistance. It was also proved that neither length nor depth was a barrier to the advancement of submarine telegraphy if managed with the care and attention necessary to ensure success. It was likewise ascertained at this time that pressure in water did not develop faults but concealed them. Therefore, the time and money expended on this

cable was not all wasted; rather should we be thankful for the many useful lessons gained during its manufacture and laying.

Mr. C. T. Bright, as engineer to the Atlantic Telegraph Company, received the honour of knighthood at the completion of the laying of this cable.

CHAPTER VII.

Compound—Four Multiple Cable—Dunwich to Zandvoort—Order Received—Core Tested—Usual Mishaps—Mr. C. F. Varley—Fault Localised—Cable Coiled—*William Cory*—Extraordinary Proceedings—Cable Laid—Fault Discovered—Twelve Months Removing it—Action, Glass *v.* Boswell—Insulation Destroyed by a Nail—Verdict—New Trial Applied for—Remarks—New Trial Refused.

In December, 1857, I first advocated the use of a compound composed of gutta percha, Stockholm tar and resin, as an adhesive mixture; this was for application between each separate covering of the gutta percha, instead of passing it through so quick a solvent as coal-tar naphtha, which had been the practice of the Gutta Percha Company ever since they commenced covering wires with more than one coating of gutta percha. It was also suggested that the solid or strand conductor should pass through this mixture, before receiving its first covering of gutta percha. Experience soon proved that this mixture had not only good adhesiveproperties, but that wires covered with it had higher insulation than those covered in the ordinary way. Comparatively short lengths of "compounded wire" had been supplied and had given great satisfaction.

The small cables manufactured at Sunderland, and laid from Orford Ness to the Hague for the Electric Telegraph Company, had given so much trouble and caused so much expense in repairs that it was decided to replace them by a large and heavy four-wire multiple cable, to be laid from Dunwich

to Zandvoort, Messrs. Glass, Elliot & Co. being engaged to manufacture and lay it.

To give the compound a good and practical trial, it was arranged that two of the conductors should be "compounded," while the other two were insulated in the ordinary way. On Monday, June 14th, 1858, the Gutta Percha Company received the order from Glass, Elliot and Co. for 560 knots of a solid copper wire No. 13 Birmingham wire gauge, to be doubly covered to No. 0, same gauge. It was to be in four equal lengths, one to be plain and the others to have respectively 1, 2, and 3 projecting ribs of gutta-percha upon their surface as distinguishing marks. Nos. 2 and 3 were to be "compounded," and the other two covered in the ordinary way.

On Friday, July 2nd, Mr. Latimer Clark, as engineer to the Electric Telegraph Company, and a representative of Messrs. Glass, Elliot & Co. tested, at the Gutta Percha Company's works, the first four knots, in coils of one knot each. The insulation of Nos. 2 and 3 was four times better than No. 1 and plain, that is to say, the "compounded" coils gave 4° each, and the other two 16° each. These were delivered at Greenwich, the manufacture of the cable commenced, and about the middle of the following September it was completed.

All those concerned in this improvement congratulated themselves that the value of the compound was to be granted so practical a test, and great interest was evinced at every stage of the proceedings; great then was the concern on the announcement that the cable, when laid, had one of the "compounded" wires faulty. Messrs. Glass, Elliot & Co. were thought at the time to be acting wisely when they placed the electrical department of the expedition in charge of Mr. C. F. Varley, who was not

only electrician to the company for whom the cable was laid, but a great authority with the public generally on telegraphy and matters electrical. He had, to his own satisfaction at least, accomplished what no other man had been able to do, that is to say, he had localised a fault in the Atlantic cable. It was generally supposed that in such skilful and experienced hands this expedition would be all that could be desired, instead of which it proved to be a series of mishaps from start to finish.

The cable was coiled into the fore and main holds of the S.S. *William Cory*, familiarly known as *Dirty Billy*. The shoring of the eye of each coil consisted of the usual rough wooden planks nailed together, and was erected while going down the Thames on the way to Zandvoort, where, with all speed, the shore end was landed and the laying of the cable commenced. It seems to have proceeded in an extraordinary manner, as nothing that occurred induced those in command to stop until off Dunwich, where the other shore end was landed. During the laying, some of the shoring in the eye of the coil fell in, causing trouble and confusion, and two or three kinks were allowed to pass, although one of them was so bad that a buoy was pitched overboard to mark the place. Insulation was totally destroyed, but such was the system of testing, that it was fully twenty-five minutes before this fact was discovered. At first the fault was supposed to be in the connections, and much time elapsed before it was traced to No. 2 wire; then, although it was of low, if of any appreciable resistance, it was not localised with any degree of certainty. It is true that generally, at the latter end of September, the North Sea is unsuitable for cable laying, but upon this occasion even bad weather was not suggested as an explanation of the novel and strange proceedings.

Several attempts were made to remove the fault, but it was twelve months before these efforts succeeded, and then the mischief was only discovered after taking up two knots of the cable; a nail had been driven in so as to form contact between No. 2 conductor and the outer wires. A similar accident had happened to other cables while being shored. It was satisfactory to learn that the compound was not at fault; on the contrary, the tests were highly in its favour.

Twelve months after the completion of the repairs, and more than two years from the date of laying the cable, when passed troubles might well be supposed buried and forgotten, all the circumstances were vividly revived. Mr. Glass brought an action for damages against Mr. Boswell, the London agent of Messrs. Newall & Co., for having engaged a man to accompany the laying expedition and intentionally destroy insulation by forcing a nail into the cable.

The transcript of Messrs. Cock's shorthand notes of the whole trial was published in book form by Messrs. Waterlow & Sons. I think no unbiassed person who has read the book with an endeavour to understand it, can have closed it without a firm conviction of regret that the men, selected to decide the case, had not even a slight knowledge of the subject. Had it been otherwise some pertinent questions would certainly have been asked and some judicial remarks made during this remarkable trial.

Much importance appears to have been attached to the fact that Mr. Boswell induced a Mr. Curtis to get him a piece of the cable. This should have carried no weight, for it was the constant practice, especially with rival contractors, to endeavour to get hold of a specimen of each other's cables, and many amusing anecdotes might be

related of the devices adopted to achieve this end. Some tried for specimens merely from curiosity, while others dissected the pieces obtained to find out what class of materials was used, the length of lay, &c.; for, be it remembered, the materials of which submarine telegraph cables are made can differ considerably both in quality and in gauge, and consequently in price also. If the contractor specified for the best material of a certain gauge, and used inferior material of a light gauge, then, of course, the cost of production would be considerably reduced; and to obtain, as I have said, specimens of the different cables, was one way the contractors had of watching each other's proceedings. The stops of the cable are simply hemp strings, which fasten each ring or circle of the cable together, to prevent its springing or getting out of place while coiling. These stops are put on at regular intervals, radiating from the centre to the circumference, thus forming lines similar to the spokes of a wheel. During the laying, one man has charge of each line, and his duty is, not only to cut the necessary stop, but having done so, to hold his section of the cable in position until it is taken from him by the running out portion. The foreman of the coil is supposed to see that each man performs his allotted task. Cutting stops, &c., is simple work enough, but most important, and no man dares to leave his post without getting the consent of his foreman, who has to provide a substitute; for, if the stops be not properly cut, the consequences are likely to be serious. It would certainly have been more satisfactory, if the man who relieved Curtis during his alleged absence, or the foreman in charge at the time, had been called upon to give evidence. It is noticeable that the Plaintiff only called two witnesses who were actually on board the *William Cory* when the fault occurred. One

of these witnesses was Curtis, who said that he drove the nail in intentionally, and the other, the electrical assistant who discovered the loss of insulation.

The language of truth is simple; the foundation being sure no number of repetitions can shake it; but the evidence of Curtis, although difficult to follow, is in substance, if I rightly interpret it, as follows:—

"I am a ship-rigger by trade, but at intervals, for the last eight years, I have been employed by Messrs. Newall & Co. in various capacities. In August, 1858, the Defendant, Messrs. Newall & Co.'s agent, engaged me to get employment some way or other by Messrs. Glass, Elliot & Co., to accompany their ship which would soon start on a cable-laying expedition; not only to see whether they infringed Mr. Newall's patent in shoring the cable, but, if possible, to injure the cable by driving a nail into it while they were busy laying it, and, at the request of the Defendant, I obtained a piece of the cable, so that he could the better instruct me how to accomplish this object. The cable was coiled in the fore and main holds, but was in one continuous length. During the laying I, with about nineteen others, was engaged upon the coil cutting the stops. All the cable had been payed out of the after hold, and about five turns of the first flake of the coil in the main hold, when I left my duty and went *into one of the corners of the coil*, and with the aid of my knife and a piece of wood drove into the cable, about four flakes down, a 2½-inch new nail which I had picked up on deck about twelve hours previously. Having driven it in as far as I thought necessary I *cut* it off, *broke it off*, and it was very soon reported that one of the communication wires was gone. They could get no message from it."

Now if there is one time more than another when the

cable hands are required to be at their posts, especially with such a large cable, it is when the uncoiling is being transferred from one hold to another. The uncoiling always commences from the centre, where, of course, the turns are small, requiring great vigilance on the part of all employed to prevent kinks, &c. It is therefore difficult to understand how, at this time, Curtis could, unobserved, have left his duty and done what he says he did.

As regards the shoring Mr. Winter, in his cross-examination, says:—

"In the centre of the coil were wooden struts, roughly nailed together, and these were knocked away, being in the way of the paying out of the cable."

This is precisely what was done with a similar cable where, as already described, one of the nails destroyed the insulation of one of the wires. Unless the insulation is affected it is impossible to tell what is in the cable, for the slightest film of gutta percha between the conductor and any metallic substance is sufficient to prevent detection, but the movement of the cable from a ring to a straight line, as in cable-laying, has been sufficient to develop a fault by forcing the two into contact.

If Curtis cut the nail, as he says he did, surely the top part would have projected between the iron wires, yet Mr. Glass, in his evidence, said:—"We discovered, after stripping the wire—— We could see nothing externally —— After stripping the wire we found a small piece of iron between the wires—— After the wire was stripped the piece of iron showed itself." He then goes on to say:— "It confirmed his (Curtis') account exactly."

With regard to the electrical department Mr. Winter states in his evidence:—"I am an assistant engineer to the Electric Telegraph Company. This was the first time

I had been engaged in cable-laying. During my watch I had no assistant. The insulation test was usually taken at intervals of from ten to fifteen minutes—— At this moment the test had been at 8.40 p.m. There was a lapse of twenty-five minutes, during which I was taking observations, by the revolution of the rotometer, of the depth of water and the speed at which the cable was paying out." . . . . "Between 8.40 and 9.5, during which time the fault occurred, the speed was at the rate of 3·78 nautical miles per hour. I should say there is 1·25 miles in a flake, but cannot say positively."

Assuming that there was only *one* mile in a flake, and that Curtis did injure the cable four flakes down, then the fault must have been well in-board when discovered, and ought to have been localised there.

The verdict was given for the Plaintiff, and the Defendant moved for a new trial, where affidavits both *pro* and *con.* were taken. In one of them three of the leading cable hands in the employ of the Plaintiff stated:—

"It was part of our duty to superintend the men in cutting the stops; the cutting commenced from the eye of the coil and the men would always have their backs turned towards the outside of the coil, and, being in a stooping position and naturally intent on a dangerous occupation, they would not be likely to see any person on the outside of the coil standing on the flooring of the hold or beams running across the hold, more especially if he stooped so as to keep his head below the coil."

But surely men so placed have a full view of all the hold. It has often been a subject of comment that cable hands take such an interest in their work that they are the first to call attention, if they have the slightest suspicion that any of their number is neglecting his duty. Knowing the

truthfulness of this, and the way in which the foremen perambulate round the coil, how Curtis could accomplish his object in the way he describes, is to me incomprehensible.

The affidavit goes on to state:—"The uncoiling of each flake occupied about fifteen or twenty minutes; so for a great portion of this time the men employed in cutting the stops would be a considerable distance from the outside of the coil." Suppose the mean of fifteen and twenty be taken, which would be 17·5, and multiply it by 4, the number of flakes given by Curtis, the result would be 70 minutes; and if, as is supposed, the fault occurred directly after Mr. Winter's test at 8.40, then 25′ from 70′ leaves 45′, or 2·5 flakes in-board when it was discovered.

As to the assertion that "The rust driven off the cable caused so thick a dust that it was impossible from the deck to distinguish who the men were in the hold," my experience with similar cables has been, that the pressure at the lay plate of the closing machine has been such as to squeeze the tar in the serving through the interstices of the iron wires over which the coiler's hands spread it, and by that means the cable has a covering of tar which prevents dust at any time. Also during the laying, only the watch on duty were allowed in the hold, and the "corners of the coil" were more or less filled with the pieces of the shoring from the centre of the coil.

Lord Chief Justice Erle, who presided at the trial, is reported to have said:—"A clear understanding of the cause of complaint has a very material bearing in my mind upon the evidence. The electric cable, as probably is well known, is made with a wire in the middle, a sheath with a long conducting substance, and, for marine purposes, coated

wire on the outside. If there is any metallic contact with the wire enclosed and the non-conducting substance, the efficiency of the cable is destroyed."

This definition reads curiously, especially from such a man. The leading counsel for the Defendant, Mr. Bovill, too, must have felt that he had been wasting his time, when after detailing most minutely the position of the cable and how Curtis said he injured it, Mr. Justice Byles interrupted him to ask, "Was the coil into which you say the nail was driven on the deck or in the cabin?"

A new trial was refused, nevertheless I leave the subject with the firm opinion that the fault was accidental and not caused by malice.

CHAPTER VIII.

Light Cables—Candia and Alexandria Cable—Order—1858—Insulation Test —Coils sent to Birkenhead—Attempt to Lay Cable—Failure after Three Attempts—Different Cables Used—Mishaps during Laying—Electrolysis—Hemp Cables—Fresh Order—Wire Manufacturers—Two Qualities of Gutta Percha—Red Sea Telegraph Company—Distance of Sections—Jointers—Bad Joints—Cheap Core—Tests—Pressure Tank—Messrs. Siemens and Halske—Red Sea Cable Laid—Perfect Paying-out Machinery—Faults Developed—Cable soon Useless—Government Support—New Cable—Special Arrangements for Manufacture—Stranding Machine—"Gib Core"—Insulation of Coils—Covering of Core—Experiments—Tests for Government—Dr. Esselbach—Mr. Reid's Cylinder—Static Electricity—Gutta Percha—Temperature—First Test of "Gib Core"—Numerous other Tests—Theory *v.* Practice—Vacuum and Pressure—Pressure Tank—Strand Compounded—Rangoon and Singapore—Rejected Core—Electrical Resistance—Insulation—Reduction of Standard—Discharge of Electricity—Cable Coiled—S.S. *Queen Victoria*—Heat Generated—Resistance Thermometers—Malta and Alexandria Cable—Death of Mr. Gisborne—Cable Laid in Three Sections—Staff—Line Leased to Messrs. Glass, Elliot & Co.

THIS trial has led me somewhat ahead with my jottings. I will therefore retrace my steps and endeavour to keep more closely to my text.

Messrs. Newall & Co. were evidently in favour of what are called "light cables," for wherever they had entire control, they used them, as in their Holyhead and Howth, their Black Sea, and the Candia and Alexandria cable which I am about to describe.

Whether these lines were adopted with a view to advance submarine telegraphy by actual and practical experiment or for the purpose of economy is still an open question.

In May, 1858, the Gutta Percha Company received an

order from Messrs. Newall & Co. for 380 knots of No. 12 stranded wire doubly covered to No. 1; this represented 150 lbs. of copper and 170 lbs. of gutta percha per knot, making the thickness of the gutta percha ·093. It was immersed in water of no specified temperature, in coils one knot in length, and so tested for insulation by either Mr. Robert Reid or Mr. James Reid, on behalf of Messrs. Newall & Co., at the Works of the Gutta Percha Company. The tested coils were packed in cases and sent to the Works of Messrs. Newall & Co. at Birkenhead, where, when practicable, they were wound on iron reels and again tested for insulation, under pressure in a tank or iron cylinder constructed for the purpose.

The process of exhausting the air, admitting water and applying pressure, developed air indentations on the surface of the gutta percha which were not developed at the Gutta Percha Works, but they in no way influenced the electrical tests; it was only in appearance that they were objectionable.

On the 3rd July, 380 knots were completed, and Messrs. Newall & Co. covered this length with tarred hemp cords and with it endeavoured to connect Candia and Alexandria. They failed to do so owing to a combination of adverse circumstances, although three attempts were made.

For their second attempt the hemp was covered with iron wires, put on similarly to those on the gutta percha of their Holyhead and Howth line. In the third and last attempt they used the length saved from this line, and some iron bound cable borrowed from a company for whom they were making it. The iron bound cable they laid, but when they came to their own length, failure again attended their efforts. They returned home sadder

but let us hope wiser men, having lost over 800 miles of "cable" on these three expeditions.

These failures were not conducive to the advancement of submarine telegraphy, the cables being, as those well acquainted with the facts knew, badly designed, badly manufactured, and badly put down. The line was never immersed excepting as the laying proceeded, and while attempting to remedy the faults then developed, the cable broke. It also broke without warning, in mysterious ways, while it was being laid in deep water on a rough and rocky bottom, with less than one per cent. of slack. Through blundering the steamer was twice run aground while the cable was being paid out.

At some time or other the line must have been submitted to a very high temperature, causing the conductor at frequent intervals almost to touch the circumference of the gutta percha, and accounting for the gradual development of faults.

It was said "the slight film of insulating medium in those places allows a sufficient portion of the current to pass through it, electrolysis sets in and destroys insulation." The theory is ingenious, but my belief is that there were faults concealed by the tarred hemp which developed rapidly when the cable was immersed, just as in the instance of the Atlantic cable already described. As to electrolysis, I may mention that it is a very simple and easy process to make gutta percha globes much larger and thinner than the "rubber air balls" with which children play. Let such a globe, containing, say, water, be suspended in a glass vessel containing a similar fluid, and one end of a battery placed in the vessel and the other end immersed inside the globe, have a make and break so arranged as to reverse the battery or not; no difference

will be noticed in the insulation, no matter what the speed or strength of the current may be. At least my maximum and minimum has been 1 to 500 per minute from 1 to 500 Leclanché cells for nine months. With perfect globes no apparent effect was produced, but if there was the minutest defect, such as a speck of foreign matter, or an imperceptible flaw, it was curious, and at the same time instructive, to watch the action of the current, in the formation of gas, by the decomposition of the water, at the identical place, until at length the insulation became totally destroyed.

A mile length of similar hemp cable was wound in a coil and immersed in water. Owing to the action of the water upon the hemp, the gutta percha covered wire was drawn into forms most remarkable. The contraction of the hemp appeared to alter daily, until at the end of a month it presented the appearance of a bundle of Gordian knots.

The advocates of hemp cables need not be discouraged by anything which happened to this one, they need only bear in mind that in the shallow water the hemp was soon demolished by insects. Samples of hemp cables properly made have stood experimental tests remarkably well, and are therefore worthy of a more practical trial on a larger scale.

On Saturday, 17th July, 1858, Mr. Gordon, one of the firm of Newall & Co., after experimenting at the Gutta Percha Works, with a coil of "compounded" and one of ordinary covered core then in course of manufacture for the Zandvoort and Dunwich cable for Glass, Elliot & Co., gave an order for 3,500 knots of No. 0, Birmingham wire gauge, with a covering of the compound on the strand and between the gutta percha. This was equivalent to 180 lbs. of copper and 212 lbs. of gutta percha per knot, and their

diameters for this were ·116 of an inch copper, ·340 of an inch gutta percha, giving a thickness of only ·112 of an inch for so large a strand. Allowing for waste, this length would require at least 320 tons of copper drawn into 24,500 knots of No. 19 Birmingham wire gauge. To ensure the production of this quantity at the rate of 300 knots per week, many firms of wire manufacturers had to be employed; each promised to do its best, but refused to be bound to any standard of conductivity, considering such a demand arbitrary and altogether impracticable. Although, with some, bad was their best, it was evident that others were trying to outdo their rivals, and thus establishing a healthy competition.

The impracticable was fast vanishing, and long clean lengths, uniform and of higher conductivity, were being produced.

I doubt whether it has ever been fully recognised how important were the labours of these men; by responding quickly to the call made upon them, they were the first to sow the seed, the fruit of which, not only in the electrical, but in many other branches of science, is now being reaped in an abundant harvest.

This length of wire would also require about 410 tons of gutta percha. Just then the Gutta Percha Company were sorting their gutta percha into two qualities known as "A" and "B"; "A" being used exclusively for covering wire, and "B" for general work, such as sheets, millbands, &c., &c. This large order following quickly upon the completion of the core of the Atlantic cable, which had taken about 450 tons of "A" quality, did not give the Company time to replenish their stock, so they arranged to use the "B" quality for the second covering of this and all other wires.

This length of core was required for the Red Sea Telegraph Company's cable to be laid in sections as follows, the figures giving the distance of each section in knots.

Suez		Kosseir		Suakim		Aden		Hallini		Muscat		Kurrachee
	254		477		645		717		488		477	

Messrs. Gisborne and Forde were appointed engineers, but took no part in the designing, manufacturing or laying of the cable ; in fact, it was purely a contractors' "go as you please" sort of arrangement, and from what follows I think it is evident that full advantage was taken of the opportunity.

The British Government who had so liberally subsidised this line did not apparently think it necessary to look after their own interests, and they had to pay dearly for the neglect. The contractors appointed no representative to test the wire in London, but they had to deliver it at the Works of Messrs. Newall & Co., Birkenhead, where, it was said, it would be tested in water, under a pressure of 1,000 lbs. per square inch. The coils were at first delivered in as nearly one knot lengths as possible, the Gutta Percha Company sending men to join them as required. For a time these jointers were allowed in the Works, but, under the plea that they were learning too much of the art of cable making, they were confined to a private room, the ends of the wires to be joined being passed to them through a hole made in the wall for that purpose. This arrangement did not last long, the men being sent back to London, accused of making bad joints, and the "cable makers" arranged that their own men should undertake this work.

On the Gutta Percha Company investigating the subject,

Mr. Gordon admitted, with the greatest candour, that the amount of friction they thought it necessary to apply to keep the wire taut while passing into the core and iron covering machines, might possibly stretch it, but thought that well-made joints ought not to stretch so little and break so frequently as these had done. The Gutta Percha Company demonstrated to Mr. Gordon how liable joints and repaired places were to become defective or to break under the like conditions, and strongly advised the discontinuance of such a system. The Company also suggested that their jointers should again undertake the work, as the joints submitted to their inspection were decidedly inferior, both electrically and mechanically. The jointers, however, never returned, and there is reason to believe that the stretching continued to the end. With a view to obtaining a cheap core, a few miles of this strand were covered to the required size, with a very soft and common gum called gutta percha mixed with from 12 per cent. to 25 per cent. of shellac. These coils were sent to Birkenhead to be tested under pressure and to be otherwise experimented upon. When done with, they were to be returned to the Gutta Percha Company, but unfortunately, owing to a misunderstanding on the part of Messrs. Newall's assistants as to what the coils were, they were allowed to pass into the cable, the fact not being discovered until too late for their removal. The Gutta Percha Company had also every reason to believe that some of the short lengths of this wire were, by accident, joined in with the regular core at their Works, and passed into the cable without detection.

When about 1,800 knots, had been delivered, iron reels on which in future the wire was to be forwarded, arrived from Birkenhead. Each reel held four knots and was sup-

posed to fit the pressure tank, but, within a month, the Gutta Percha Company were requested to send half knot coils only, as the pressure tank was out of order.

In three days' time one knot lengths were asked for, and this was continued for about two months, when the four knot reels were again used.

Although the electrical tests at Birkenhead were kept secret, it is fair to suppose that they were not of an elaborate character, if one may judge by the short time the wire remained in the pressure tank.

The pressure tank process did certainly show that the Gutta Percha Company had yet much to learn with regard to excluding the air from their covering machines. A few of the coils were returned as being too low in insulation, but it was time, not pressure, that had developed these defects.

On March 9th, the Gutta Percha Company were requested to suspend the manufacture of the "Red Sea Cable" and with all speed, proceed with 56 knots for the Candia Alexandria cable which has been already described.

On August 19th the order for the "Red Sea" was continued, the length being increased to 4,600 knots, and in the following September the Gutta Percha Company completed that quantity.

During the laying of this, or rather these cables, the electrical department was in charge of Messrs. Siemens and Halske, of Berlin, and Mr. Werner Siemens of that firm accompanied the expeditions.

Some of the sections were laid at a speed of 8·5 knots per hour with only 3 per cent. of slack; in fact, it is on record that from Aden towards India 254 knots of cable covered 252 knots of distance, "so perfect was the paying out machinery."

No wonder that faults soon developed which it was impossible to repair; in some places the elongation of the iron wires had nipped the gutta percha, and in others the iron wires were much stretched and broken. Of course the contractors did not consider themselves to blame; they could not be held responsible for ship's anchors, lightning, high battery power used in ignorance, nor for inexperienced men employed by the Company.

All the sections soon failed and became useless, but the English Government alone suffered, finding, when too late, that they had "paid too dearly for their whistle."

Considering the position of England, far from other parts of the world where she had many colonies and dependencies, it was but just and right that submarine telegraphy, whose birth promised great things for communities in general and for the British Government in particular, should, at least during infancy, have looked to Government for support and succour. Some people said that the assistance given by Government was very erratic, that at one time it strained at gnats, while at another it cheerfully swallowed camels. However that may be, it must not be forgotten that concessions were granted, soundings taken, men provided, and ships lent to assist in the laying of the cable; also that, in the case of the Red Sea Telegraph Company, a subsidy was granted which cost the British taxpayer £36,000 per annum; from this outlay the public, owing to circumstances which ought never to have occurred, reaped no benefit whatever. Surely this was a case of killing the goose that was expected to lay the golden eggs. Well might the Government join issue with the Atlantic Telegraph Company to hold a joint committee of enquiry into the history of submarine telegraphy, and to suggest, if possible, a remedy for its many lamentable failures. The

Government also undertook to investigate the subject, and employed well-known men to conduct experiments. These were of course steps in the right direction easily understood and commended as such, but why, on the eve of such enquiry, the Government should, without any apparent reason, think it advisable to order a cable, is not so intelligible.

On June 1st, 1859, the British Government ordered of the Gutta Percha Company 1,200 knots of a seven copper wire strand, weighing 400 lbs. per knot, trebly covered with gutta percha to the same weight, so that the whole was 800 lbs. per knot.

They appointed the firm of Messrs. Gisborne and Forde as their engineers, and this firm engaged Mr. J. C. Laws as electrician. The proportions of the conductor and coverings were as follows:—

The strand consisted of 7·056 wires=400 lbs.=·168 diameter.

This was covered,

Firstly with 80 lbs. of gutta percha to ·235 diameter, giving a thickness of ·033.

Secondly with 150 lbs. of gutta percha to ·365 diameter, giving the thickness of ·098.

Thirdly with 170 lbs. of gutta percha to ·467 diameter, giving the thickness of ·149. This was such an exceptionally large size that special arrangements had to be made for its manufacture.

Archibald Smith's horizontal quick stranding machines, as used at the cable works to twist the iron strand for the Atlantic cable, were employed to make the copper strand. The peculiarity of these machines is that the bobbins remain stationary while the frame revolves, thus making it possible to use comparatively large bobbins, and consequently, longer

lengths of copper. The engineers reported of this core that it *stretched* 25 per cent. and broke at 9·4 cwt. It was stated that the core was for a cable to be laid from Falmouth to Gibraltar, so it came to be known as the "Gib Core." On June 27th, three knots were completed, and Mr. Laws commenced experimenting with them. On July 6th, the first fifty knots were passed. I should use the term coil rather than knot, as they differed in length, but were kept as near 2029 yards as possible. The Gutta Percha Company had to find a suitable room and fit it with all the apparatus required for electrical purposes. The insulation of these coils was taken while they were suspended along the outside of a "Fly Boat," moored in the basin of the canal, at the back of the Gutta Percha Works. The battery used consisted of 504 cells of the ordinary sand type, and a sensitive horizontal galvanometer. Neither the time of electrification nor the temperature was taken into account, but, with a view to obtaining an approximate co-efficient for temperature one of the coils was removed from the canal where the temperature of the water was 74° Fahr., and kept for 24 hours in water at a temperature of 58° Fahr., when the deflection on the galvanometer fell from 70° to 2·5°. Lengths of this core were supplied to cable makers, and also to those who wished to become so, to cover as they thought best, and deliver at the works of Messrs. Siemens & Halske, at Millbank. Here, in the presence of the engineers and as many of the makers as chose to attend, these samples were submitted to experiments similar to those made by the Atlantic Telegraph Company, at Messrs. Brown, Lenox & Co.'s, in 1856.

Early in September the Gutta Percha Company were informed by the British Government that Messrs. Siemens & Halske, of Berlin, were appointed by them to electrically test

the core now on order, and, a few days afterwards, Mr. C. W. Siemens and one of his assistants visited the Gutta Percha Works, with a view to selecting a suitable test room. They thought it probable that a new room would have to be built to suit the sensitive apparatus they had to use, but for the present they selected a suite of rooms on the top floor in the front of the building. On October 1st men were unpacking and fixing the instruments in those rooms, but twelve days later they were all removed, because it was found that, being mounted upon slabs of slate, the loss of insulation was far too great and variable to enable any reliable tests to be obtained. Up to October 31st 400 knots of the completed core had been certified as perfect and paid for; in addition to these there were about 200 more knots in various stages of manufacture; no order for the delivery of the passed coils having been received, the Gutta Percha Company were overstocked, and at their wit's end to know where to put them. Still they were not allowed to decrease the manufacture, but received instructions to meet the difficulty by purchasing more boats; this they hesitated to do, considering that they had already encroached too much upon the canal. The Gutta Percha Company had been informed that the core would be tested under pressure before it left their works, and made provision for Mr. W. Reid to fix two of his cylinders for that purpose; but not until November 12th did Mr. C. W. Siemens intimate his desire to immerse the core, while on the iron reels ready for the pressure tank, for twenty-four hours in water kept at a uniform temperature of 80°, the water supplied to the pressure tank to be of the same temperature. Although this would cause further delay, it was considered a step in the right direction, and arrangements were at once made to place iron tanks in the cellars of a new building erected for the cylinders, each

tank being sufficiently large to hold two coils. About this time there were 542 coils completed and stowed in various parts of the works, some in water and others dry. On November 22nd Mr. Siemens' assistant, Dr. Esselbach, began to test the copper resistance of each coil. This was done on the principle of the Wheatstone bridge, composed of resistance coils, multiples of what was known as Siemens' unit, which was supposed to be equal to the resistance of a prism of mercury, one metre in length and one millimetre square, at a temperature of 0° Centigrade. The resistance of each coil was recorded in these units. On December 2nd, one of Mr. Reid's cylinders arrived at the Gutta Percha Works; it was a very formidable looking affair, which might have been mistaken for a steam boiler.

The Gutta Percha Company had represented to Government that their business was being seriously interfered with through the accumulation of the stock of "Gib" core; in reply they were informed that Messrs. Glass, Elliot & Co. were to manufacture the cable, and that they would soon be ready for the core.

Mr. Siemens had an idea of using static electricity for testing the insulation of the coils, and for that purpose, on January 2nd, 1860, one of Armstrong's hydro-electric machines was brought to the Gutta Percha Works. A few experiments were, however, sufficient to prove that such high tension was totally unsuitable, for the current passed through the gutta percha in all directions, making perforations resembling small air or "blow" holes.

On January 19th, after many failures, Mr. Reid got a fairly good vacuum and a pressure of 600 lbs., which he said was as high as he intended to go, and consequently he considered the tank was ready for practical work.

On January 27th, Dr. Esselbach reported that he had

discovered what the Gutta Percha Company thought was a self-evident fact, that the core on a reel did not take up the temperature so quickly as when in a coil, and that he had not yet learnt how long it would take to arrive at a uniform temperature of 80°. This was not all; the Company were cautioned against the error of assuming the resistance of the conductor to give the true temperature of the gutta percha surrounding it. The conductor being in the centre, it was reasonable to suppose that the gutta percha was the only means of conducting the temperature to the copper, but, paradoxical as it may appear, experience had taught that the conductor was at the true temperature long before the dielectric.

In round numbers the gutta percha of the core was shown by analysis to consist of

Pure Gutta Percha	80
Soft Resin	14
Vegetable Fibre	2
Moisture	3
Ash	1
	100

To account for such an unexpected problem with regard to temperature, I imagined the interstices of the molecules of pure gutta percha to be filled with foreign matter, which conducted heat more freely than the pure gutta percha did.

Of course assuming the temperature to be 80°, when it was really lower, gave the lengths a higher insulation than they possessed, but the error at the same time being of an unknown quantity and very irregular, there was shown to be a want of uniformity. Against this the Gutta Percha Company strongly protested, for they were aware that many persons were trying to lower gutta percha from the high eminence it had attained, and to replace it by a substance with which they were more intimately connected.

When it became generally known that temperature was such an important factor in calculating the resistance of gutta percha, what a multitude of sins it was made to cover! Unexplained phenomena were attributed to this cause, and it stopped further investigations, from which much would have been learnt.

Thursday, February 9th, 1860, was an eventful day at the Gutta Percha Works, as the first test of the "Gib" core under pressure then took place. On this occasion the wire, wound on two iron reels, kept in water at a temperature of 85° Fahr. for five hours, which Messrs. Siemens & Halske considered equivalent to twenty-four hours at 80°, was placed in the pressure tank. When what was considered a fair vacuum was established, water at a temperature of 85° was let in, and just as a pressure of 600 lbs. was attained, the twenty-four screw iron bolts intended to secure the lid of the tank snapped in two, between the cover and the tank, as though divided by a sharp instrument; while the iron plate upon which the base stood (the tank was placed vertically with about three feet of the top projecting through the floor) broke, as though it had been violently struck in the centre, and the tank fell carrying all before it.

The Government had gone to the expense of purchasing more boats in which to store their core, but it was now quite evident that something besides this must be done, for 890 knots had been certified for the engineers and paid for by the Government, while 152 knots were in various stages of manufacture; making in all 1,042 knots. The engineers consented to discontinue the manufacture for one month, Dr. Esselbach employing the time in experimenting with samples of the cores which the Gutta Percha Company had made and sent to the Government experimenters.

On Monday, February 27th, all was ready for another

trial under pressure, but the instruments of Messrs. Siemens & Halske were out of order; however, next day, the first four miles were tested under a pressure of 600 lbs. after being kept in water at a temperature of 80° for six hours.

If the application of electrical tests could ensure a good core, surely the "Gib" core ought to have been perfect, for never was core more thoroughly tested. The Gutta Percha Company made their test, then followed Mr. Laws for the engineers, Mr. May for Glass, Elliot & Co., and lastly, Messrs. Siemens & Halske for the English Government. The three first named used 504 cells of the sand type and a horizontal galvanometer, all of which were supplied by the Gutta Percha Company. Messrs. Siemens & Halske used their own instruments and battery, consisting of 100 cells of a Bunsen type; these were, no doubt, much more uniform and higher in what is now known as electromotive force, but lower in resistance than the old sand cells. The fibre suspension horizontal galvanometer had a glass prism so fixed, at the end of a spy tube, that the needle and divided circular paper card appeared vertical, the deflection of the needle being so read. The deflection caused by each length was ascertained in this way, and then converted into Siemens' units as follows. What was called the constant of the galvanometer was ascertained at the commencement of the test, and assumed to remain the same until the finish. To illustrate my meaning, assuming that one cell through 100,000 units gave a deflection of 50°, then the 100 cells were supposed to give the same deflection through 10,000,000 units. Now assuming the length under test to be one knot, and that after one minute's electrification it gave 5°, this deflection would be converted into units of resistance as under :—

$$100.000,000 = \frac{10,000,000 \times 50}{5}$$

It was also assumed, that every cell of which the battery was composed was equal, in every respect, to the one used for the constant; a careful consideration of such details, the importance and influence of which will readily be imagined, goes far to show that in these tests, a great deal had to be taken on assumption. Test your wire while it is under as high a pressure as possible, advised *theory*. Pressure may do harm and can do no good, retorted *practice;* it makes faulty coils appear perfect, and has never been known to develop them.

Now, unfortunately, in those days practice was but as a dwarf of dwarfs, and reason seemed to back his gigantic opponent, theory; small wonder then that victory fell to the strong. Time, however, that universal and unbiassed umpire, whose verdict only fools or knaves dispute, decided in favour of practice, proving thereby that, however feasible theory may appear, it cannot afford to ignore fact.

Vacuum and pressure combined developed "air-holes," which were in some cases connected by "gutters" or "tunnels," but it was argued that such defects left undeveloped would have done much less harm than did the treatment resorted to for their remedy. After each length had passed all the tests and been certified good, it was pulled about in a search for "air-holes," and pieced, "tooled," or even a length cut out of it, according to the caprice of the superintendent on duty, and some of these gentlemen could not be congratulated upon a profound knowledge of the work they were appointed to superintend.

On March 1st, 1860, the first four reels, containing eight knots of the "Gib" core, were delivered at the Works of Messrs. Glass, Elliot and Co., Morden Wharf,

East Greenwich, where the core was to be covered with a serving of tarred hemp and eighteen iron wires No. 11 Birmingham gauge. The only difference between this and the Red Sea cable was that the latter required eighteen No. 16 iron wires because of the difference in the diameter of the core, the thickness of the hemp serving being in each case the same. If imitation be the sincerest flattery the designer of the first cable ever laid deserves our congratulations.

Messrs. Glass, Elliot and Co. threatened to return this core, as it had been subjected to what they considered a dangerously high temperature, but used it on being assured that it was all right, water of 110° not affecting the mechanical properties of gutta percha.

On the 16th of the same month the second pressure tank arrived at the Gutta Percha Works, and was considered far superior to its predecessor. On April 11th the tank was used for the first time, and five days afterwards the pressure was increased to 750 lbs. per square inch.

As the core was sent to Greenwich on the same reels as were used in the pressure tank, it was found that their number was insufficient; and, to keep Greenwich supplied, the core was often tested in water at a normal temperature, what was considered a correct co-efficient being used by Messrs. Siemens, Halske and Co. in their calculations, and the results given as though the temperature had been 75°. The core frequently got damaged while being placed in, or taken out of the pressure tank; so much so that upon one occasion, when pressure was applied, the water flowed along the strand as through a tube, and issued from the ends which projected through the stuffing boxes; the whole of this portion was rejected. To obviate a recur-

rence of this, I caused the centre wire of the strand to be passed through my compound before the other six were twisted, thus making a solid mass through which no amount of pressure obtainable could force the water. It was also useful in other ways, as the compound coming through the interstices of the strand amalgamated with the compound put on with the first covering of gutta percha, not only causing better adhesion but increasing insulation.

The Gutta Percha Company having in hand several important orders for cores, did not recommence manufacturing the Government core until the accumulated stock had nearly all been sent to Greenwich. With a view to its improvement, both mechanically and electrically, compound was used in the stranding, while the gutta percha was put on it in four coverings, instead of in three as heretofore.

During the discontinuance of the manufacture of the core, the order was increased to 1,385 knots, and rechristened the Rangoon and Singapore core.

All but Messrs. Siemens, Halske and Co. admitted that the new core was an improvement, but their firm rejected some of it as not up to their standard before and after pressure, although they admitted that, while under pressure, it exceeded their standard. It was experimentally demonstrated to them that the resistance of the gutta percha increased daily, and that the reason why what had gone before was so high in insulation was, that the core had been manufactured many months before they commenced their tests, whereas what they were now testing was quite new.

That the core which was thought to be below their standard should be passed by them, while better lengths were rejected, was most puzzling, and showed that some-

thing was wrong somewhere. This was proved by the fact that the rejections of one day were passed the next under a new number (separate lengths were known by a number), and by the same manipulator. Different manipulators also unwittingly passed those which their colleagues had rejected; so when Mr. Lionel Gisborne was brought to see what was presumed to be a large number of rejections, he was surprised to learn that all had been passed.

There can be no question as to the great desirability of the employment of a recognised unit of electrical resistance, the electrical resistance of substances being given in terms of such unit. Much credit is due to Messrs. Siemens and Halske for their assistance in the endeavour to establish such a system; in such a case theory may be the architect, but practice must be the builder, if the erection is to be a firm and lasting one. Now it was just this practical knowledge that Messrs. Siemens and Halske lacked, especially in the testing of comparatively short lengths of core of high insulation, and therefore they were not justified in acting as they did.

The Gutta Percha Company naturally thought the publication of untrue statements very unfair to them, and misleading to others. For instance, Messrs. Siemens and Halske stated "The covering of the Rangoon and Singapore cable, now in process of manufacture, insulates fully ten times better than the covering of the Red Sea and Indian cable did before it was laid. This marked improvement is due to the greater care taken by the Gutta Percha Company in the manufacture, under a system of stringent electrical tests, which we are charged by the British Government to apply."

For obvious reasons the testing of the two cables will not bear comparison: no more care was bestowed upon the

manufacture of one core than upon the other, and, as cores, their insulation, as tested by the Gutta Percha Company, was about the same. Considering that over 1,000 knots of the core was completed before Messrs. Siemens and Halske commenced their tests, it was presumption on their part to assume that the "stringent" tests referred to had anything to do with the care bestowed upon its manufacture.

Again, they say "The lower horizontal broken line represents the standard of 90,000,000 of units at 75° Fahr. to which it was found necessary to reduce the original standard of 100,000,000, in consequence of the inability of the Gutta Percha Company to provide sufficient material of such high insulating qualities." The fact was that the Gutta Percha Company was opposed to the reduction of the standard, knowing that with newly manufactured core it was impossible to exceed what Messrs. Siemens and Halske termed 90,000,000 resistance, but that after a few days it would be equal to their 100,000,000 standard. It was in order to keep the Cable Works going that the engineers ordered the standard to be altered. The Gutta Percha Company was not in any way dependent on the tests of Messrs. Siemens and Halske, so that it was immaterial whether the coils were passed or rejected.

It may be correct for theory to assert that anything once charged with electricity never entirely loses it, but practice has no need to recognise this; at least so thought the Gutta Percha Company when it was requested to deliver the lengths of the Rangoon and Singapore core without ascertaining their electrical condition. The reason assigned for such an unprecedented and unreasonable request was, that the core so treated interfered with the tests of Messrs. Siemens and Halske, but in such short lengths a few minutes were more than sufficient to discharge them for

all practical purposes. In fact, no indication of their having been charged could be traced, therefore the Gutta Percha Company took no notice of what was considered an unnecessary demand.

On November 23rd, 1860, the last length of the 1,385 knots was passed under pressure by Messrs. Siemens and Halske, and three days afterwards the engineers wrote to thank the Gutta Percha Company for their valuable assistance, and to congratulate them upon the satisfactory way in which the order had been executed.

The first portion of this cable was coiled in its wet condition in the holds of the SS. *Queen Victoria*, but no sooner had this been done than Messrs. Siemens and Halske announced that heat was being generated to an extent that would soon destroy the cable.

It had long been recognised that the conductivity of copper wire altered per every degree Fahr. ·21 per cent., it was thought therefore that the resistance of the conductor of the cable would have been the best guide on this occasion. Messrs. Siemens and Halske apparently held a different opinion, as they constructed what they termed "resistance thermometers" in the following manner:—Round a rod of iron 18 inches in length and 1 inch in diameter was wound fine silk-covered copper wire of about 1,000 Siemens' units resistance at 32° Fahr., this was covered by strips of india rubber, and placed in a metal tube.

A length of gutta percha insulated wire was joined to each end of the fine wire. These "resistance thermometers" were placed between the layers at various parts of the cable, and the gutta percha covered wires were led to the test room, where they were so connected that the "resistance thermometers" formed one side of a

Wheatstone Bridge, while ordinary resistance coils completed it.

From the results obtained by tests so made, it was asserted that the heat was increasing 3° per day, and that it attained to 86°. At this point the engineers pumped water on the cable, but with apparently about the same result as would ensue if oil were employed to subdue a conflagration, for Dr. Miller, whom the Government had called to its assistance, reported that the heat was caused by the oxidation of the wet iron wire where exposed to the atmosphere, while Dr. O'Shaughnessy asserted that oxidation of the gutta percha was causing the mischief.

It did, certainly, appear strange in the face of all this evidence that ordinary thermometers in the vicinity of such a mass of dark heat, should not be affected by its radiation, but such was the case; they showed an uniform temperature of 62°. I do not know the amount of battery power used in these tests, but it is a fact that, if fine wire be wound round the bulb of an ordinary mercury thermometer, and a battery power applied, the column of mercury will at once show an increase of temperature. When Professor Thomson first called attention to the great variation in the specific conductivity of copper wire, this was suggested as one of the plans for its measurement.

The theory of Dr. O'Shaughnessy, which a man of his high position ought never to have started, was at once rejected, and it was argued that, if Dr. Miller's theory were correct, the mischief would cease as the exposed part became dry. So the *Queen Victoria* left for her destination, but having occasion to put in to Plymouth she went ashore there, sustaining so much damage that she could not proceed.

Mr. Lionel Gisborne brought from there a piece of the

cable, cut from what was reported to have been the part most affected by the increase in the temperature, and no signs of deterioration could be anywhere detected; in fact, it was pronounced perfect.

The cable was re-coiled into water tanks fitted for the purpose on board the SS. *Malacca* and *Rangoon*, and re-christened the Malta and Alexandria cable.

Mr. Gisborne was not permitted to see all these changes carried out, as he died in London, March 7th, 1861.

The cable was laid from Malta to Alexandria in three sections, viz , from Malta to Tripoli, from Tripoli to Bengasi, from Bengasi to Alexandria.

Messrs. Canning and Clifford, the engineers of the contractors, had charge of the engineering department, Mr. de Sauty, their electrician, being responsible for the electrical department. Dr. Whitehouse was also on the expedition on behalf of Messrs. Glass, Elliot and Co., the whole being under the control of Mr. H. C. Forde as engineer for the Government.

The section from Malta to Tripoli had to be laid in comparatively deep water, but for the other two sections along the shores of Africa two lines of soundings were marked out, with a maximum depth of 100 and a minimum of 30 fathoms.

Between these two lines the cable was laid in a serpentine course, with the idea that it would be the more readily lifted for repairs. During the laying three Government steamers were employed in taking soundings and placing flag-buoys and recovering them.

The paying out only proceeded while there was sufficient light to discern the buoys, consequently the expedition anchored each night. The laying occupied just four months, commencing May 28th, 1861, and finishing

September 28th following. During this period the testing was in the hands of the contractors, but on its completion Messrs. Siemens and Halske tested the line and pronounced it perfect, at the same time regretting that the system of testing adopted by them during the manufacture and shipping of the cable had not been continued throughout. When all was completed the Government leased this line to Messrs. Glass, Elliot and Co. Soundings had shown the bottom to be in places very rough rock, and so uneven that it was difficult to keep to the proposed lines; the iron of the cable was designed for deep not shallow water, but still it was thought that the very large core would remain intact even if oxidation destroyed the iron wires and marine insects devoured the hemp serving.

After longer and shorter periods of immersion faults were developed, some of which clearly showed that they had occurred during the manufacture of the cable, but had been more or less concealed by the insulating properties of the tar used in the serving.

Perhaps if Messrs. Siemens and Halske had not been so positive that the reduction in insulation was owing to "a general decrease of the insulating properties of the gutta percha" rather than "to any local effect," many of these defects would have been earlier discovered and removed in less time, and certainly at much less cost.

I shall have occasion to refer to this cable again later on.

CHAPTER IX.

"Joint" Committee, 1859—Competition—Report—Cable Manufacturers—Merits of Gutta Percha—Evidence of Mr. C. W. Siemens—India-rubber—Wray's Compound—Professor Hughes—Colonel Hyde—Self-repairing Core—Mr. Fleeming Jenkin—Experiments—Speed—Toulon and Algiers Cable—Mr. Robert Stevenson—Tests—Fault in First Section—Laying Commenced—*Gomère*—Accident—Cable Buoyed—Broken in Lifting—"Black Cable"—Otranto to Corfu—Laying Commenced—Cable Lost—Grappling—Splice—Cable Laid—*William Cory* ashore—Return Home.

THE details given of the Malta and Alexandria cable have carried me somewhat ahead in my narrative; so, following the example of the good weaver, I will go back to pick up the broken thread.

The "Joint Committee," to which I have already referred, commenced its labours about the middle of 1859. Here was a rare opportunity, all being invited to try their skill. Good umpires and all necessary appliances being supplied, the competitors were allowed to proceed at pleasure in a fair field with no favour; it was therefore certain that the best man would win. Many accepted the liberal invitation to compete, but when, two years later, the report was published many of them found out that "Experience is the most effective schoolmaster," although, as Jean Paul observes, "The school fees are somewhat heavy."

Others appear to have failed because, "In general, all fatal, false reasoning proceeds from people having in their heart some one false notion, with which they are resolved that their reasoning shall comply."

The report is contained in the usual formidable-looking

Government Blue Book. I should not recommend its perusal on the score of accuracy in all respects, there being, to my knowledge, statements (especially of the opinions expressed by different witnesses) that do not even require time to prove their incorrectness. Still, from my own observation, I cannot help thinking that many so-called "electrical engineers" of the present day might read, mark, learn, and inwardly digest some of its contents with advantage.

In the days of which I write there were, what may be termed, three "cable manufacturers," viz., Messrs. Newall & Co., Messrs. Glass, Elliot & Co., and Mr. Henley; and their evidence as to the merits of gutta percha for cable cores certainly does not agree.

Mr. Newall says, "I think from what I have seen lately that my confidence is entirely gone. I would never undertake to lay down another cable encased in gutta percha. The faults have been so great and so frequent that I have not the least confidence in it now."

In reply to the chairman's remark, "And that is evidence of your opinion of gutta percha as an insulator?" Mr. Glass says, "Yes. We have had samples submitted to us of many other insulators which certainly show a superiority as regards their insulating property, but we have no means of judging what the effect would be of dealing with those substances, particularly in laying the cable."

In answer to Professor Wheatstone's question, "What should you prefer above all things that you know?" Mr. Henley said, "I should prefer pure gutta percha, in my opinion."

It is an old saying, that what is one man's meat is another man's poison, and certainly this seems, from the foregoing paragraphs, to have been the case with gutta

percha. The Gutta Percha Company rejoiced when Mr. Newall declared that he would never use gutta percha again, they having long thought that he had treated that material very unfairly.

Whether it was his inability to find a substitute for the despised gutta percha, or the result of the verdict given in the trial of Glass *v.* Boswell, is not generally known, but certain it is that Messrs. Newall & Co. retired from cable manufacture, leaving the field entirely to Messrs. Glass, Elliot & Co. and Mr. Henley. These two firms often reminded me of athletes competing for a prize, so eagerly did they race and wrestle to gain the coveted prize in the shape of a fresh order.

The Gutta Percha Company, knowing that Messrs. Siemens, Halske & Co. held views somewhat similar to those of Messrs. Newall & Co. as to the unsuitability of gutta percha covered cores, and that they also were in search of a substitute, waited with curiosity to hear what they would tell the Committee. Mr. C. W. Siemens, one of the partners in the firm of Messrs. Siemens, Halske & Co., of Berlin, who was located in London as their representative, twice submitted himself for examination, and although the Gutta Percha Company knew that facts did not agree with many of his assertions, being of opinion that he went out of his way to attack the character of gutta percha and to injure the reputation of that material, it was surprised to find how easily and rapidly crude ideas could assume a tangible form.

In his first evidence before the Committee Mr. C. W. Siemens says, "My experience of india-rubber as an insulator is very limited." He also stated that he was unacquainted with Wray's composition. Yet in his second evidence, given about four months afterwards, in reply to

the Chairman's question, "How would you propose to construct a deep-sea cable?" he says, "In constructing a deep-sea cable the conditions to be fulfilled are to get good insulation, great security from external injury, and lightness. The material to be used immediately upon the wire should be one possessing very little inductive capacity and high insulating property. Perhaps gutta percha, after we have learned something more of its capabilities, may be rendered a high insulator, but at present compounds, such as Wray's mixture, appear to possess decided advantages. There is one difficulty in using compounds of that description, namely, that they lose very much in quality by being exposed to heat in the covering machine. I therefore think it very desirable to coat the conductors without heating the material, and I have constructed a machine which appears to accomplish the object very well. Here is some wire coated with Wray's mixture, which can be twisted about anyhow, and though it is single coated it tests remarkably well. I should not be satisfied, however, with a coating of one material only, because an action similar to that we have observed in gutta percha, namely, the core becoming eccentric, may arise, although the risk of eccentricities will be greatly reduced in avoiding heat in the process of covering, and the liability to air-holes will be entirely removed. Therefore I should always prefer to give one or more coatings of pure india-rubber. India-rubber possesses very remarkable properties; in addition to its high insulating property and low inductive capacity, it can be stretched to a great extent, and it possesses great continuity in itself. Therefore, if any cavity should exist in the lower insulating medium, the external pressure will tend to fill the same with india-rubber, and thoroughly exclude the water from the inside. It is very important to put on the external coating

of india-rubber without the application of heat, because the heat will not only injure the india-rubber itself, making it sticky and oily, but it is certain to injure the coating below it, and therefore I have tried to accomplish that also without the application of heat. Although for insulation a very thin covering is all that could be desired, so long as the insulating medium employed possesses very high insulating properties, it is necessary to add to its thickness in order to diminish the influence for induction. It is not necessary, however, that this additional covering should possess high insulating properties; we may, therefore, select a material combining great strength with moderate insulating properties. I propose for this purpose to put a number of hemp strands saturated in insulating cement, such as marine glue and shellac, or any other compound, in several layers upon the insulated conductor, and to bind the whole together by a band of copper or brass, in order to protect the saturated fibre from external injury. The copper should be either soldered up solid or it may be made so as to form a complete gripe joint. In this way a cable may be produced combining a very low inductive capacity with great relative strength and permanency. Its specific weight would be about = 1·4, and it would be capable of supporting sixteen miles of its own weight in sea water. Its absolute strength is above two tons, and, what is important, it breaks with little more than two per cent. of tension, whereas an iron-covered cable extends above three per cent. The hemp fibre, being thoroughly impregnated and bedded solid in the elastic cement, can suffer no contraction or deterioration, being thoroughly excluded from the sea water. This cable has, moreover, no tendency to untwist or to form kinks. The copper sheathing is intended as a permanent protector against abrasion and marine animals. A cable

constructed in this manner will not be more expensive than an iron-covered cable. In shallow seas, and for shore ends, an additional iron or steel sheathing will still be required."

Now the Gutta Percha Company knew that Wray's compound consisted of a mixture of india-rubber, shellac, silica, and gutta percha; that it could be manufactured like gutta percha and that it resembled that material in appearance, but that it absorbed water, and had a higher specific inductive capacity than gutta percha. As to pure india-rubber, the company's experience of it was very unsatisfactory; much wonder was therefore felt at the proceedings of Messrs. Siemens and Halske in this direction.

Professor Hughes and Colonel Hyde were introduced to the Gutta Percha Company, as from America, to demonstrate a system the adoption of whch would ensure any defect that might occur in the cores of submarine cables to be self-repairing. Their idea was to place an insulated conductor in an insulated tube filled with their specially prepared "semi-fluid," resembling in appearance thick, dark tar, and if a core so placed became by any means defective the "semi-fluid" would almost immediately heal it by filling up the cavity. This system was very taking, but during the manufacture of two miles of it, ordered for experiments by the Committee referred to, many difficulties presented themselves which seemed likely to prove insurmountable and a bar to its general adoption, especially for submarine cables, even if only of short length. In forming their opinion they had not taken into account one fact which time revealed, namely, that the gutta percha, so to speak, soaked up the "semi-fluid," which from the want of moisture became dry, and crumbled as gutta percha does after the evaporation of its solvent.

The evidence of Mr. Fleeming Jenkin, as far as it goes,

with reference to his experiments with two coils of core, supplied by the Gutta Percha Company to Messrs. Newall & Co., must not be taken as correct, for in error, as I pointed out at the time, he mistook the component parts of these coils. Messrs. Newall & Co. expressed regret that the results of these experiments should have been published, and Mr. Jenkin promised to "set the matter right with the public."

Formula for calculating the working capacities of differently proportioned cables were many and misleading, while statements of the results obtained in the actual working of laid cables were very conflicting. For instance, Mr. Newall in his evidence before the Committee says, "The clerk was not aware that I was taking his speed, and I saw seventeen words a minute sent through that cable from Varna to Balaclava on the Morse instrument." While Mr. H. C. Forde in his evidence gives the practical speed of the 480 knots, in the section of the Red Sea cable from Kurrachee to Aden, as twelve words per minute. Comparing the statements as follows—

Length.	Copper per knot.	Gutta-percha per knot.	Speed.
310	63	140½	17
480	180	212	12

this data might be used in support of their argument by the persons who assert that the outer covering of iron affects the working capacity of cables; for, be it remembered, Mr. Newall is speaking of a simple gutta percha covered wire without any protection, save at its iron-covered shore ends, and Mr. Forde of a core covered with iron wires throughout. I have no doubt that, theoretically, with rapid reversals, such metal coverings have a retarding influence, but for such low power as that used for working cables I do not think it makes any difference. Of course much depends in either case upon the skill of the operators.

While Messrs. Glass, Elliot & Co. were manufacturing what eventually became the Malta and Alexandria cable they were also engaged in making one for the French Government, to connect Toulon with Algiers. This cable consisted of a 7 copper wire strand conductor, weighing 107 lbs. per knot, covered with 4 coats of gutta percha and compound to No. 0 size, and weighing 197½ lbs. for same length. This was served with tarred yarn in the usual way, and then surrounded with ten No. 14 tar-saturated, hemp-covered iron wires, known as Wright's patent; it did not make what is termed a "pretty cable." Opinions differed as to the qualities of this system of outer covering, but specimens similarly constructed were tried at Messrs. Brown, Lenox & Co.'s Works in 1856, when the Atlantic Telegraph Company were making their experiments there, and the results proved highly satisfactory. Mr. Robert Stevenson had stated, "Iron is also a material which is liable to rapid destruction in sea water from rust, and steel is liable to a similar objection, although quite admissible as regards strength. When either of these materials is employed it should be enclosed with hemp, which not only protects it to some extent from rust, but if properly combined assists materially in increasing the strength."

He might also have said with equal truth, that with such an arrangement the sea water has free access to the gutta percha, and that sea water is the best-known preservative of that material.

The core was tested under pressure at the works of the Gutta Percha Company by Messrs. Siemens and Halske on behalf of the French Government, and by Mr. Joseph May, one of Mr. de Sauty's assistants, for Messrs. Glass, Elliot & Co.

During the manufacture of the first section of this cable,

480 knots, there were 20 twists or "rings up" at the lay plate of the machines, 7 breaks, five times want of continuity in the conductor, and there were in all 387 joints.

On August 29th, 1860, the Gutta Percha Company completed the order of 700 knots for this cable, and in this length there were 710 joints in the second covering, 688 in the third covering, and 2,169 in the fourth covering, making a total of 3,567 joints. Had more time been given to the manufacture of this cable the number would have been considerably less.

The first section of 480 knots was coiled in the hold of the S.S. *William Cory*, the process occupying five days, and it was taken to Toulon, where the laying commenced. The *William Cory* was accompanied by the *Gomère*, a large, brig-rigged, paddle gunboat belonging to the French Government, her allotted task being to communicate positions and soundings. All went well, and at noon on the fourth day they were in 700 fathoms with a stiff breeze blowing and a chopping sea, having laid 380 knots of the cable. At this time the *Gomère* was observed to be approaching the *William Cory*, but as it was thought she was only engaged in her usual avocations, no notice was taken of her until she came full speed stem on and struck the latter vessel on her port side just abaft the bridge. As the flying jib-boom and bowsprit of the *Gomère* reached completely over the decks of the *William Cory*, she carried away most of the things thereon as she drifted astern, but as soon as she got clear she went full speed ahead, and it was two hours before she returned. Fortunately, although much damaged, the *William Cory* was kept afloat, and they managed to attach a buoy to the cable before parting with it. The *Gomère* then towed the unfortunate cable ship into Toulon, and it was seven weeks before she was ready to resume work. When

her repairs were completed, the *William Cory* again started, and after two days' searching found the buoy, but the cable broke in lifting and was at once abandoned, no further attempt being made to regain it, then or afterwards, and the ships returned to Toulon. The *William Cory* had on board 90 knots of ordinary cable, which was called "black" because the iron wires were ungalvanised. These 90 knots were to be laid between Otranto and Corfu, so the *William Cory* left Toulon to carry out this purpose; she had not proceeded far, however, when, disabled by a gale, she had to return there. After necessary repairs she made another venture, and arrived safely at Otranto, where the laying of the cable commenced. Owing to those in charge not being prepared for the sudden changes of depth, the cable of its own accord ran out with great velocity, and the ship was put full speed ahead in the hope of reaching a more manageable depth, but the length of cable exhausted itself before the desired goal was reached, and the buoy attached near the end went down with it and was no more seen. After grappling for four days the cable was brought to the surface, and a length of the Toulon and Algiers cable spliced to it, 27 knots of this cable bringing them to Corfu. On the way back to their starting-point the *William Cory* went ashore full speed about 16 miles from the cable house at Otranto, with no building nearer. The ship was lightened as much as possible, all hands having to live and sleep as best they might in improvised tents on shore. On the fourth day, after much difficulty, H.M.S. *Scourge* floated the *William Cory*, and she eventually reached London with all on board, apparently none the worse for the many disasters and unpleasant experiences they had sustained.

CHAPTER X.

Mr. Truman—Washed Gutta Percha—1860—Electrical Tests—Comparison—Mr. Brooman's Patent—"Wet Serving"—Mirror Reflecting Galvanometer—Ohm's Law—Compounding Iron Wires—Mr. John Mackintosh—Mr. Duncan—Experiments—Waste Core—Multiple Cable under Repair—Conductivity—Insulating Wires with Colodion—"Cable Company"—Blend of Gutta-percha—/r\—Two Prices for Wire—Mr. Wray's Tests—Letter to the *Electrician*—"Coil Current"—Wexford and Whitehead Core—New Zandvoort Cable—Dr. Cattell—Cleansing Gutta Percha by Solvents—Cable from Carbonara to Marsala—Cylinder Fixed for Mr. Reid.

Mr. Truman, a surgeon-dentist, who employed gutta percha for professional purposes, used to select small pieces suitable for his requirements from the stock of raw or semi-manufactured material at the Gutta Percha Works. These pieces he took home, and having no steam-power at command, he placed them in a small masticator turned by hand in hot water. By thus working the material he found that it became much cleaner than by any process used at the Works; he therefore patented the method.

On November 22nd, 1860, the Gutta Percha Company prepared lengths of No. 18 copper wire, doubly covered to No. 7, with gutta percha that had been washed for three hours, and similar lengths prepared in the ordinary way, but without compound.

The electrical tests were made with 504 cells, and a large horizontal galvanometer which was considered very sensitive.

The coils were immersed in water which had been kept

at a temperature of 75° for twenty-four hours. The results were as follows:—

Yards.	Charge.	Deflection after 1 min. Electrification.	Discharge.
		WASHED.	
1760	55	1·0	54·5
1760	55	·9	54·4
1679	52	·7	50·7
		PLAIN.	
1760	64	1·2	62·2
1760	65	1·2	62·2
1677	63	1·3	60·0

This comparison showed in favour of the washed, especially in induction.

Nine days afterwards, under exactly similar circumstances, tests were made with a coil of ordinary plain gutta percha containing twenty per cent. of compound, the latter material being used in the wire between the coverings; the following were the results:—

Yards.	Charge.	Deflection after 1 min. Electrification.	Discharge.
1760	54	·1	51

This was, therefore, the best coil both for insulation and induction. However, notwithstanding this, and the fact that a similar system of cleansing gutta-percha in hot water was illustrated and described in a patent granted to Mr. Brooman in 1845, the Gutta Percha Company paid Mr. Truman a royalty on every pound of gutta percha "washed" at the Works.

Customers were charged extra for the material which had undergone this process, and an advantage thus secured to both parties.

No doubt the washing process was a step in the right direction, as it removed the small particles of foreign matter which would have otherwise remained; this was more marked in the "thin sheet," manufactured and sold

for various purposes by the company, than in the electrical qualities of insulated wires.

On December 30th, 1860, I first mentioned my "wet serving" system of saturating the serving of cables with a conducting instead of, as hitherto, with an insulating fluid, the core thus served being coiled in suitable tanks, supplied with water in such a manner that the core could be under a continuous electrical test, and the pressure of the iron wires on the serving at the lay plate of the closing machine sufficient to force the water into any flaw that might exist in the gutta percha.

It was easily demonstrated that tarred hemp concealed faults, while hemp saturated with water immediately developed them. On one occasion the experiment was tried of making, in various ways, several serious faults, then serving the core with tarred hemp in the ordinary way, and immersing it in water. There it tested as perfect for 2,348 hours; then after twenty-four hours' reversals at the rate of 200 per minute from 100 cells, the faults in some cases developed, but in others neither time nor reversals, so far as could be ascertained, seemed to have the least effect.

My system was condemned at first by the many who thought tar necessary to the preservation of gutta percha, but as it quickly manifested its superiority it became universally adopted.

Early in 1860 Professor Thomson's mirror reflecting galvanometer was coming into practical use; the Gutta Percha Company therefore consulted him by letter upon the subject. Professor Thomson sent Mr. Fleeming Jenkin to ascertain what was required, but it was not until March, 1862, that the arrangements for its use were completed by the Company. The galvanometers were made in Glasgow

under the personal superintendence of Professor Thomson; the resistance coils, switches, and keys in London, under the personal superintendence of Mr. Fleeming Jenkin, the unit of resistance being the "B.A." (British Association). The keys, switches, &c., looked very pretty, and were indeed *multum in parvo;* all were mounted on the bottom of a vulcanite case, with a cup at each corner to hold chloride of calcium; the whole was covered by a glass lid through which keys to manipulate switches, &c., could be inserted. But in this arrangement the connections interfered with each other, so it had to be abandoned. It was while engaged, on March 3rd, 1862, in endeavouring to trace the cause of so much faulty insulation, that Mr. Jenkin noticed that Ohm's law does not hold good after you get a certain tension. To give an idea of the comparative results of two modes of testing the induction of an immersed coil, a No. 1 mirror galvanometer and one cell gave eighty deflections; a horizontal galvanometer with 504 cells gave forty-seven.

When the mirror galvanometer first came into use it was considered necessary, while watching it, to cover one's head, as in focussing an object before photographing it; experience soon proved a semi-darkened room to be all sufficient.

On February 28th, 1861, I advised the passing of iron wires through my "compound" as they entered the machine to receive a hemp covering, and on the following day I made a sample for inspection.

Mr. John Mackintosh failed in an attempt to cover wires with pure masticated india-rubber by the aid of rollers which he had fixed at the Gutta Percha Works.

At this time also Mr. Duncan was experimenting with canes for the outer covering of cables in lieu of iron wires.

Some of his specimens looked very well, but it was found that the specific gravity of such a cable would be too light for its purpose. The Gutta Percha Company made specimens, using wet leather for a serving, and taping and painting each iron wire separately, or using it as an outer covering; this process was considered too expensive.

In May, 1861, Messrs. Newall & Co. sold to the Gutta Percha Company a lot of waste core, amongst which was found a great many lengths of Red Sea core. These must have been subjected to a great heat, as the conductor was at the surface of the gutta percha, although concealed by the tarred yarn which adhered to it. This is what had happened to parts of the Atlantic cable. Lengths were found also of the same core injured by the mechanical means used in the manufacture of a cable.

In May, 1861, the multiple cable, eventually laid from Portpatrick to Donaghadee, was under repair by the "Magnetic Telegraph Company," and when finished it had 128 splices in a length of thirteen knots. During the repairs a piece of the cable was obtained and the conductivity of each of its six copper conductors tested as follows, the Gutta Percha Company's standard being ·85 of pure copper.

No.	1	wire	=	·46
"	2	"	=	·40
"	3	"	=	·48
"	4	"	=	·46
"	5	"	=	.45
"	6	"	=	·41

The Gutta Percha Company had contemplated purchasing Mr. John Mackintosh's patents for insulating wires with collodion and other things, but experiments failed to warrant the company in taking this step. About the same time the short-lived "Cable Company" closed

their premises at Millwall, and sold off what machinery, wire, &c., it had. This company started with the intention of making cheap cores and light cables; as far as I know, however, it never got beyond the experimenting stage.

In June, 1861, Messrs. Glass, Elliot & Co. were manufacturing the Toulon and Algiers and the Toulon and Corsica cables in the way already described.

When the Gutta Percha Company first began to sort their gutta percha into two qualities it was a distinction without a difference, as neither electrically nor mechanically could any difference be detected. In 1861 the gutta percha when imported was of such varied, and in many cases questionable, quality that it had to be sorted, and experience soon taught those concerned how to mix the different qualities so as to make a good blend for insulation and induction.

The core for the Algerian cable, sixty knots in length, which Messrs. Glass, Elliot & Co. were making in July, 1861, was the first to contain some of this blend known by the company as △P (triangle P), because in it there were three qualities of equal proportion.

One mile of No. 16 copper wire doubly covered to No. 4 with best "washed" gutta percha, which had been immersed in water for six months at a temperature of 100°, began to fall in insulation; this proved to be caused by a mended place in the first covering, over which was a small speck of impurity in the second covering. With compound and a lower temperature, perhaps this fault would not have been developed.

Dr. O'Shaughnessy experimented in the pressure tank with 128 yards of core, the same size as that used in the Malta and Alexandria cable; the dielectric was, however,

india-rubber. It proved very bad in insulation, and could, in fact, only be tested with a low battery power, and even then the deflections were very unsteady.

The fault that had recently been found in the Toulon and Algiers cable resembled a puncture made by some sharp instrument.

In November, 1861, for reasons not very clear, the Gutta Percha Company quoted two prices for their wire, making the difference in some cases between the first and second quality as much as £10 per knot. This did not last long; the second quality proved the better insulator, and there was no perceptible mechanical advantage in the first quality, so the former was generally specified for; the Company therefore soon returned to one uniform price.

In December, 1861, Mr. Wray tested, for induction only, two lengths of his wire that had been sent to the Gutta Percha Works by Messrs. Glass, Elliot & Co., and he became convinced that they were much higher than gutta percha; he also stated that his best proportions were as follows:—

India-rubber	2
Shellac	1
Powdered flint	1
Gutta-percha	0·5

And that the mixture should not be allowed to enter water during the process of manufacture.

In January, 1862, Messrs. Siemens & Halske sent three samples of core, one covered with india-rubber, the other two with Wray's mixture, to the Gutta Percha Company to be covered with gutta percha.

On February 11th, 1862, I sent to the *Electrician* a letter upon the subject of my experiments on "coil currents," a subject at that time exciting attention.

About this time the phenomenon of "coil current" manifested itself; that is, that when an insulated core becomes damaged the discharge is more than from a similar coil perfectly insulated, but the discharges are generally erratic and sometimes opposite in sign. On February 14th, 1862, the *Electrician* published the result of my experiments in that direction.

On March 7th, 1862, the Gutta Percha Company completed for Messrs. Glass, Elliot & Co. 253 knots of core for the four-wire multiple cable which they eventually laid between Wexford and Whitehead.

On April 11th, 1862, Mr. Reid removed one of his pressure cylinders from the Gutta Percha Works to Mr. Silver's Works at Silvertown.

On May 8th, 1862, the Gutta Percha Company completed 548 knots of core for the new Zandvoorst cable, which was manufactured and laid by Messrs. Glass, Elliot & Co. In this core all the wires were compounded.

On June 4th, 1862, Dr. Cattell commenced at the Gutta Percha Works his experiments on the cleansing of gutta percha by means of solvents. There is no doubt that by bringing the gutta percha into a liquid state, and continually straining it through fine strainers, the material becomes very clean, but when "thrown down" its mechanical properties are destroyed, and it becomes totally unfit for covering wires.

On June 7th, 1862, Messrs. Glass, Elliot & Co. ordered of the Gutta Percha Company 200 knots of core the same size as the "Red Sea," for a cable to be laid from Carbonara to Marsala. At this time also Mr. Reid was having fixed at the Gutta Percha Works a cylinder, in which, it was stated, that a pressure of 10,000 lbs. on the square inch could be maintained.

CHAPTER XI.

White Gutta Percha—1862—Colonel Stewart—Cable for Indian Government—Description—Manufacture—Method for Testing Joints—Diagram—Persian Gulf Core—Tests—Before Pressure—After Pressure—High Resistance—Segmental Wire—Increased Order—Core Finished—Another Order—Mishaps Increased by Segmental Wire—Data—Cable Laid—Death of Dr. Esselbach — Experiments in Pressure Tank — Faulty Coil — Different Woods—Moulded Cones—Copper Wire Covered with India-rubber—Messrs. Siemens and Halske—Experiments—Core Delivered—Oran to Carthagena—Specific Conductivity of Copper Wire—Limited Liability Company—Mr. Pender—Prospectus of Telegraph Construction and Maintenance Company—Death of Mr. Samuel Statham.

It has been well said that what to-day we spurn with scorn and contempt, on the morrow, grown wiser, we embrace with openarms. This truism was amply verified by the Gutta Percha Company in November, 1862, when they purchased what they understood to be the best "white gutta percha." In the course of manufacture it was found that this gutta percha was difficult to manage. It was a new class of material, one of which they had no experience, and ignorant of its virtues they became alarmed, fearing their purchase worthless. But from experiments they learnt that, not only were its mechanical properties good, but that its electrical qualities far surpassed these of ordinary gutta percha. At this they rejoiced exceedingly, congratulating themselves upon its possession, in the nick of time, to refute the assertions of those who condemned gutta percha for its low insulation. By adding a portion of the new material to their "blend," the resistance of even the new core could be made to equal, if required, 500 units per knot, after one

minute's electrification at 75° F., and as it improved in this respect with age, in the same way as ordinary gutta percha, it was difficult to put a limit in its resistance.

Tests were now made at various temperatures, pressures, and times of electrification, extending over a long period, with lengths of wire differently covered. Messrs. Hall and Wells used india-rubber, Messrs. Silver gutta percha, Mr. Hooper his material, and the Gutta Percha Company plain gutta percha, and also gutta percha over the core made under Mr. Wray's instructions. Colonel Stewart decided for the Gutta Percha Company, and ordered of their firm 850 knots of gutta percha core for a cable to be laid in the Persian Gulf for the Indian Government. The order was given on November 29th, 1862. Messrs. Bright and Clarke were the engineers, ably assisted by Messrs. Laws and Lambert and Dr. Esselbach, while Colonel Stewart represented the Indian Government. The core was to consist of a segmental copper conductor weighing 225 lbs. per knot, covered with four coatings of gutta percha and four of compound to 275 lbs., the total weight being 500 lbs. The diameter of the segmental conductor was ·111 of an inch, and the Gutta Percha Company proportioned the covering of the gutta percha as follows:

1 covering	·174 diameter	=	36·5 lbs.
2 coverings	·245 „	=	97 „
3 „	·313 „	=	174·5 „
4 „	·380 „	=	275 „

The specific conductivity of the conductor was to equal 85 per cent. of that of pure copper, and the resistance of the gutta-percha per knot 125,000,000 of Siemens' units, after one minute's electrification and 24 hours' immersion at 75° F., before being tested under a pressure of 600 lbs. per square inch. The copper wire consisted of four segments which

when laid together resembled a solid wire, and these were encased in a tube of the same metal. It was thought that by this arrangement the mechanical advantages of a strand would be obtained, combined with the electrical advantages of a solid; but a greater mistake it would be difficult to imagine, and the Gutta Percha Company ought, instead of making, as they did, verbal complaints, to have entered a written protest against its use, for the following reasons.

It was only produced in comparatively short lengths, of very varying conductivity. The tube frequently allowed the sections, which were found to be covered with a very fine powder and very dirty, to protrude. During the manufacture of the core the conductor had to be wound and rewound no less than twelve times, but the tube frequently split in places while being wound only three times, this being one of the tests to which each length was subjected before being used; and, worst fault of all, the tube stretched and frequently broke at the joints while passing through the covering machines. No wonder the weight per knot was, when completed, 17 lbs. below the average weight certified for at its commencement.

The deliveries were so small, and the rejections so large, that the manufacture of the cable would have been prolonged indefinitely, had not another manufacturer produced what he called a "segmental wire," which was, however, simply a solid wire inside a tube. This wire was almost as objectionable as the first, and for similar reasons, but by the aid of the two the work was kept going until near its completion, when, in order to keep to the time of contract, a solid wire only was used. Mr. Glass, or one of the other representatives of the firm of which he was the head, took an active part in the experiments, the Gutta Percha Company being

under the impression that Messrs. Glass, Elliot & Co. were to manufacture the cable; great, therefore, was their surprise when, on December 18th, Mr. Henley informed them that he had received the order.

The number of joints in the core of a cable varies with circumstances, its length and size being two very important factors, but when it is remembered that these joints are frequently counted by thousands, it will be readily understood how important it is that they should be separately tested.

A method of testing the joints had long been sought in vain until the manufacture of this cable commenced, when Mr. Latimer Clark introduced a system which proved very effective and caused a great improvement in the method of joint making. This system was known as the "accumulating joint test," and was as follows:—

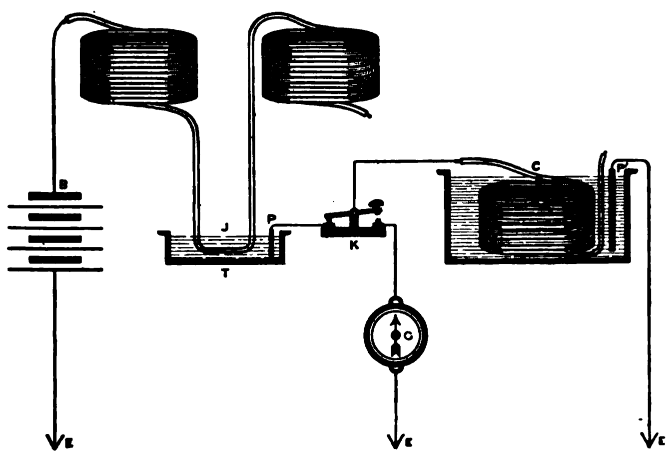
An insulated trough was filled with water, in which the joint to be tested was immersed; in this tank also was placed a copper plate that could be connected with or disconnected from one side of a coil of insulated wire. The wire containing the joint was charged as in tests for insulation, and of course the amount of current passing through the joint accumulated in the coil, and was measured by its effect upon a galvanometer in discharging.

The sketch on the opposite page may assist in forming an idea of the arrangement:—

The standard generally was that the discharge from a joint after one minute's accumulation should not be more than that from six feet of the core under the same conditions.

Let us assume that the joint had passed at the core works, and after long immersion had been again tested at the cable works, where it was found to be below the standard;

the question would naturally arise, was it better to replace the joint by a new one, of which it was impossible to say what its condition would be after long immersion, or to retain the original one? Of course a line must be drawn somewhere, but I have known joints to be cut out which, in my opinion, ought certainly to have been allowed to remain in. By way of experiment, I collected joints cut out of various cables, and joined them together until I had one mile of core composed entirely of joints immersed in



B. Battery for charging the line.
J. Joint to be tested.
T. Tank insulated.
C. Coil in canal.
G. Galvanometer.
P. Copper plate.
E. Earth.

water. The insulation was of course comparatively low, but they stood the test of quick or slow reversals from high or low power remarkably well, and although I tested them at frequent intervals, extending over a period of several years, they never were broken down.

On February 3rd, 1863, the first six lengths of the core for the Persian Gulf cable were tested, with the following results:—

BEFORE PRESSURE.

No.	Yards.	Millions of Siemens' Units.
1	2,029	556·5
2	2,029	445·2
3	2,348	445
4	1,780	488
5	2,339	367
6	2,440	348

AFTER PRESSURE.

1	2,029	856
2	2,029	556·5
3	2,348	515·2
4	1,780	742
5	2,339	515
6	2,440	496

The Gutta Percha Company were much concerned at the high resistance of the gutta percha, imagining that it would lead to a discussion which they were anxious to avoid. However, greatly to their relief, the only comment made upon the subject was of a favourable kind, and to the effect that the test proved highly satisfactory, and that the Company did not know what they could do until put to it.

Some persons thought that the high resistance was due to the segmental wire, while Mr. Truman considered it was owing to his system of washing the gutta percha, but it was in reality due to the blend with the white gutta percha before mentioned.

The six lengths of core were, after being tested, joined into two lengths, wound on to two of Mr. Henley's wooden reels and sent to his works at North Woolwich, where the core was served with wet tanned hemp, round which were laid, helically, 12 galvanised iron wires. Over these wires were wound, in reverse directions, two coverings of tarred hemp, the whole being passed through what was termed "Bright and Clark's compound"; consisting of tar, pitch and silica, applied at a high temperature. As this was com-

pressed by passing through a pair of grooved rollers, the cable was in external appearance smooth, even, and of a black colour. The heat did not affect the gutta percha as it passed through this compound unless it were allowed to remain stationary, when it became soft; this happened several times owing to the negligence of the man whose duty it was to lift it from the trough when the twisting machine stopped.

On February 26th, 1863, the order was increased to 1,045 knots, and on June 26th of the same year it was further increased to 1,240 knots.

By means of salt and ice a temperature of 30° F. was obtained, and the gutta percha resistance of a coil of the Porsian Gulf cable at this temperature was 3,000 Siemens' units per knot. At a pressure of 5,040 lbs. per square inch the resistance of the gutta percha increased 122 per cent

On September 16th, 1863, the Gutta Percha Company completed all the core that had been ordered for this cable, the last consignment of it being delivered at Woolwich on September 30th.

On October 13th twelve moreknots were ordered, making the total length 1,257 knots. The conductor of this newly ordered length was a solid wire, and its mean resistance 6,075 ohms, but, owing to the many peculiarities of the segmental wire, the proposed maximum standard of 6·75 was much exceeded.

The mean resistance of the gutta percha per knot was 196 millions Siemens' units, consequently there was a great difference between the maximum and the minimum in this respect. The variation arose principally from the endeavour to blend the electrical qualities of the gutta percha so as to keep as nearly to the standard as possible, a task by no means easy on account of the many unknown factors which

entered into the calculation. The number of mishaps which appeared to be inevitable in the manufacture of cables was, in this instance, increased by the aforesaid peculiarities of the segmental wire, and by the application of Messrs. Bright and Clark's compound.

After twenty-four hours' immersion in water kept at 75° F., and one minute's electrification, the means per knot of the Persian Gulf cable were

Conductor	6·25 ohms
Gutta percha	190·00 megohms
Inductive capacity	·349 microfarads

The cable when completed was coiled into iron tanks fitted in the holds of sailing vessels, and thus conveyed to the Persian Gulf. On arrival there the vessels were taken in tow by steamers, and the cable laid in four sections, under the personal superintendence of Sir Charles Bright.

It was while engaged on this expedition in the Persian Gulf, that, much to my regret, Dr. Esselbach met with his death. I had learnt to respect him as a true man of science, for he was bound by no creed or dogma, and had a great thirst for knowledge, which, when obtained, he freely imparted to others.

During the manufacture of the core of this cable many experiments were made in the high pressure cylinder; some, although not connected with electric telegraphy, are, I think, worthy of notice and may prove interesting.

In one of these there were placed, in the cylinder, a live lobster, two living fresh-water fish, four bottles of ale, and one tightly corked empty bottle. After a pressure of $2\frac{1}{2}$ tons per square inch, the fish were found to be dead, but quite unaltered in appearance; the cork of the empty bottle had been forced in, and the bottle was full of water; the

bottles of ale were affected in the same way, only curiously enough the metal capsules remained intact.

A faulty coil, which gave a resistance of 49 Siemens' units per knot before pressure, increased to 115 under pressure; immediately the pressure was removed, the resistance further increased to 178, and it was two hours and a-half gradually falling to its original 49. This experiment was repeated on the following day with the same result, high or low battery power making no apparent difference.

On another occasion an experiment was made with eight pieces of different woods; 60 cubic inches each submitted to 6,000 lbs. pressure; they gained in weight as follows:—

1. Yellow deal	40	per cent.
2. Pine	161	"
3. English oak	46	"
4. Elm	86	"
5. Beech	83	"
6. English oak, wet	75	"
7. American oak	35	"
8. Pine, with knots	95	"

Under the same pressure were placed moulded cones of the following dimensions:—Height, 6 inches; base, 4 inches; apex, 1 inch. They were made respectively of Wray's mixture, pure masticated indiarubber, a mixture of half indiarubber and half gutta percha, and gutta percha. Upon each, near its apex, was placed a heavy gun-metal ring or collar, the object being to ascertain if the material contracted while under pressure, but only a slight, if any fall of the ring could be detected.

Four of these cones, one Wray's mixture, one half indiarubber and gutta percha, one indiarubber, and one gutta percha had a string fastened round them by which they were suspended in a room. The indiarubber cone slowly but surely yielded to the pressure caused by its own weight,

as after hanging for a long time the string was observed to be more than half way through it; the other cones remained intact as when first suspended.

Similar cones were placed on a shelf, in the same room, in close proximity to each other, and after a time, without any apparent cause, the surface of one of the indiarubber cones became covered with patches as though decomposition had set in. In bending over, the apex of this cone found rest on a neighbouring cone, also composed of indiarubber, and at the point of contact inoculation took place, gradually extending more or less over the whole cone, but never to the same extent as in the first one, as it remained erect and apparently proud to support its fellow cone in its helplessness, no matter what the danger might be to itself. Other indiarubber cones, together with those made of the other materials aforesaid, remained perfect.

In the case of some of the sample lengths of the copper wire which Messrs. Siemens' had covered with indiarubber, and which the Gutta Percha Company had afterwards covered for them with gutta percha, although so recently made, the indiarubber had burst through the gutta percha and studded the surface with dark bead-like spots. This was due to the combination of two forces, viz., contraction of the gutta percha and the decomposition of the indiarubber.

It was supposed that Messrs. Siemens and Halske had learned something of the character of this and other materials, especially when, on June 15th, 1863, they ordered of the Gutta Percha Company 130 knots of a 16-gauge strand, doubly covered to No. 2 gauge. This core was to be submitted to a pressure of 1,400 lbs. per square inch, and a suitable room was to be provided in which their own instruments and batteries could be fixed for testing

purposes. The proceedings of Messrs. Siemens and Halske, however, partook more of the character of experimental research than of practical work. Frequently they were occupied for three, and sometimes four, days in testing a batch of six coils, and seldom was a charge tested but they placed in the cylinder with it sample lengths of their own or other people's manufacture.

On one occasion a solution of salt and ice was mixed in the cylinder, and when a temperature of 30° F. was attained, two coils of the core were immersed in it with the intention of submitting them to a pressure of 5,000 lbs.; but when it was found that the low temperature had so contracted the cylinder that it was impossible to get the cover on it, Mr. Reid became alarmed and would not proceed with the experiment.

Messrs. Siemens and Halske found that their indiarubber covered wire absorbed water, and that under a pressure of 5,000 lbs. its electrical resistance was quite destroyed. At these high pressures the ends were frequently forced through the stuffing boxes with great force like arrows from a bow, as those whom they struck could testify.

When about 80 knots were completed, it was intimated that a gauge would be supplied by Messrs. Siemens and Halske through which the core must be passed before delivery. If the joints would not pass at first they would have to be spokeshaved until they did.

On September 3rd the first six lengths were delivered at the new buildings at Charlton, where they were covered with hemp cords that had been saturated with a conducting fluid, laid longitudinally, and over these was wound an overlapping thin brass tape (at least it was so designated.) On October 20th the last delivery was made, and when the core was all covered and formed into one length, it was wound

on to a revolving wooden cone, fixed in the hold of a French steamer, and taken to Oran, from whence it was proposed to lay it to Carthagena. The would-be equestrian, no matter how profound his book-learning may be, finds that his knowledge is very inadequate to his purpose when he comes to apply it practically. So it was with the use of the revolving cone, theory and practice did not agree; the motion of the vessel soon caused the revolving gear to break, the water made the hemp shrink, and produced kinks, while the deep water broke it; the expedition was therefore eventually abandoned.

In April, 1864, forty-seven more knots of this core was supplied, but how covered, or when or where laid, I do not know.

Being curious to know what was the specific conductivity of the copper wire in use before Professor Thomson called attention to its great variation, I availed myself of every opportunity to test the same, and found there existed a great difference even in various samples of the same cable. The standard against which they were compared was said to be equal to pure copper, and designated 100. The lowest specific conductivity of the samples tested by me was 17, and the highest 74·2. A sample of the experimental line laid from Dover to France, in 1850, was 71·2; that of the cable laid in the following year, after twelve years working, was 72·5; and a piece of the same which had never left the Gutta Percha Works, 73·5.

Comparing the two samples last mentioned, I conclude that the specific conductivity of wire, in submarine cables, does not alter by the continual application of tension such as would be employed in signalling or testing.

The original "Holyhead and Howth" was 40·6; the mean of the six conductors in the cable from Portpatrick to

Donaghadee, 47·6; and the mean of eight samples in the used wire of the "Electric Telegraph Company," 34·2.

In one length of the 1850 line, recovered after 17 years' immersion, the gutta-percha had the same appearance as when first laid, but the copper wire was in sections of about half an inch in length, measured and divided with a precision which surprised me. My opinion was, and still is, that the cable had been suspended where the effects of the tide caused great tension and constant vibration. I produced something like the same result by letting a length revolve for a considerable time, as an endless band does on a machine.

It is fair to suppose that when Messrs. Glass, Elliot & Co. suggested to the Gutta Percha Company that they should amalgamate with them to form a Limited Liability Company they were cognisant of the following facts:—That Mr. Henley had successfully manufactured the Persian Gulf cable, and that Sir Charles Bright was as successfully laying the same; that Messrs. Silver had converted their works into a Limited Liability Company for the purpose of making and laying cables; and that Messrs. Siemens and Halske had erected large works at Charlton for the same purpose.

The terms they suggested were very tempting, but the Gutta Percha Company wisely considered the reverse side of the picture, anxiously inquiring how they were to be indemnified, supposing the scheme did not succeed. Mr. Pender (now Sir John Pender, K.C.M.G.), became a guarantor for the amount required as an indemnity, and a prospectus was issued with the following directors, offices, &c.:—

The Telegraph Construction and Maintenance Company (uniting the business of the Gutta Percha Company with

that of Messrs. Glass, Elliot & Co.), is constituted as follows:—

DIRECTORS.—John Pender, Esq., M.P., *Chairman;* Alexander Henry Campbell, Esq., M.P., *Vice-Chairman;* Richard Atwood Glass, Esq. (Glass, Elliot & Co.), *Managing Director;* Henry Ford Barclay, Esq. (Gutta Percha Company); Daniel Gooch, Esq., C.E., M.P.; Thomas Brassey, Esq., Samuel Gurney, Esq., M.P., George Elliot Esq. (Glass, Elliot & Co.); Lord John Hay, Alexander Struthers Finlay, Esq., M.P., John Smith, Esq. (Smith, Fleming & Co.)

BANKERS.—The Consolidated Bank, London and Manchester.

SOLICITORS.—Messrs. Bircham, Dalrymple, Drake & Ward; Messrs. Baxter, Rose, Norton & Co.

SECRETARY.—William Shuter, Esq.

OFFICES.—54, Old Broad Street.

LONDON WORKS.—Wharf Road, City Road, and East Greenwich, S.E.

In those days Limited Liability Companies were comparatively new things, and more in favour with the public, so that the shares of this fresh company were eagerly sought for, and consequently no difficulty was experienced in launching it successfully.

The Wire Rope Works of Messrs. Kuper & Co. were practically the germ from which the firm of Messrs. Glass, Elliot & Co. sprung, but Mr. Elliot (now Sir George Elliot, Bart.), having removed them from Camberwell to Cardiff soon after the company commenced submarine telegraph work, they were not included in the new company.

During the formation of the two companies into one, a sad event occurred. Samuel, or as he was familiarly called

"Sam" Statham, who had been Manager of the Gutta Percha Company from almost its commencement, was laid to rest in the churchyard at Forest Row, East Grinstead. It would not be wrong to say he and the Company died together. From personal knowledge I can testify how zealously and conscientiously he worked for the extension of submarine telegraphy, with an energy which even failing health had not power to destroy. I never heard him otherwise than well spoken of, and by his death I, with many others, lost a true and valued friend.

CHAPTER XII.

Mr. Cyrus Field—Agreement for New Atlantic Cable—1864—Heading of Agreement—Description of Core—Experiments—Pressure Resistance—Tests—Covering at Greenwich—Specification Discussed—Diagram—Resistance of Conductor—Units—Mr. C. F. Varley—Mr. Henley—Working Agreement—Quotations from Diary—Compound at Greenwich—Fault Removed—Data for Core—Cable Completed—Condenser—*Great Eastern*—Diagram—Comparison of Condensers—Cable in Tanks—Different Earths—Speed—Tests for Electrical Qualities—Another Trial of Speeds—Examination of Shoring—Paying-out System—Expedition Started—S.S. *Caroline*—Shore End Laid—Fault—S.S. *Hawk*—Fault Discovered—Paying-out Recommenced—Another Fault—Suspicion—"The Atlantic Telegraph"—Deflection too High—Cable Broken—Efforts to Regain—Futile—Buoy Placed—*Great Eastern* Returned to Sheerness—1865.

Ever since the failure of the first Atlantic cable Mr. Cyrus Field had been unceasing in his endeavour to obtain the necessary means for making another attempt, and the number of different samples he had made to effect his purpose were, to say the least, considerable; at length his wish was gratified. Immediately after the formation of the Telegraph Construction and Maintenance Company, its directors offered to make and lay a cable.

The Atlantic Telegraph Company accepted their terms, and on May 5th, 1864, the agreement was signed. At this point I find the proceedings and dates somewhat puzzling; the scientific committee appointed by the Atlantic Telegraph Company to consider the best form of cable, &c., made their report on October 31st, 1863; the Gutta Percha Company received the first of the copper wire for the con-

ductor on December 8th, 1863; and the manufacture of the core was started on April 18th, 1864.

The heading of the Agreement was as follows:—

"Articles of Agreement made and entered into this Fifth day of May, in the year of our Lord One thousand eight hundred and sixty-four, between the Telegraph Construction and Maintenance Company, Limited, hereinafter called 'the Contractors,' of the one part and the Atlantic Telegraph Company, incorporated by Special Act of Parliament, hereinafter called 'the Company,' of the other part.

"Whereas the Contractors have made to the Company a proposal for manufacturing for the Company a Submarine Electric Telegraph Cable and for submerging the same across the Atlantic Ocean between Ireland and Newfoundland. And whereas the Company have accepted the proposal of the Contractors on the terms and conditions hereinafter contained," &c., &c., &c.

The core was to consist of a 7-copper wire strand, imbedded in compound in the ordinary way to prevent the water travelling through it; weight to be 300 lbs. per knot.

The specific conductivity of the copper was to be not less than 85, that of pure copper being taken at 100. This core was to be covered with four coats of gutta percha, and to have compound on the strand and between each covering.

The proportions were:—

Strand, 7 wires	·049 diameter	= ·147	= 300 lbs.		
1st coating of gutta percha,	diameter	= ·228	= 62 lbs.	of gutta	percha
2nd " " "		= ·311	= 91	"	"
3rd " " "		= ·394	= 119	"	"
4th " " "		= ·347	= 128	"	"

An experimental length of one knot gave the following results :—

Description.	Gauge.	Weight.	Resistance in Millions Siemens' units.	Induction comparable with each other.
Conductor.	·147	300		
1 Cov.	·228	62	2·5	516
2 ,,	·311	91	198	303
3 ,,	·394	119	288	224
4 ,,	·466	128	310	195

On May 9th Professor Thomson, Professor Wheatstone, Captain Galton, Mr. George Saward, Mr. C. F. Varley, and several other gentlemen, were at the Gutta Percha Works for the purpose of trying some experiments on behalf of the Atlantic Telegraph Company; and they confirmed what had already been stated; that the resistance of a faulty coil increases under pressure; that induction is not affected by pressure; and that the resistance of india-rubber covered wire does not increase by pressure, while that of gutta percha does, so that under pressure gutta percha has as great a resistance as india-rubber.

It was pointed out to them that, owing to the holding capacity of the high and low cylinders, if they agreed to a pressure of 6,000 lbs. it would necessitate 800 more joints in the core.

Mr. C. F. Varley was electrician for the Atlantic Telegraph Company, and on June 20th was engaged, with his assistants, in fitting his instruments and batteries in two rooms placed at his disposal in the Gutta Percha Works.

After twenty-four hours' immersion at a temperature of 75° F. the electrification and consequently the resistance of one knot of the Atlantic core was as follows :—

Time in minutes.	Resistance in millions Siemens' units.	Percentage of increase.
1	458	
2	521	13·7
3	537	17·2
4	554	21
5	568	24
6	580	26·6
7	591	29
8	599	30·7
9	608	32·7
10	608	32·7

The core was to be tested in lengths of 4,500 yards wound on an iron reel, the resistance of the gutta percha was to be again tested when in the pressure tanks, but before pressure was applied again under pressure of 600 lbs. per square inch, and again after the pressure was removed.

The wire was then to be examined while being rewound on other similar iron reels, and again tested, but in cold water, previous to delivery at Greenwich.

All the joints were tested by Mr. Latimer Clark's ingenious system, with this exception, that the tank containing the joint was more perfectly insulated, and that the accumulation took place in a well insulated condenser, instead of in an ordinary coil of wire.

One hundred knots of the core were ready and waiting for Mr. Varley when, on July 11th, he announced that he was ready to commence testing.

After twenty-four hours' immersion at 75° F. the contractors' tests of the first eight lengths were as follows:—

	Resistance of gutta percha per knot in millions Siemens' units.	Copper per knot in Siemens' units.	Discharge per knot comparable with each other.
1	358	4·88	245·8
2	456	4·88	229·5
3	553	4·78	250·2
4	558	3·96	216·4
5	566	4·01	218·6
6	582	3·98	217·8
7	544	4·03	214·8
8	512	4·06	215·5

What had long been suspected now became evident, namely, that neither Mr. Varley nor his assistants had been accustomed to test such short lengths of high resistance gutta percha and such low resistance conductors. Their tests were so wide of the mark that it was suggested they should be repeated, but Mr. Varley said he was satisfied and passed them, although in the confusion they had omitted to take the gutta percha resistance of some of the lengths while under pressure, and in no case had induction been noted.

On July 18th, these eight lengths where sent to Greenwich, where they were to be covered with wet tarred yarn for a serving, over which were to be laid spirally ten wires, No. 13 Birmingham wire gauge, drawn from Webster and Horsfall's homogeneous iron, each wire being covered with five tarred strands of manilla yarn. The breaking strain of the cable was calculated to be 7 tons 15 cwt., or 4·64 of the strength requisite for the deepest water. It was some time before the cable could be commenced, owing to the alteration and additions necessitated by the manufacture of such a long length.

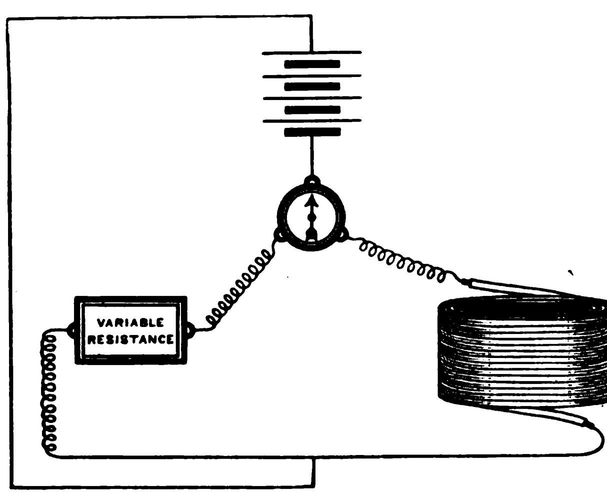
On July 25th Messrs. Canning, Varley, De Sauty, Saward, Clifford, Chatterton, and myself, met Mr. Glass at 23, Great George Street, for the purpose of discussing the specification for the cable.

It was agreed that the B.A. unit which was taken to be ·05 higher than a Siemens' unit should be used as a standard. All joints made at the Gutta Percha Works to be retested at Greenwich. The standard for the specific conductivity of the copper to be 80% and not 85 as specified.

I cautioned them concerning the compound they thought of using to cover the iron wires previously to putting on the hemp. I did not like the idea of the use of india-

rubber dissolved in oil, and thought it late for them to talk about making experiments just as they were about to commence the cable. The data, as given on the certificates by Mr. Varley, clearly showed that his system of testing was wrong, the resistance of the conductor in some of the lengths being below the standard should have been rejected, while some of the tests gave the value as above that for pure copper; the same remarks apply to the resistance of the gutta percha.

Well kept connections, particularly spiral ones, look very pretty, but they must be used with caution, especially when the unit of resistance is high compared to the resistance to be tested in Mr. Varley's units. The resistance of the conductor with a differential galvanometer and a set of resistance coils made to Varley's unit was as follows:—



I give, as an example, one case, in which the resistance was 4·33 Siemens' units, but Mr. Varley gave it as ·171 of his units.

$$4{\cdot}4973 = \frac{00{\cdot}171}{26{\cdot}3}$$

This was too high, and, on investigating the matter, it was found that the resistance of the line wire was ·45, and that of the two spirals in connection with the resistance coils ·3 Siemens' units. Now if the first be deducted and the second added, the result will be 4·3473 Siemens' units, which brings the two tests nearer to each other, but strange to say the resistance of the connections was not considered of importance, as they formed so small a part of a Varley unit.

It will have been seen that Mr. C. F. Varley's unit was 26·3 times a Siemens' unit, therefore why he should have persisted in using it, is one of those mysteries impossible to solve. It was the same when ascertaining the resistance of the gutta percha; the loss on the instruments and leads, especially in a wet or moist atmosphere, would amount to one-third of the deflection, and yet all was debited to the length under test, thus in some cases making it appear to be below the standard. The trouble and anxiety caused by this state of things at length became unbearable, and a thorough investigation was demanded, after which Mr. Varley admitted that he was wrong, and promised to cancel all the data he had given on the certificates to both the companies; these were for a length of about 400 knots. It was most extraordinary that while all this was taking place, Mr. Varley, instead of endeavouring to prove himself right, or to confute the many complaints made, was busy publishing elaborate systems as to the correct methods of testing and working long submarine lines, with formulæ for quickly obtaining what he considered correct results.

Mr. Henley had not succeeded in manufacturing a suitable core for cables, consequently he had, much against his will, to make a virtue of necessity and enter into a working agreement with his rival, Mr. Glass, who was managing

director for the T. C. and M. Co. Thus he became engaged in making the shore ends for the Atlantic Telegraph Cable, and in covering fifty knots of various sized old experimental cores, in stock at the Gutta Percha Works, for the purpose of repairing the Malta and Alexandria Cable, that line having already given much trouble owing to the frequent faults and total breaks occurring in it.

I quote the following from my diary:—

"September 2nd, 1864. Mr. E. Wright called this morning; had a long discussion concerning the compound they are using at Greenwich for the iron wires of the Atlantic cable. Showed me a piece of the cable in which there was a chemical action going on between the compound used and the iron wire; the fibres of the yarn next the iron were quite rotten."

It must be remembered that Mr. Wright was supplying the company with hemp, and also held a patent for the combination of iron and hemp for ropes and other purposes, he was therefore anxious to see that the work was properly done.

I again quote from my diary:—

"September 27th. Cautioned Mr. Varley against using naphtha in any part of the Atlantic cable core as he informed me he had been doing at Greenwich. Showed him the old experiment of merely bending a piece of one-eighth sheet gutta percha and dipping it into coal-tar naphtha, when it instantly parted at the bend."

On December 14th, a fault removed from the cable was examined at the Greenwich factory in the presence of Messrs. Clifford, J. Temple, De Sauty, Varley, Saward, and myself. From the appearance of the gutta percha, and a small mark on the conductor, it was agreed that it must be caused by a puncture from some sharp instrument.

On May 17th, 1865, the testing of the last four lengths of the 2,300 knots was finished, and on May 22nd they were delivered at Greenwich.

The mean for the core, per knot, when it left Wharf Road, was:—

Copper conductor . . .	4·27 ohms.
Gutta percha	365·00 megohms.
Inductive capacity . . .	·354 microfarads.

On the 29th of that month the whole cable was completed. At this time I made a condenser of circular plates composed of a mixture, half best white gutta percha and half shellac, and sheets of soft tinfoil, the whole being enclosed in a vulcanite case and very portable; its inductive capacity was supposed to be equal to one knot of the Atlantic cable, and its insulation can be judged by the fact that 96 per cent. of the charge remained after one minute and 93 per cent. after five minutes.

That monument of Brunel's genius, the S.S. *Great Eastern*, was chartered to carry the cable, but, as she was too large to come so far up the Thames, she was moored in the Medway just below Sheerness, her cargo being taken to her in sections coiled in hulks lent by the Government for the purpose, and towed by steam tugs.

Wednesday, May 24th, 1865, was quite a gala day on board the *Great Eastern*, for the Prince of Wales and suite honoured her with a visit. H.R.H. was much interested in all he saw and heard concerning the "big ship" and her novel cargo, and, on his departure, warmly wished every success to so great an undertaking.

The diagram (Appendix E) shows a section of the *Great Eastern*, and will give an idea of how she was fitted as a cable ship.

On June 12th I made the following notes in my diary:—

"Left the Works at 9.30 this morning for the *Great Eastern*. Met Saunders and De Sauty at London Bridge Station. As I had made arrangements to remain on board until Tuesday afternoon I was able to devote the evening, when all was quiet, to several experiments which came out highly satisfactorily. Owing to the want of a suitable galvanometer it was found to be very difficult to compare the capacity of the condenser made for De Sauty by Lambert & Elliott Brothers with mine; but, by charging the condenser from 200 cells, and then discharging it through 1,470 knots of the cable and No. 6 galvanometer (marine), we were able to get a very steady reading."

Elliott's condenser (composed of tinfoil and sheets of talc):—

31 — 31 — 31° deflection.

My condenser (composed as described):—

28 — 28 — 28° deflection.

Taking the mean inductive capacity per knot of the cable as one, the capacity of my condenser was 1·06.

De Sauty considered the capacity of his condenser 1·18, which he had taken from the mean of all the coils as tested at Greenwich; and, if the two tests are compared, it will be seen that we agree very nearly in the tests made at Wharf Road and at Greenwich:—

$$\frac{1{\cdot}18 \times 28}{31} \times 1{\cdot}066$$

INSULATION.

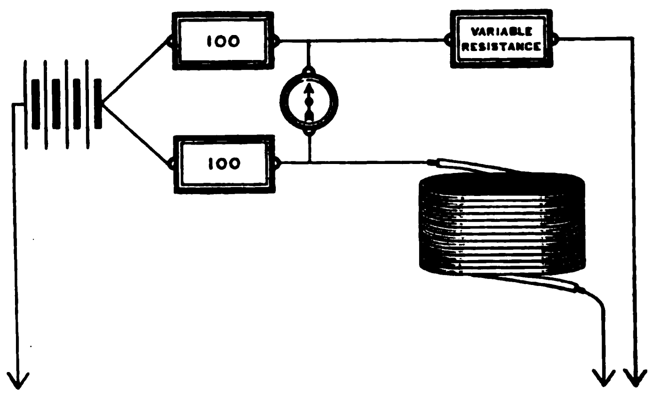
100 cells No. 6 galvanometer.
Fore tank 633·731 knots.

1′	156	divisions	=	929	M.S.U.	per knot.
2′	144	,,	=	1020	,,	,,
3′	137	,,	=	1075	,,	,,
4′	132	,,	=	1120	,,	,,

After tank 837.799 knots.

1'	215	divisions	=	864	M.S.U.	per knot.
2'	197	,,	=	947	,,	,,
3	187	,,	=	1003	,,	,,
4'	180	,,	=	1052	,,	,,

On June 27th all the cable, 2,273 knots, was coiled on board the *Great Eastern*, and a speed of 1·8 words per minute with two cells was considered satisfactory. With one knot of 16-strand doubly covered to No. 4 I tried, at the Gutta Percha Works, the resistance of different-sized earths, the connections being as shown below :—



With earth at each of the lines, the sectional area of which was ·0625 copper wire, the resistance was 99,650 units.

Copper Wire Exposed each end.	Resistance.
¼ inch	19,850
½ ,, ...	12,150
1 ,, ...	8,950
2 ,, ...	4,900
4 ,, ...	2,900

Two copper earth plates attached, 4·25 by 3·5 inches, one at each end = 225 units. This shows what care should be exercised in the selection of earths of low resistance.

Two plates, one of copper and the other of zinc, the

same size as in the last experiment, the zinc plate on the knot of wire, equalled in resistance 1,650 units.

On July 6th most of the members of the scientific committee, and others, visited the *Great Eastern* to make experiments of speed through the cable. Mr. Varley worked his curb key at the "sending station," while Professor Thomson and two assistants read from the mirror instrument at the "receiving station." The following message to be sent through the cable was given to Mr. Varley, verbally, by Sir Stuart Wortley, "We are all ready for dinner." The time taken in transmission, as taken by me at the sending station in the dining saloon was 66·5 seconds; it was a disputed point as to whether the word *the* was included in the message before the word dinner. Mr. Varley held that it was, those who received the message could not speak positively upon the subject as no record had been kept at the receiving station, and Sir Stuart Wortley was of opinion that he did not give *the*.

At 8 p.m. on the same day, when all was quiet on board, the cable was tested for its electrical qualities, the readings were taken with 40 cells and a marine galvanometer.

Minutes.	Divisions.
1	199
2	181
3	171·5
4	166
5	161
6	157
7	154
8	151·5
9	149·5
10	148
11	146·5
12	144·5
13	143·5
14	142
15	141

At the end of the test, zero was less two, therefore the last reading was reduced to 139.

Resistance to reproduce 15 minutes reading = 87,657 S.U.

$$R \times \frac{G+S}{S} \times L = G.P.R.P.K.$$

$$G = 5{,}225$$
$$S = 1{,}047$$

At the 15 minutes the G.P. resistance was 1,193 M.S.U. per knot.

Copper Resistance.
Total length = 9,935 S U. = 4·370 per knot.

Temperature given 63°; but according to copper resistance the true temperature was 66°.

On July 11th another trial of speeds took place, Mr. C. V. Walker, acted as umpire, gave the messages at the sending station, and there timed the transmission. I timed it at the receiving station, and found it very difficult to do so correctly, especially with Smyth when receiving on De Sauty's instrument, as he could not be certain when to commence receiving the trial message. After three false starts the following was received by Smyth on De Sauty's instrument in 12 minutes 10 seconds, Gott sending, "In accordance with measure meditations I have to inform you that a subscription was opened in the romasidist of the sum subscribed to this day is appended the council w b y t i s t e with nearly hundred pounds."

The same message was sent by Professor Thomson and Mr. Varley in 8 minutes 32 seconds, and was correctly received by three of their assistants.

At about 10.30 p.m., when all was comparatively quiet, Smyth received correctly from Gott in 13 minutes 40 seconds the following message, "Paper accepted for reading at the ordinary meetings are satiety which are issued as

soon as possible after each meeting proceedings also contain notices of books and memoirs."

Several messages were sent by Professor Thomson and Mr. Varley, the average speed being about five words (five letters to a word) per minute. De Sauty's speed may be taken at three words per minute. Captain Bolton (late Col. Sir Francis Bolton) also experimented with his light signals between ship and shore.

On July 14th Mr. Newall and his friends were admitted on board the *Great Eastern* to examine the shoring of the cables and the paying out system.

At noon on the following day the *Great Eastern* left for Ireland, the Cunard service kindly permitting Captain Anderson (now Sir James Anderson) to take command of her. Mr. R. C. Halpin was chief officer, Mr. Canning was in charge of the expedition with Mr. Clifford as his chief assistant, Mr. de Sauty had charge of the electrical department with Mr. Saunders as his chief assistant, Captain Moriarty, by kind permission of the Government, was navigating officer, and Professor Thomson and Mr. Varley represented the Atlantic Telegraph Company. I accompanied the expedition, at the request of the Telegraph Construction and Maintenance Company, to render any assistance in the electrical work should such be required; and, not wishing to be a mere spectator, I allied myself to the Electrical Department, Messrs. de Sauty, Saunders and myself taking alternate watches of four hours each.

Amusements such as concerts, &c., were provided for the ladies and gentlemen who had availed themselves of the opportunity of taking a pleasant and unique trip to Ireland on board the "big ship."

The weather was not what might have been confidently expected in July, and plenty of "summer gales" were

experienced. At 2.30 p.m., on July 17th, when off the Land's End, Mr. Henley's S.S. *Caroline*, having the shore end on board, was descried, and, as she was making bad weather of it and very little headway, the *Great Eastern* took her in tow. What a contrast there was in the behaviour of the two ships; here was the *Great Eastern* but little affected, majestically going on her way with all on board dry and comfortable, while the *Caroline* was tossed about by the waves like a fragile plaything in the hands of boisterous children. It did seem extraordinary that one could sit at ease at the stern of the *Great Eastern*, while a man on the bridge of the *Caroline* held his position with much difficulty, firmly grasping the rail with one hand, whilst with the other he endeavoured to represent the signals of the Morse instrument, by which means we learnt what difficulties they had encountered, and how they had not left the shelter they had been obliged to seek until the *Great Eastern* was sighted. During the night the *Caroline* had one of her boats washed overboard, and she laboured heavily all day. At 7.30 p.m., when off Crookhaven, there was every appearance of its being what sailors call a dirty night, and great fears were entertained for the safety of the *Caroline*, especially when at 4 a.m. the following morning the tow rope parted at her bows. At 6.30 she was seen at some distance from Valentia, which place she eventually reached without further mishap. Mr. Canning and a few passengers landed at Valentia; the *Great Eastern* then proceeded to Bantry Bay, where she landed more of her passengers, and waited until the shore end was laid.

From an iron dwelling erected on the high land at Foilhummerum Bay, Valentia, the *Caroline* laid the shore end and intermediate cable about twenty knots out to sea,

where, at 11.20 a.m. on Sunday, July 23rd, the end of the cable was passed to her from the *Great Eastern*, that vessel going her slowest speed ahead until the splice was successfully accomplished.

Fortunately the weather was very fine, and the sea as smooth as could be desired for the work. At 6.10 p.m. the splice was dropped into the sea, and the paying-out of the cable on board the *Great Eastern* fairly commenced. All went well until 3.10 a.m. the following day, when "spot suddenly left the scale," the cable was cut about one and a-half knots in-board, the length of the cable from ship to shore by copper resistance being 85·5 knots.

The fault was of high resistance, and consequently difficult to localise, but what was considered the best test placed it at twenty-five knots from the ship. At 11.30 a.m. the end of the cable was over the bows, connected to the picking-up machinery, and passed to the test-room. At 9.20 p.m. only 4·25 knots had been with great difficulty hove back, owing to an insufficient supply of steam to the engine of the picking-up machine, and at 12.30 p.m. about six knots had been recovered; fault still in the sea. During the picking up, messages were sent to and received from the shore by Morse instruments. At 7.30 a.m. the following day the S.S. *Hawk* arrived to ascertain if she could be of any assistance. At 9 a.m. Messrs. de Sauty and Saunders had just completed another test, which gave the fault at still twenty-four knots from the ship, when Mr. Temple came to the door of the test-room with a piece of iron wire in his hand about 1½-inch in length, and accompanied by two men carrying a bight of the cable. The piece of wire had been seen projecting out of the cable as it passed inboard, and unfortunately withdrawn, so that the actual spot was lost. The cable was immediately cut and the

insulation test applied, when the portion in-board proved faulty and that between the ship and shore perfect. Mr. Canning ordered the length of cable containing the fault to be placed in safe keeping, and no person to be allowed to see it.

At 2.50 p.m. paying-out recommenced, but for some time all were kept in a state of most anxious suspense as, through a misunderstanding, it was not until 5 p.m. that shore commenced sending signals as usual.

Again all went well until 3.4 p.m. on July 29th, when "spot suddenly left the scale" for the second time. The cable was cut two knots in board, and picking up begun. After hauling in about three knots of cable the fault, at 11 p.m., came in-board. During the night the splice was made, and the cable again ready for paying out; Mr. Canning, however, thought it better to stop all work until daylight. At 5 a.m. the following day the cable got damaged, and another splice had to be made. Paying out recommenced at 10.9 a.m., and at noon (Greenwich time two hours in advance of ship's time) the amount of cable paid out was 750 knots.

The cause of these faults was regarded with suspicion, and a jury was empanelled to investigate the matter. A large majority quickly gave a verdict of wilful murder against some person or persons unknown, while a small minority considered that the verdict ought to have been suicide. My opinion was, that, if the number of broken wires had been considered, and the way in which they were bent in the recovered cable had been properly examined, the evidence in favour of the latter verdict would have been strong. So firm, however, was the opinion that the faults were caused by wilful stabs that several gentlemen on board, who were not engaged in the actual work,

agreed to take watch and watch in the tank during the uncoiling of the cable, in the hope of discovering the perpetrator of so diabolical a deed.

During the voyage Mr. H. O'Neil, A.R.A., issued from time to time, though far too seldom, *The Atlantic Telegraph*, a paper which certainly touched a chord of humour that would otherwise have remained mute amid the cares and anxieties felt by all.

Of course much of the contents of these papers can only be appreciated by those who were on board at the time, but nevertheless I publish them in extenso (Appendix A). In them will be found two cleverly executed sketches, the first showing how one of the aforesaid gentlemen was seen keeping his watch, and the second depicting in the form of a nightmare how Mr. Canning saw the nails being driven into the cable while Mr. de Sauty pointed out the mischief that would ensue.

The suspicion engendered by the discovery of these faults had a very depressing effect, for it was justly observed, "The faults do not occur in the same watch, so that there must be more than one person concerned."

Now that the cable hands were suspected they appeared to lose all interest in their work, and were certainly not in the humour to receive from the crew, what at another time they would have considered good-natured chaff.

On July 31st, at 5.5 a.m., paying out recommenced; at this time about 850 knots had been let go, and the depth of water below us was about 2,250 fathoms. All went well until 8 a.m. on August 2nd, when the deflection given on the commencement of the half-hour test was 290 deg., instead of about 47 deg., as it should have been. Picking up was the consequence, and the cable came in in good condition, but unfortunately the want of a sufficient supply

of steam to the engine of the picking-up machinery caused many stoppages. During one of these the cable became fixed across the ship's "fore-foot," and, in endeavouring to clear it, too great a strain was brought to bear upon the cable, which parted in-board just behind the stopper, the end going overboard at 12.35, ship's time. The total length then paid out was 1,213·962 knots, distance run 1,064·4 knots. Endeavours were at once made to regain the cable, but, owing to the breaking strain of the picking-up machinery, the unsuitability of the ship's capstan as a substitute, the loss of grapnels through the breaking of their ropes, unwieldy shackles, and other causes, the task was given up in despair. A buoy was left behind to mark the place (*vide* sketch in *Atlantic Telegraph*, Appendix A), and the *Great Eastern* started at 11.30 p.m., on August 11th, for her old moorings at Sheerness, arriving there on the 20th of the same month.

CHAPTER XIII.

New Atlantic Cable Commenced—Anglo-American Telegraph Company—Agreement—Constant Test Required—Letter to Mr. Glass—Reports on New System—Mr. Clark—Professor Thomson—Mr. Cyrus Field—Testing Joints—Tests of Cable at Greenwich—Experiments with New System—Shore Ends—Letter from Captain Bolton—Telegraph Code—Programme of Proceedings—Engineer—Instructions for Ship and Shore—Data for Completed Cable—Staff—Diary of Mr. Thomas Willey—Note for July 9th—Diary Continued—"Great Eastern Telegraph"—Messages—Gooch to Glass—Smith to Glass—Line Handed Over—Data for 1866 Cable after Laying—Diary Continued—Grappling for 1865 Cable—Description of Grappling Rope—End of Cable Secured—Illustrations—Table of Distances—Fault Occurred—Cable Completed—Handed Over to the Anglo-American Company—Arrival in England—Honours Received—Engraving of Medal—Address.

A FEW days after the return of the *Great Eastern* 1,600 knots of the same size core for a new cable was commenced. On investigation however it was found that, financially, both the Atlantic Telegraph Company, and the Telegraph Construction and Maintenance Company much resembled two ships labouring in a storm, on a lee shore, and it was with the greatest difficulty that the Anglo-American Telegraph Company was launched for the purpose of assisting them. Had not this Company come to their rescue it is impossible to say what might have happened. It was not until March 1st, 1866, that the "Heads of Agreement," between the Atlantic Telegraph Company and Mr. Richard Attwood Glass was signed on behalf of a new Company, to be formed and called "The Anglo-American Company, Limited, or some other name."

Two days later, another agreement was signed, headed as follows: —"Heads of Agreement between the Telegraph Construction and Maintenance Company, Limited (hereinafter called 'The Contractors'), and the Anglo American Telegraph Company, Limited (hereinafter called 'The Company')."

The manufacture of the cable now went on more briskly, for, up to this time, only about 300 knots had been completed.

It was finally agreed that "The Contractors" alone should electrically test this length, so, after "The Company" had tested several lots, they discontinued testing and removed their instruments from the Gutta Percha Works, when "The Contractors" at once dispensed with testing the core while under pressure.

The iron used was softer than in the previous cable and was galvanised, and only covered with strands of manilla hemp. I can understand why the compounds hitherto used to cover the iron wire were discarded, but I think a more suitable compound might have been used with advantage, as also I believe that tarred hemp would have made the cable less lively. It is difficult to conceive why it was not used, unless from motives of economy.

As far as I knew it had always been the practice in cable laying to make all necessary tests independently of each other; thus in the case of the last Atlantic expedition, the hour was divided into four parts and a certain test had to be repeated in the time allotted to it.

The first thirty minutes were occupied on ship-board in testing the insulation, or resistance of the gutta percha, of the entire cable, and during that time the end of the conductor on shore had to be insulated. The other thirty minutes were divided into three equal parts, which were

devoted respectively to receiving reversals from the shore, ascertaining the resistance of the conductor, and sending reversals to the shore. The most important tests, indeed the only ones absolutely necessary during the submersion of a cable, are those for insulation and continuity of the conductor. A ready means of immediate communication between the ship and shore is also desirable. Hitherto each test had been applied independently; that is to say, while the continuity test was being made, the insulation test had to be neglected and *vice versa.* Consequently, in the arrangements above mentioned, the state of the insulation of the cable was not known during the last thirty minutes of each hour, so that if a fault passed overboard during that time, it might be two or three miles astern before it was detected.

How best to devise a system which would keep up the constant test for insulation and continuity, and at the same time allow free communication through the cable between the ship and shore, was now the question. In trying to solve this problem I took for my basis the following fact. Were it possible for a submarine cable, and the water surrounding it, to be placed in an insulated trough, the resistance of the gutta percha enveloping the conductor could be ascertained, not only by measuring the amount of current passing into the cable after a certain time had been allowed for electrification, which constitutes the ordinary insulation test, but also by merely placing a wire from one terminal of a galvanometer in connection with the water, and a similar wire in connection with the other terminal to earth, the actual amount of current passing through the dielectric could be measured, and thus tests could be made by two separate persons quite independently of each other. Upon this I built the

system which induced me to write to Mr. Glass on September 28th, 1865, as follows :—

"Dear Sir,—It occurred to me during the laying of the Atlantic Telegraph Cable that it would have been advantageous, had it been possible, to have kept the core constantly under an insulation test, so that when the slightest fault occurred, it would have been immediately detected. Since my return from the *Great Eastern* I have given this subject some attention, and I am pleased to be able to inform you that I have succeeded, above my expectations, in perfecting a system which will allow not only the ship, but also the shore to keep up a constant insulation test; and, when necessary, signals could be exchanged without interfering with the arrangement. If you think this of sufficient importance, I shall have much pleasure in submitting my scheme to you and then shall be better able to enter more fully into detail.

"(Signed) WILLOUGHBY SMITH."

On October 25th Mr. Glass visited the *Great Eastern* to witness my experiments through the 1,027 knots of cable left from the late expedition. He appeared to be much pleased with the results, and promised to at once employ an expert to make experiments and report to him on the whole matter. Mr. Latimer Clark, who was the expert employed, visited the *Great Eastern* on February 3rd, 1886, for the purpose of testing my system, there being present (besides his assistant, Mr. J. C. Laws), Messrs. Field, Gooch, Fothergill Cooke, Shuter, De Sauty, Chatterton, Canning, Smyth, George, Graves, Medley, &c., and Capt. Anderson.

In his report Mr. Clark stated :—

"I have examined the system carefully, and have experimented upon it through upwards of a thousand miles of Atlantic cable now on board the *Great Eastern*, and I find it in every way suited for practical use; it allows of the free application of the various tests requisite during submergence of a long submarine cable, and it has the peculiar merit of giving an absolutely continuous test of insulation, and at the same time of enabling the tests for continuity of the conductor, and the transmission of intelligence, to be carried on uninterruptedly without the necessity for any change in the connections of the apparatus employed either on ship or on shore."

Mr. Graves' report to the Atlantic Telegraph Company was equally favourable.

Later on, Professor Thomson reported as follows:—

"I found its action through the cable on board the *Great Eastern* quite perfect so far as signalling each way without interfering with the ship's insulation test is concerned. The plan by which he allows the shore operator to signal to the ship is particularly simple and well arranged."

The following extracts on the same subject are taken from a report made by Mr. Cyrus Field.

"Mr. Willoughby Smith, of the Gutta Percha Works, who was on board the *Great Eastern* last year, and who saw the difficulties we had to contend with, has, since his return, devised quite a new system of testing a cable electrically during its submersion. Of the merits of this system there can be no question, as it has been thoroughly tried through the 1,000 knots of Atlantic Cable now on board the ship with perfect success. Professor Thomson and all the gentlemen competent to form an opinion upon the subject, speak of it in the highest terms———.

"Another advantage in this system may be mentioned, namely, the simplicity of all its arrangements. There is not throughout the entire voyage any alterations in the connections. Whatever takes place there cannot be any confusion in the handling of the apparatus. Experience has shown that in the excitement of laying a submarine cable great trouble is caused by having to change the apparatus so frequently for the different tests; but in this new system all these tests are combined in one, and thus this great annoyance is completely obviated."

On April 4th I went to the Greenwich Works to inspect their system of testing joints, as seventeen had been rejected in succession. I was there informed by Messrs. Canning and Clifford that Mr. De Sauty had left the service of the Company on the previous Saturday, although they had not known of it until the day before; they also told me that Mr. Joseph May was in charge of the electrical department.

As to the joints, had I been the judge, I certainly should not have rejected them; the case was a difficult one to decide. Supposing, after long submersion, the joint to be tested fell below the standard, was it more desirable to pass it, or to make a new one of the conditions of which nothing could be certainly known?

Having promised to remain with the Gutta Percha Company until they gave up possession to the Company who were about to take over the business, I was still considered to be in their service, when, on April 7th, 1866, at the request of Mr. Glass I visited him at St. Leonards, where he was staying for the benefit of his health. It was there agreed that in addition to my position at the Gutta Percha Works I should accept the post of chief electrician to the Telegraph Construction and Maintenance Company, and as

such, should have sole charge of the electrical department during the next Atlantic expedition.

On April 11th I noticed that by using a very high resistance in taking the constant I obtained a higher value for the resistance of the gutta percha, in the proportion of about 1 to 1·25, and this value I adopted. Mr. Latimer Clark had been appointed by the Anglo-American Telegraph Company, to test all the sections of the cable at Greenwich, so, on April 13th, Mr. Laws proceeded there to make the tests on his behalf, and obtained the following values expressed in millions of Siemens' Units.

Section.	Total Length.	Temp. of Cable by Thermometer.	Temp. of Core by Copper Resistance.	Insulation resistance, Siemens' Units, Millions.
2	135·992	49	—	3,453
3	119·465	49	60	3,497
4	68·333	48	59	3,035
5 B	21·783	48	61	2,087
6	92·982	48	59	3,213
7	68·739	49	65	3,245
8	12·257	49	57	2,039

On April 19th Mr. Laws went to the *Great Eastern*, there to test the 211 knots of new cable which had left Greenwich before it was finally settled that Mr. Clark would have to certify the cable, and on the same day I arranged with Captain Halpin that he should, on the following Monday, lay a length of insulated wire, attached to one end of the core of the cable on board to the shore. Here, nearly opposite to the place where the *Great Eastern* was moored, I had engaged a herdsman's cottage. This cottage I fitted as the shore station, so that the electrical staff, to be engaged to work my system during the laying of the cable, could test through the entire length while it was being coiled in the tanks of the ship. Thus, not only were continuous tests applied during the coiling of the cable, but the operators got well used to their respective duties before the actual laying of the line commenced.

On April 28th Mr. John Pender and friends visited both the ship and shore to see my electrical arrangements; they appeared much pleased with the way their messages were sent and received through the cable without interfering in the least with the insulation tests.

On May 14th Mr. Henley began to manufacture the shore ends for this cable; on May 18th I proved that a fault represented by one inch of bare copper strand did not with my system prevent signalling through the cable; on May 30th the manufacture of the 1,646 knots of cable was completed, and on June 6th Mr. Graves tested the cable on board the *Great Eastern* on behalf of the Atlantic Telegraph Company.

Mr. Cyrus Field had received the following letter from Captain Bolton.

"Chatham, 14*th February*, 1866.

"Dear Mr. Field,—In reply to your enquiry as to how I am getting on with my Telegraph Code, it will doubtless interest you to know that it is now rapidly approaching completion. When I made the trial through the 2,300 knots of cable on board the *Great Eastern*, in July last, I succeeded in gaining 14 minutes out of 32 in the transmission of a message. The Code of that time was incomplete.

"Now I fully expect to be able to gain (at the lowest average) cent. per cent. over any instruments worked on the existing telegraphic system.

"Another advantage possessed by this code is its correctness in the rendering of telegrams, added to which is its simplicity. I have proposed to the Telegraph Construction and Maintenance Company to open negotiations for the commercial working of

my code, not with the Atlantic Cable alone, but with other existing great lines, especially India; and I am induced to believe that by doubling the working powers of a line the market value of the shares must necessarily be advantageously influenced. I hope to see you again shortly on the subject, meanwhile believe me.

"Yours very truly,

"(Signed) Frank Bolton."

"CYRUS W. FIELD, Esq.,

"Palace Hotel, London."

Every facility was therefore given to Captain Bolton to continue his experiments and he appeared to spare neither time nor expense over them.

On June 26th Mr. Glass visited the *Great Eastern*, to test his system; on this occasion Captain Bolton was at the sending and his assistant Major Knapp Barrow at the receiving station. One of the test messages handed to Captain Bolton was as follows:—

"Bad news from the home-farm. Trichinæ spiralis in all the last year's bacon, and the bull-pup laid up with distemper."

This message took Captain Bolton 45 minutes to code, the clerk 8 minutes to send the figures representing it, and Major Knapp Barrow 20 minutes to translate with two mistakes.

The same message by the ordinary system was, by the same clerks, sent and received in 5 minutes 10 seconds, after which Mr. Glass decided not to enter into any agreement for working, until the cable was laid and he had seen what we could ourselves do in that direction.

The engineers' programme and the electrical ship and shore instructions, printed in leaflet form and freely circulated, were as follows:—

Programme of Proceedings for Laying the Atlantic Telegraph Cable.

Morden Wharf Greenwich,
June 20th, 1866.

1. The S.S. *William Cory* having received on board at North Woolwich the shore end and machinery for the Irish coast, will leave the Thames not later than the 30th instant, and proceed to Berehaven to be in readiness to lay the shore end when the weather is sufficiently fine.

2. The S.S. *Albany* having her recovering machinery, ropes, buoys, and stores on board will leave the Thames on the 26th and proceed to Cardiff, fill up with coals, and go from thence to Berehaven to assist the *William Cory* in laying the shore end. She will afterwards accompany the expedition to Newfoundland.

3. The S.S. *Medway* having all her coals, cable, and machinery on board, will leave the Thames about the 5th July, and proceed to Berehaven to join the *Great Eastern* and be ready to accompany her in laying the cable.

4. The *Great Eastern* will leave Sheerness on the 30th June for Berehaven to complete her coaling, and be ready to steam out to the buoy on the shore end on or about the 10th July. The splice to the main cable will be made on board the *Great Eastern.*

5. After the shore end is laid by the *William Cory* and buoyed, if the weather is fine she will remain by the buoy, and the *Albany* will return to Berehaven for the *Great Eastern.*

6. Upon commencing to lay the cable from the *Great Eastern* the position of the *Terrible* will be ahead of the *Great Eastern* on the port or starboard bow, to keep other vessels out of the course, and the *Medway* will be on the

port and *Albany* on the starboard quarter in readiness to pick up or let go a buoy or do other work as may be signalled from the *Great Eastern.*

7. All the accompanying ships to keep their allotted positions, and within signalling distance of the *Great Eastern.*

8. The speed of the ship over the ground, in paying out the cable, should in no case exceed six knots per hour.

9. In laying the cable of 1865, the average slack paid out through the deep water was 15·6 per cent. at an average speed of ship of 6·34 per hour, and with a strain ranging from 10 to 14 cwts.

10. The total length of cable taken out this year being 2,724 miles, it will be seen from the following estimate that 764 miles will be left to complete the line of 1865:—

	Distances.		Cable Required.	
	Shoal Water.	Deep Water.	Shoal. 7 per cent. Slack.	Deep Water. 20 per cent. Slack.
Valentia to Heart's Content	1,670		1,960	
1866. Valentia to end of shoal water, lat. 52° 21′, long. 14° 40′ . . .	164	—	175·5	—
Deep water	—	1,333	—	1,599·5
Heart's Content to end shoal water, lat. 49° 17′, long. 49° 40′	173	—	185	—
Totals for line of 1866 .	Distance 1,670 miles		Cable 1,960 miles	
1865. From the end of cable of 1865 to Heart's Content	173	427	185	512·5
Totals for line of 1865 . .	Distance 600 miles		Cable 697·5 miles	

Taking this 697·5 miles from 764, we have 66·5 miles of cable left, and the cable of 1865 must, therefore, be grappled and spliced within this distance from the end.

11. In the event of any unforeseen occurrence, in laying

the Cable of 1866, by which the cable could not be recovered in the deep water, it becomes necessary to fix upon the length remaining on board with which it would be prudent to start again from the point latitude 52° 21′ N., longitude 14° 40′ W., or 164 miles from Ireland.

Taking the figures in the previous paragraph with 20 per cent. of slack through the deep water, and 7 per cent. through the shoal water, the length of cable required between Ireland and Newfoundland is 1,960; this taken from the total length 2,724 miles leaves 764 miles, which could be paid out, and yet have sufficient cable left to begin again if an accident happened at that place; but as the cable can be grappled in between 200 and 300 fathoms depth at latitude 52° 21′ N., longitude 14° 40′ W., this would give 175·5 miles to be added to the 764 miles, making 939 miles, which might be paid out and yet have sufficient cable to commence again at the above position and reach Newfoundland; but in deciding upon a point of such importance, I consider a larger margin ought to be allowed, and should not therefore advise re-commencing at the end of the shoal water if more than 830 miles had been paid out when the end of the cable was lost.

In the event of such an occurrence, the Expedition must first return to Berehaven, or some other port, where the Cable can be transhipped from the *Medway* into the *Great Eastern* before making another attempt.

12. The disconnecting gear on the *Great Eastern* should be tried on the passage round to Berehaven, to ascertain how she will answer with both paddle and screw.

13. In the case of a fault being discovered, a signal from the testing room will be immediately made by gong to the bridge and to the paying out machine to reverse the

engines, and by electric bell to the coil, and as soon afterwards as possible with safety to the cable to commence hauling back.

14. Should a fault occur, a buoy placed ready at or near to the stern will be immediately attached to the Cable to buoy up the bight. The ship would then be kept as near this position as possible, and other buoys can be attached at intervals if necessary, and if the weather is such that, from the drift of the ship or other causes, too much cable is being lost, and it is necessary to cut the cable, the end will be moored and buoyed with a large ocean buoy.

The latitude upon which the Cable will cross each degree of longitude to be given to each officer in charge of the *Medway* and *Albany* in order that, should the ships part in a fog, any ship having missed the *Great Eastern* can steam ahead to a meridian which she can be sure the *Great Eastern* cannot have reached, then steam slowly back with the view of picking up the *Great Eastern*, which may be engaged picking up a fault.

Both Maryatt's and Colomb's signals to be used, the latter method having been already applied to the codifying of all probable signals.

At any time the *Great Eastern* may be heard firing guns, it is to be understood by the accompanying ships that they are desired to close with the *Great Eastern.*

In case of fog on approaching the Newfoundland coast, the *Terrible* will keep close ahead of the *Great Eastern*, and direct the latter to alter course by firing one gun to port helm and two guns to starboard same; three guns danger ahead. If the *Great Eastern* fires one or more guns, attendant ships to close in with her.

If when near the land, our position or Trinity Bay

cannot be ascertained on account of the fog, and the weather is calm, the *Great Eastern* can be kept nearly in her then position with the Cable, or if, for the safety of the ship, it is necessary to keep further from the land whilst the fog lasts, the Cable can be cut, moored, and buoyed, and watch-buoys put down to facilitate in finding the Cable Buoy.

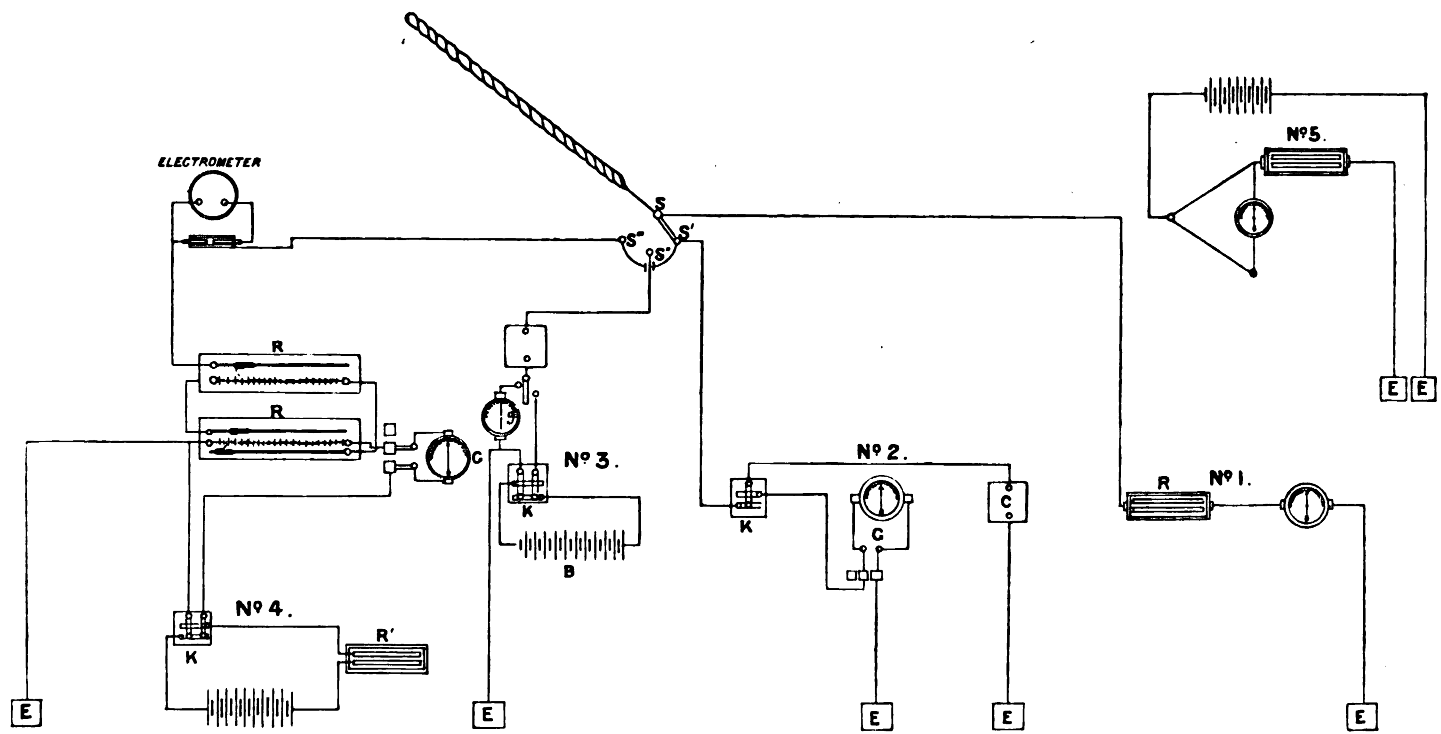
This could also be done should a gale of wind be blowing up Trinity Bay, or whilst making the splice, so that it may be considered dangerous or unadvisable for the *Great Eastern* to go nearer the land.

As soon as the *Terrible* has taken in coal, she will proceed with the *Albany* to the position about one mile from the end of the Cable of 1865, and place mark buoys for guidance in grappling. The *Medway* and *Great Eastern* will follow as soon as they have coaled; but should they not join the *Terrible* and *Albany* by the time they have placed the mark buoys, the *Albany* will proceed to grapple for the Cable, and if she succeed in grappling it, she will lift it as far as possible without approaching the breaking strain; she will then buoy the grapnel rope, and grapple for the Cable again further on. By continuing this she may succeed in lifting the bight or an end to the surface, and buoy it in readiness for the *Great Eastern.*

Should the *Great Eastern* and *Medway* arrive before the bight or end of the Cable is grappled or raised, they will take up their position and commence grappling.

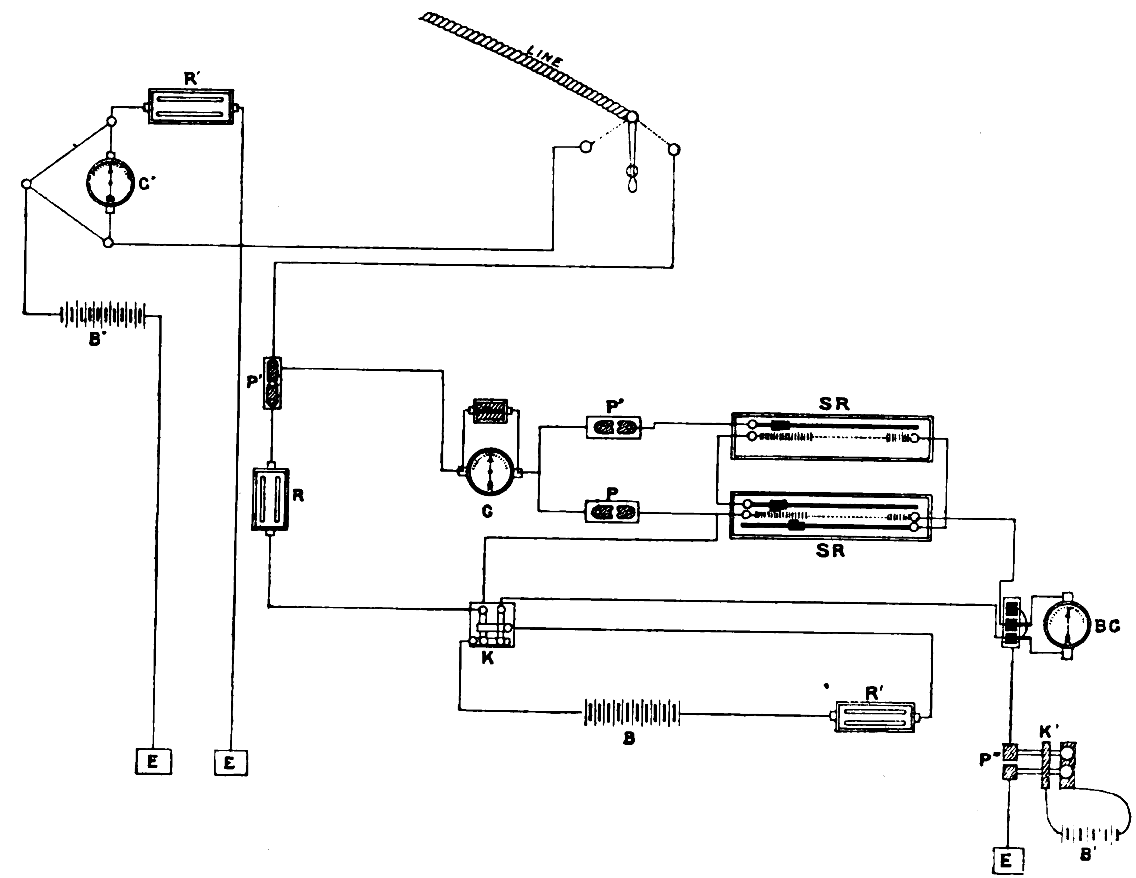
If the three ships are grappling for the Cable at the same time, their relative positions will be: the *Medway* to the west, with the greatest lifting strain, the *Albany* to the east, with the least lifting strain; so that, if the Cable is broken by the *Medway* the end will be secured either by the *Great Eastern* or the *Albany*.

No. 1.—SHORE.



ELECTROMETER
S
S'
S''
S'''
R
R
C
Nº 3.
K
B
Nº 4.
K
R'
Nº 2.
K
C
C
R
Nº 1.
Nº 5.
E
E
E
E
E
E
E
E

No. 2.—SHIP.



The ships will be provided with grapnels both for breaking and holding the Cable.

If the ships have hold of the Cable and a gale of wind springs up, so as to prevent the possibility of raising the Cable to the surface, buoys are provided for buoying the grapnel ropes, and watch buoys placed to assist in sighting the grapnel buoys, in case the ships are driven away from their position.

SAMUEL CANNING,
Engineer.
(Approved) R. A. GLASS,
Managing Director.

INSTRUCTIONS FOR SHIP AND SHORE.

1. The tests to be applied on shore may be put, for convenience, under five heads. The instruments on shore are to be connected, as showed in the accompanying diagram (No. 1), and not to be altered under any pretence throughout the voyage unless instructions are received from the ship to do so.

2. The end of the cable must be brought direct to the test room, and the conductor firmly secured to the switch S.

3. No. 1 arrangement consists of a very high resistance, R, permanently attached to the conductor, and one end of a galvanometer, G, the other terminal of the galvanometer being connected to earth. This being a variable resistance, it should be adjusted so as to allow a deflection of about 200 divisions on the scale of G, from the tension of the ship battery. This deflection never, on any account, to be allowed to exceed 300. The purpose of this arrangement is to enable ship to speak to shore by either reversals, or

reduced or increased tension. It will also be an insulation and continuity test for shore, as well as a control tension test for ship. As this arrangement will not require to be altered during the voyage, to ensure a good and constant contact the connection had better be soldered to the conductor.

4. No. 2 arrangement consists of a condenser, C, equal in inductive capacity to about thirty miles of the cable, connected to an ordinary key, K, in such a way that it can be charged from the line at will, and discharged through the galvanometer G′. This is to serve for a continuity test for ship, to ascertain the potential of the line at the shore end, and as a call signal when shore wishes to speak to ship.

5. No. 3 is an arrangement for enabling shore to speak to or receive from ship through a condenser, C′, equal to about 80 miles in inductive capacity. C′ is connected to the line when required by means of the switch S″, so that either positive or negative currents from battery B may be sent into the condenser. This will produce on ship's insulation galvanometer deflections either to the right or left, which will represent dots and dashes in the code, the left, or negative, being equivalent to a dot, the right, or positive, to a dash.

6. No. 4 is an electrometer arrangement for ascertaining the potential of the line. The battery galvanometer must always be kept at one reading by means of the resistance coils, R′ (ordinary 1 to 10,000). Before reversing the battery at any time by its key, the galvanometer must be short-circuited by putting the galvanometer key into its middle position, and when the battery is reversed, the reversal of the galvanometer may be completed. By aid of the electrometer and its key, the potential of the fine slide is to be always kept equal to that of the insulated end of the

cable. The actual electric zero of the electrometer at the time is to be worked to. This may vary a good deal. The slide number, to be telegraphed to the ship at certain times, consists of hundreds from the lower scale, and units from the upper. Thus 713 is the number corresponding to the positions shown on the diagram. But ordinarily, when all is well, the lower slide will be much nearer the right, and the numbers will, generally, consist of four figures, as, for instance, 8,213, if the upper spring of double slide touches the number of 82, and the upper or fine slide is as shown in the diagram. Shore is to adjust his battery and resistance so as to find 8,000 for his slide reading when the cable is first joined up. Thenceforward his battery galvanometer is to be kept at one reading as constantly as possible.

7. No. 5 is an ordinary bridge arrangement for testing the copper resistance of the line. It must be kept ready for use, but must not by any means be connected to the line until ship gives orders for the test to be made. It can then be attached to switch S by the wire leading to resistance R, and it will thus not interfere in the slightest degree with the other connections.

8. The cable on board the *Great Eastern* will be joined into one entire length, and when joined to the shore end, ship will charge and commence the insulation test with 100 cells. This tension will be maintained throughout the voyage, unless it should be thought prudent to alter it, of which due notice will be given to the shore.

9. The resistance R on shore must be so adjusted as to obtain the desired deflection on galvanometer G, and must not again be altered unless the deflection exceed 300 divisions; or unless a serious fault occur, when it will have to be reduced until a sufficient deflection is obtained to enable ship to speak to shore by reversals. The deflections must

be taken at stated intervals, directly after the zero of the instrument has been adjusted and carefully tabulated for future reference.

10. The continuity test (No. 2 arrangement in the diagram) will be applied every *five* minutes, commencing at the sixth minute after each hour, unless shore is speaking to ship, and then it can be discontinued during the time of speaking, and the discharge reading carefully tabulated. One charge of 10 s. duration will be sufficient for this test. It is important, in order to make this reading very accurate, that it should be as high as possible, and, therefore, the readings should always be taken on the same side of the scale, with the zero point at the extreme end of the other side, by which means a reading of 600 divisions can be obtained. Shunts will have to be employed to regulate these readings. Shore must multiply these readings by the value of the shunt (which he will have previously determined) and telegraph to the ship the true value of his readings.

11. Ship will reverse the currents every fifteen minutes, in addition to this, ship will send four reversals of two minutes each, commencing at the thirtieth minute of each hour. After each of these reversals, the tension of the line must be taken on electrometer E, condenser C, and galvanometer G. As it is important that the potential should be taken on E and C simultaneously, S′ and S‴ will be generally connected together by means of a plug or some other simple arrangement. Each of the four readings of each instrument must be sent to the ship by No. 3 arrangement in the diagram. The ordinary Morse "number" code to be used:—

1	. — — — —	6	— . . . .
2	. . — — —	7	— — . . .
3	. . . — —	8	— — — . .
4	. . . . —	9	— — — — .
5	. . . . .	0	— — — — —

These readings are to be taken at 31m. 40s., 33m. 40s., 35m. 40s., and 37m. 40s. The slide reading of the electrometer test *must* always be sent FIRST, then the discharge reading from the condenser, and lastly the reading on G. The code will be worked as follows :—Suppose the readings to be slide 87, condenser 600, and galvanometer 194, they would be signalled to the ship in this order, viz., – – –^{8}. ., 15 s. pause, – –^{7}. . ., 15 s. pause, then "the understand" (. . . . – . to indicate that the first reading is completed). – .^{6}. . ., 15 s. pause, – –^{0}– – –, 15 s. pause, – –^{0}– – –, 15 s. pause, then "the understand" as before, – – –^{1}– ., 15 s. pause, – – –^{9}– ., 15 s. pause, . .^{4} . . – 15 s. pause, then "the understand" to denote the finish. In case of one reading being doubtful, D. D. (– . . . – . .) will be sent instead.

12. Ship's ordinary mode of communicating to shore will be by K′ and B′, the plug P‴ being first removed. At the end of each word ship pauses long enough to get an approximate or accurate insulation reading.

13. A "time" code as follows may be used :—

1	—	50 s.
2	—	60 s.
3	—	70 s.
4	—	80 s.
5	—	90 s.
6	—	100 s.
7	—	110 s.
8	—	120 s.
9	—	130 s.
0	—	140 s.

All messages can be sent by the code annexed hereto *in numbers* the spelling code providing 1,000 signals, by which any word can be spelt in syllables. Therefore, the use of the alphabet will seldom be required.

The advantage of this code is the frequency of the reversals, which allowing an insulation reading to be taken after

each. This will be a good test of the electrical condition of the cable. The insulation test will also not be interrupted for more than 15 s. at any one time.

14. When speed is necessary, ship will speak direct by K′ and B′ as above, working by two currents, as in the ordinary single needle code. Three reversals of 20 s. duration will be the quick-speaking signal.

15. Shore will send a daily Greenwich time signal to ship at 10h. 11m. 0s. a.m.

16. To sum up, the ordinary tests will be as follows:— Continuity test from shore, when not otherwise provided, every five minutes, commencing at the sixth minute after each hour (§ 10).

17. Ship will reverse current every fifteen minutes, when not otherwise engaged.

18. At the thirtieth minute of each hour reversals will be sent and potential of line taken on shore (§ 11).

19. To open communication with shore, ship will give three 15 s. reversals for the "time" code, three 20 s. reversals for the quick code, and three 25 s. reversals for the "number" code, all of which will be continued with pauses between until shore gives "the understand."

20. Shore's call signal will be one continuity test each minute until attention is secured (§ 4). G. G. will be the signal for shore to commence speaking, but a reversal from ship will mean that shore is not to proceed speaking until the G. G. signal is given. G. G. would not be doubtful in case of a fault.

21. As ship will be on the alert for the hourly tension test from shore; shore need not send the call signal, but may at once proceed to transmit results, having first sent S. S. S.

22. The following signals taken from those in the code

will be sent from ship to represent the corresponding instructions :—

10. Double battery power on speaking instrument.

83. Half do. do. do.

40. Double capacity of condenser for continuity.

04. Half do. do. do.

49. Take potential on electrometer slide every exact minute of ship's chronometer time, beginning on an even minute. Send results immediately after four readings taken.

38. Take resistance of line: first, negative, and then, positive, and send results. We will free the line for six minutes.

91. Take copper resistance: first, negative, and then positive, and send results. We will put line to earth for six minutes.

95. Put end of line direct to earth for five minutes.

58. Put end of line direct to earth for two minutes.

23. If it be found necessary to add to or alter any of these instructions, ship will do so by giving due notice to shore; but in no case is shore to depart from their instructions, unless ship gives them permission to do so.

24. Should ship reverse the current while shore is speaking, or at any other time than that stated in the instructions, shore will understand it as a signal for them not to interfere in any way with the line until ship gives G. G., when the ordinary signals or tests may be proceeded with.

25. Ship will work to Greenwich time with a chronometer, and shore, except at 10h. 11m. a.m., must take that time as being correct, and work to it.

26. When the cable is laid, the entire system must be transferred to the end of 1865 cable, and the galvanometer,

G, carefully watched for signals. Unless ship instruct otherwise, it will be understood that the same instructions are to be observed during the completion of that line.

27. Should a misunderstanding arise while adjusting speaking instruments, after the line or lines are laid, the paying out speaking arrangements must be again adopted.

28. Records of the tests made and the results obtained are to be carefully kept both on ship and shore.

29. Once a day ship will send distance run, miles paid out, and insulation resistance per mile, in millions of ohmads.

Special Instructions for Ship.

1. The connections are to be made as in the annexed diagram. No. 2.

2. For ordinary insulation test plug P must be inserted, and P′ and P″ removed.

3. Minute readings must be taken on G and recorded. Slide resistances S R and S R′ must not be used or interfered with, except by the electrician on duty at the time. When required to ascertain the resistance of the G P by the slide arrangement, the plug P must be removed, and P′ and P″ inserted. When altering connections, care must be taken to shunt off the galvanometer G, so as not to allow too strong a current to pass through it.

The resistance of S R and S R′ must be varied by the slides, until the image on the scale of G stands at zero.

If n be the number read on the slides,

R″ resistance in line with cable,

I″ Insulation resistance of the cable,

then

$$I = R\left(\frac{10,000}{n} - 1\right)$$

The same formula gives copper resistance if the remote end is put to earth.

(Signed) WILLOUGHBY SMITH.

The mean per knot for the 1866 cable when completed was as follows:—

Copper Conductor . . .	4·198 ohms.
Gutta Percha	358 megohms.
Inductive Capacity . . .	·370 microfarads.

Captain Anderson again commanded the *Great Eastern*, Mr. Robert Halpin was his chief officer; Captain Moriarty also accompanied the expedition in the same capacity as in the previous year. Mr. S. Canning, with Mr. H. Clifford as his chief assistant, was in charge of the expedition, and I, ably assisted by my staff, had sole charge of the electrical department.

Professor Thomson and Mr. J. C. Laws were on board as representatives of the Atlantic and Anglo-American Telegraph Companies, while Mr. Glass, Mr. C. F. Varley, and Mr. Latimer Clark remained at Valentia. Mr. Daniel Gooch, Mr. Cyrus Field, Captain Hamilton, a Director of the Atlantic Telegraph Company, Mr. J. C. Deane, Secretary to the Anglo-American Company, Dr. C. V. Poore, as Medical Officer, and Mr. Robert Dudley, artist, were also on board.

As I was fully occupied in the electrical department, my able assistant, Mr. Thomas Willey, took notes for me, and I do not think I can do better than give them here as they were given to me. They are brief, but still I think sufficient to show the daily events of this memorable expedition.

"*Saturday, June 30th*, 1866.

"Almost exactly at 12 this morning our anchor was

weighed, and the engine started. We steamed slowly out of the river, cheered loudly by the men-of-war which we passed. We reached the Nore at 3.30, and dropped anchor there for the night, as the tide was not high enough to carry us over the bar. The weather was exceedingly fine, but towards evening a rather stiff S.W. breeze sprang up, promising something disagreeable for us the next day.

"*Sunday*, *July* 1*st*, 1866.

"As we expected yesterday, we had this morning a very heavy gale, with frequent showers of rain and hail; they said it had been raining all the previous night. While we were at 'church,' in the grand saloon, the men above were weighing the anchor, and at one o'clock we started once more; we were accompanied by Mr. Pender's yacht. The weather in the afternoon became exceedingly rough, so much so that the yacht was obliged to put back again. About 7 o'clock we noticed a small steamer from Deal or Dover making direct for us. The sea was so rough it seemed as if she would be swallowed up entirely. Every now and then her bows went clean under water, the sea streaming over the deck. However, she held up against it, and presently, at 7.50 she came alongside us, and took away our pilot, thus saving us the trouble of stopping at some port to land him.

We passed	Margate . . .	4.0 p.m.
,,	North Foreland .	4.30 ,,
,,	South ,, .	7.30 ,,
,,	Dover	8.15 ,,
,,	Dungeness Light	10.45 ,,

"The gale continued strong all the day.

"*Monday*, *July* 2*nd*.

"Passed Ventnor 3.0 p.m. Weather still rough.

"*Tuesday*, *July* 3*rd*.

"Passed Lizard 3.30, Land's End, 7.0 p.m. Weather very rough all day.

"*Wednesday*, *July* 4*th*.

"Weather all day was very rough. We sighted Irish land at 7.0 p.m. In the evening we had a theatrical entertainment in the grand saloon. The piece was entitled 'The Field Glass,' being a pun on the names of our two chiefs (see Appendix B). As we were so near our destination somebody started a sweepstakes, 10s. each. Each of the tickets had a certain hour marked on it, and the prize was to be given to the one whose time came nearest to the time of our arrival next morning. The first prize was won by Lord Hastings.

"This being the anniversary of the American Declaration of Independence, the American flag was hoisted, and speeches made in compliment to Mr. Field.

"*Thursday*, *July* 5*th*.

"We entered Bantry Bay at 5.30 in the morning, and dropped anchor about five miles from Castletown, in a part of the bay completely screened from the roll of the Atlantic.

"*Friday*, *July* 6*th*.

"The *William Cory*, with the shore end, arrived in harbour at 1 o'clock p.m., having experienced very rough weather all round. She left again for Valentia, with Mr. Smith and the staff and instruments, at 9.0 p.m., the *Great Eastern* saluting with one of her guns.

"The *Terrible* arrived at 10 p.m.

"*Saturday, July 7th.*

"The *Albany* arrived in the harbour about 11 a.m., and left for Valentia late in the evening.

"The *William Cory* anchored in Foilhummerum Bay at 7 a.m., having met the *Terrible* entering Bantry Bay. Mr. Glass landed just before 8 o'clock to arrange boats, &c. About forty boats were engaged to carry the shore end from the ship to the beach. At 2.20 (Greenwich) the shore end was about half way to the shore. It was raining, and there was every appearance of a rough day. The end of the cable was not long enough to come into the test room, so it was joined to a piece of taped wire, about thirty yards long. At 3.55 the end of the cable was brought into the testing room—signals from ship were good, on a Morse.

"At 5.20 the *Cory* commenced steaming out of the Bay. The insulation test was taken on shore every five minutes, the rest of the time being occupied in speaking on the Morse.

"Before the boats could be made to take up their positions they crowded so round the ship, it was found necessary to play upon them with a hose, to get them off.

"*Sunday, July 8th.*

"At 3.10 a.m. disconnected the end from the office, as ship wished to seal the end. Sent telegram to Field and Glass, informing them of the successful laying of the shore end. At 12 noon tested the cable—resistance 817 M.S.U. per knot. The resistance when the paying out was commenced was 251, and each test showed a gradual increase. The last test made previous to disconnecting was 688.

"At 6.30 p.m. Messrs. Glass, Thomson, Field, Varley, and Latimer Clark arrived. The latter gentleman made the resistance 801, all readings after one minute.

"The *William Cory* left for Berehaven, and was obliged to keep outside the harbour for 60 hours, until Tuesday morning, the fog being too thick to allow her to proceed any further."

The following note for July 9th I was enabled to make for myself:—

The shore end being laid, and all the arrangements made at the shore station, I left Mr. J. May in charge, and in the evening started across country to join the *Great Eastern* at Berehaven. Fortunately for me Captain White, of the coastguard station, allowed one of his men to accompany me on what was at night far from a pleasant trip to contemplate. After six hours' drive through a "Scotch" mist, which I thought might have been more aptly termed an Irish one, we, about midnight, arrived at a place called West Cove, where, with difficulty, the coastguardsman got together a crew to take us across the Kenmare river. It was so dark that I could only make out the number of men from their voices as they, with the volubility of their nation, boasted of the number of titled personages they had rowed and sailed across the river, and the large amount of money they had received for this service. They, of course, protested that they would not have taken us, more particularly on so dark a night, for the insignificant sum (20s.) had they not felt so great a respect for the "big ship" and her mission to connect more closely old Ireland and young America. I could not well judge of their boat in the darkness, but, if the titled personages appreciated the

"very ancient and fishlike smell" arising from it, I certainly did not, but I can testify that they got plenty of it for their money.

We now met with an instance of Irish superstition, which, had it not come within my own experience, I would not have believed possible. The men had pulled well and strong together, and, in response to a demand for my opinion, I had expressed unqualified approval both of their skill and speed, when, suddenly, with exclamations of fright, they "in oars," and refused to row another stroke. It then transpired that in the Kenmare river there was an island which, according to their reckoning, they ought to have made by this time; not having done so they solemnly affirmed that on dark nights like the present, evil spirits, to spite them, frequently removed the island. Thinking that they had simply missed their way, and were treating me to a little blarney, I proceeded to jest upon the subject, but my guide, who was himself an Irishman, warned me to be careful, as the men were in earnest, and nothing that I could say or do would make them alter their convictions. My superstitious crew were huddled together in the bows talking in a low, and to me unknown language; for all I knew to the contrary they might have been under the impression that I was the evil spirit, and discussing how best to dispose of me. Thus, for three long hours, did we drift, and from the increased motion of the boat it was evident that the tide was carrying us seawards. At length, at early dawn, it was discovered that the island had been replaced, and in its usual position too, for I noticed that the men, with renewed energy, rowed to a certain part of the island well-known to them, and from thence steered their course to the opposite shore. Daylight did not lend enchantment to my view of either the boat or its crew, and

being once more landed on *terra firma* I was heartily glad to have done with them.

The only conveyance obtainable at the place where I landed somewhat resembled a broad short ladder, supported horizontally by being fixed on a cross bar of iron attached to a wheel on either side; this arrangement, which was totally guiltless of springs, its owner called a cart. The horse—well, I am not much of a judge, but even my ignorance was surprised when I was told that its progenitors were well-known Irish race horses. I thought it fortunate for me that he had not apparently inherited their speed, for the way was rough, and his driver made much use of an apology for a whip, accompanied by many exclamations of an inspiriting nature. However, nothing induced him to move beyond a jog trot, and at every indication of a more than usually rugged piece of road he invariably walked. Eventually I reached the *Great Eastern* with a good store of food for future reflection in the incidents connected with my journey from Valentia to Berehaven.

Mr. Willey's notes continued:—

"*Tuesday, July* 10*th*,

"The *Albany* came into Bantry Bay early, and the *William Cory* arrived at one o'clock p.m. The live stock was being taken on board the *Great Eastern* to-day; there were 100 sheep and a score each of bullocks and pigs, besides a large number of fowls of different kinds.

"The *Medway* arrived in the harbour in the evening.

"*Wednesday, July* 11*th*.

"The *William Cory* left us for England at 3.30 p.m., saluting us with two guns as she passed. At 5.30 the *Racoon*, twenty-one gun ship, sailed into the harbour.

"*Thursday, July* 12*th.*

"The three ships, *Terrible*, *Medway*, and *Albany* left Bantry Bay for Valentia early in the morning. We were getting ready to start all the day long, and at 6 o'clock p.m. the *Racoon's* boat came alongside and took away all those in the *Great Eastern* who were not going to Newfoundland.

"We started about 7 o'clock, with the *Racoon* following. It became very foggy as we left the harbour, and we were obliged to keep the fog signals going continually.

"*Friday, July* 13*th.*

"We came in sight of the buoy to which the shore end is attached, off Valentia, about 6 o'clock a.m. The *Terrible*, *Medway*, and *Albany* were stationed in different positions around, so as to guide us to the buoy. We were setting ourselves down until about 10.30 (Greenwich) when we began to haul in the chain fixed to the cable. The end of the cable was shipped at 12.20 (Greenwich), the depth of water being 100 fathoms. The joint was immediately made, tested, and found perfect, and when the splice was completed at 3.20 it was thrown overboard—the *Great Eastern* firing her two guns to announce the fact to the other ships. Paying out was at once commenced, the ship proceeding at about five knots per hour. The whole operation of hauling in was performed amidst floods of rain, which drenched everybody who was not well protected. The wind was slightly against us, but the great ship hardly rolled at all, while we could see the other ships tossing terribly.

"We received the first signal from shore at 2.6 p.m. (Greenwich). The weather continued dull all day, and became foggy again in the evening. Everything went on

Thursday, July [illegible]

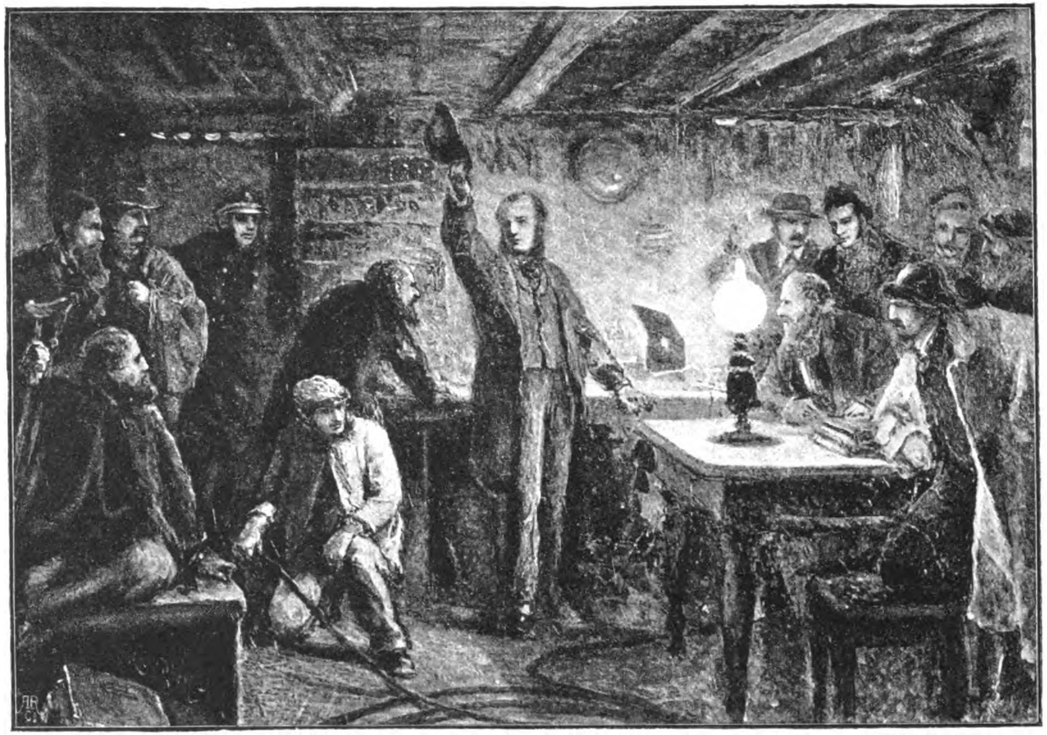
[illegible] and [illegible] We were [illegible] and took [illegible] were not going to New-[illegible]

[illegible] the *Resource* [illegible] we were [illegible]

Friday, July 13 [illegible]

[illegible] the [illegible] The *Terror* [illegible] in different positions [illegible] We were setting [illegible] when the [illegible] The whole [illegible] well protected [illegible] the other [illegible]

[illegible] at 2.0 [illegible] evening [illegible] went on



"IN THE TEST ROOM."

S.S "Great Eastern," September 2nd, 1866.

well during the remainder of the day. The paying out arrangements were perfect.

"*Saturday, July 14th.*

"Throughout the whole of the day the weather was splendid. The testing and paying out proceeded most satisfactorily, and the signals from shore were quite distinct. The cable is paid out at the rate of about six knots per hour, the ship running five knots. The *Great Eastern* behaves herself admirably; she is much quieter than when coming round the Channel, and all her motions are much more gradual, owing to the increased size of the waves.

"At three o'clock a man fell overboard from the *Terrible*, but was fortunately recovered, after delaying the vessel some time.

"At 10.45 p.m. we received the following message from shore:—'General Cialdini is marching upon Rovigo with an army of 100,000 men and 200 guns. The Austrians have evacuated the whole territory between the Mincio and the Adige.' It was immediately written, and published as the first number of the *Great Eastern Telegraph*."

(Before leaving I had arranged with Mr. May that, as opportunity offered, he should telegraph to the ship any news likely to prove interesting to our little world so soon to be crossing the Atlantic, with no other means of knowing what was taking place in that bigger world of Europe. Fortunately, all went well electrically, so we daily received a batch of news, some of which I posted outside the test-room door, heading it *The Great Eastern Telegraph*. The test-room being a deck-house in the centre of the ship was a capital position for the purpose, and it was gratifying to see those who were not actually on duty

attracted to the spot, eagerly discussing the news thus received, and anxiously awaiting more.

There can be no doubt that all this had a healthy tendency, as it taught the men the importance of their work, for was it not strange that they on ship-board in mid-Atlantic should be able to read news from that day's *Times*, seemingly, owing to difference of time, before it was circulated in London. To give my readers an idea of the style of the paper and the news contained therein, some copies of it will be found at the end of this volume (Appendix C). The cover was designed by Mr. Robert Dudley.)

"*Sunday, July* 15*th*.

"At eight o'clock this morning we had the nicest possible escape from a mishap with the cable. It was just after we commenced to pay out a section of last year's cable. One of the outside wires had broken, and was sticking out like a hook. As it was being paid out, it caught up the flake of cable underneath, and there would inevitably have been a thorough confusion and, perhaps, a breakage had not the piece of wire fortunately snapped off and allowed the flake underneath to fall into its place again. To prevent a recurrence of anything of the kind orders were given to the men to lift up the cable as it went round and round with their hands, so that in case of another broken wire, it would be detected at once.

"*Monday, July* 16*th*.

"We had all the day a 'dead calm'; the sea was literally without a ripple except where the paddles had been disturbing its surface. Everything has proceeded most satisfactorily throughout the day; signals from shore were quite distinct and readable. We have been pro-

ceeding rather slowly on account of the difficulty in paying out the section of 1865 cable.

"*Tuesday*, *July* 17*th*.

"At 7.55 this morning the last of the section of 1865 cable was paid out, and we thought everything would go on all right again. But this day must be remembered only as one disaster. In the first place, there was a complete change in the weather; instead of the calm we had yesterday there was a rather stiff S. wind, and towards the afternoon a good deal of nasty small rain beat about us.

"About four o'clock one of our staff accidentally set the bell fixed in the tank ringing. Those in the tank, without any hesitation, ordered the engineer to stop the ship, and it was some little time before the mistake was discovered.

"A much more serious affair happened at 12.30 a.m. (Greenwich). One of the outside wires of the cable had broken in a certain place, and when it came to be paid out it caught up three or four turns of the flake below. In a twinkling the whole bundle of cable rushed up out of the tank into the machines, forming an apparently inextricable mass of kinks and twists. The ship was at once stopped, and all hands put to work to unravel the tangle, while a buoy was got ready in case the cable should break. In about two hours, by extraordinary exertions, the cable was made a little straight, and paying out slowly recommenced. During all this time the rain was coming down heavily, and the sky was dark as pitch. Our companion ships had all gone ahead, having taken no notice of our signals. The insulation of the cable, fortunately, remained perfect, and all the testing continued as if nothing had happened. The water is very deep about here, 2,400 fathoms is marked in the chart.

"*Wednesday, July* 18*th.*

"At 6.22 a.m. an accident of exactly the same nature as that recorded yesterday took place. For the third time the ship's engines were stopped and reversed. We should have had all the trouble of yesterday had not one of the men, at the risk of severely hurting himself, fortunately caught the tangle before it went out of the tank. As it was he had a pretty heavy fall on his back, but the cable was saved, and everything went on as before. The weather in the morning was rather finer than yesterday, but there was a considerable swell resulting from yesterday's wind. Towards evening the rolling greatly increased, and things were pitched about the cabins anyhow. Fears were entertained, although, perhaps, not expressed, that the foretank, in one of the ship's heavy lurches, might shift, and most likely knock the vessel's sides out, and then, of course, it would be all U.P. with us. The night passed, fortunately, without any mishap of a serious nature, and on

"*Thursday, July* 19*th.*

"both weather and sea were a little calmer. By the afternoon the weather had quite changed, and the sun came out brilliantly. To everybody's satisfaction the after tank was emptied to-night, and the paying out of the cable in the fore tank commenced. Everything in the fore tank being put in readiness the ship was stopped at 12.45 (Greenwich), and at 1.5 the last yard came out of the after tank, and paying out proceeded without the occurrence of a single mishap. The night was very fine, contrasting greatly with the weather during our pick-up at Valentia. No difference whatever was perceived in the testing, but everything proceeded most satisfactorily.

" *Friday*, *July* 20*th.*

" Although it was so fine and quiet yesterday evening, the wind began to blow to-day, and, increasing gradually, it became a thorough 'sou-wester' gale by evening, accompanied by heavy showers of rain. We managed to get along without any very bad rolling, but the three ships accompanying us, especially the *Albany*, seemed as if they could not live through the night. The *Albany* was repeatedly ducking her bows quite beneath the billows. Notwithstanding the state of the wind and sea, the paying out of the cable proceeded just as usual. In the very height of the gale, we were receiving a message from shore of 208 words and not one of the signals had to be repeated. The trim of the ship improves as paying out from the fore tank goes on.

" *Saturday July* 21*st.*

" The wind continued N.W. all day, and the weather was splendid. It appeared that we had been the previous night on the S.E. edge of a cyclone, fortunately escaping the worst of it.

" *Sunday*, *July* 22*nd.*

" Weather continued very fine all day, the wind gradually changing to S.W. About 11 o'clock a.m. we were at the nearest point—thirty-four miles S.—to where the cable broke last year. Everything proceeds excellently.

" *Monday*, *July* 23*rd.*

" Weather continued fine during the morning, but towards the afternoon it became foggy, with a good deal of rain and wind just in our teeth. The wind is very cold indeed now.

" *Tuesday*, *July* 24*th.*

" Weather still foggy, rainy and cold.

"*Wednesday, July* 25*th.*

"Weather same as yesterday. This morning we changed from the fore tank to the main tank. The ship was stopped at 2 a.m. (Greenwich), and paying out recommenced from the main tank at 2.20. The weather was foggy, but very quiet, and so far suitable for the work we had to do. Everything went off admirably.

"*Thursday, July* 26*th.*

"The weather was somewhat clearer to-day. At daybreak the *Albany* left us to go in search of one of the men-of-war, which are stationed near Newfoundland, to guide us in. She returned about 6 p.m. in company with the *Niger*, and we all sailed on in company—five of us. We passed Baccalon Point at the entrance of Trinity Bay at 11 p.m., after beating about a good deal in front of the Bay.

"*Friday, July* 27*th.*

"We sailed into Heart's Content Bay this morning, the people standing on the hills cheering us as we passed. At 9 o'clock a.m. the *Great Eastern* finished her work, and the cable was handed over to the engineers to splice to the shore end on board the *Medway*. At 11 o'clock we dropped anchor, while the *Medway* was getting ready to finish the laying of the cable. This was done at 8 p.m., when the fact was made known by a salute of 21 guns each from the *Terrible*, *Lily*, and *Great Eastern*. Congratulatory messages were immediately sent between Newfoundland and Valentia." (For the Queen's message to the President, which was received this morning before the completion of the cable, and the President's reply, see the *Great Eastern Telegraph*, Appendix C.)

(Every one on board was permitted to send free messages,

the only restrictions being that no code should be used, and that they should be written so that they could be readily understood; the number of the messages may be imagined. These restrictions had to be made as communications of a doubtful character had been passing.

On July 27th the following message was sent:—

"Heart's Content.

"Gooch to Glass,

"Our shore end has just been laid, and a most perfect cable under God's blessing has completed telegraphic communication between England and the continent of America. I cannot find words to express my deep sense of the untiring zeal, and the earnest and cheerful manner in which everyone on board, from the highest to the lowest, has discharged the anxious and arduous duties they in their several departments have been called on to perform; of their untiring energy and able and watchful care, night and day, for the period of two weeks required to complete this work can only be fully understood and appreciated by one who, like myself, has seen it. All have faithfully done their duty, and glory in their success, and join with me in hearty congratulations to our friends in England, who have in various ways laboured in carrying out this great work.")

"*Saturday, July 28th.*

"The line was opened to the public to-day, and several messages were received from England for parties in New York. Mr. Smith had charge of the station and line until 6.30 p.m., when it was formally handed over to Mr. Collett by Mr. Smith in the presence of Messrs. Gooch, Hamilton and Canning, Mr. Clark having previously certified the cable to be perfect."

(After the official tests had been made by Mr. Latimer Clark at Valentia, and Mr. Laws at Heart's Content, and the certificate given, at 6.58 p.m. on July 28th, I sent the following message:—

"Smith to Glass,

"I have just handed the line to Mr. Collett as representing the Anglo-American Company, in the presence of Mr. Gooch, Capt. Hamilton and Mr. Canning."

The total number of words sent and received through the cable from the time the laying commenced until the line was handed over, a period of fourteen days, was 6,437.

The data for the 1866 cable after it was laid was as follows:—Length, 1,852 knots. Average depth, 1,400 fathoms. Resistance of copper conductor, 3·89 ohms. Resistance of gutta percha per knot 2,437 megohms. Temperature by copper resistance, 39° Fahr.

In laid cables, especially cores of this size, and where low temperature and great pressure so influenced the result, it is impossible to obtain reliable data as to the true resistance of the gutta percha immediately after the completion of the laying. This is a case in point and shows that it takes a long time to reach its true condition, for when handed over, the gutta percha in this cable was said to be 2,437 megohms per knot after one minute's electrification; but if the temperature was really what the resistance of the conductor made it, and the formula for pressure correct, it should have been 5,361 megohms. I had an opportunity of testing this cable some months afterwards, and the gutta percha resistance was then above the calculated value, which was to be expected owing to the increased improvement by age. In short lengths it was customary to take the readings after

one minute's electrification although at that time polarisation would be far from having arrived at its maximum; but in long lengths especially, such as laid cables, for the same reason nothing less than readings after fifteen minutes' electrification should have been taken.)

" *Wednesday, August 1st.*

" The *Albany* and *Terrible* went to the grappling ground in the morning.

" *Tuesday, August 7th.*

" To-night our coaling was finished.

" *Wednesday, August 8th.*

" By this morning the whole of the cable was transferred from the *Medway* to the *Great Eastern.* The Governor of Newfoundland came in the *Lily* on Wednesday evening, and slept on board.

" *Thursday, August 9th.*

" The *Medway* cleared out this morning at 10 o'clock, and the *Great Eastern* followed in company with the *Lily* (the Governor having previously left the ship at 12 o'clock, ship's time). The weather was very calm, but there was a heavy shower of rain as we steamed out of the harbour. The *Lily*, after giving us a cheer, sailed away towards St. John's, and we went on with the *Medway* ahead.

" *Friday, August 10th.*

" Distance run at noon (ship's time) 188 miles—weather fine, but wind rather strong.

" *Saturday, August 11th.*

" Distance run at noon 380 miles. The wind continued to blow strongly, and by evening the sea was terribly rough.

The *Great Eastern* gave us a specimen of what she can do in rolling. Hardly anybody could sleep at night through the combined noise of the waves and the rolling of the ship.

"*Sunday, August* 12*th.*

"The rolling of the ship increased since yesterday, rendering it almost impossible to stand on deck. At noon the distance run was 586 miles, and by 2 o'clock (ship's time) we sighted the *Albany*, and the *Terrible* about a quarter of an hour afterwards. We learnt from the *Albany* that they had hooked the cable twice, and buoyed it once, but the buoyed chain had snapped, and the cable dropped again. The wind all the time was blowing hard, so as soon as we had spoken to the *Albany* we put our head to the wind and steamed slowly against it.

"*Monday, August* 13*th.*

"The wind had gradually abated during the night and the sea was very much calmer this morning. About 9 a.m. Mr. Temple and Mr. Clifford came on board from the *Albany* and after a little consultation, our grapnel was let down with about 2,300 fathoms of rope attached to it. (The cable itself was surrounded by only ten hemp covered wires, but the grapnel rope was composed of a strand of seven such wires twisted together, and then seven of these strands again twisted in the same way, so that it contained forty-nine wires and was about 5·75 inches in circumference. At every eighty fathoms of this huge rope was a large and cumbersome metal swivel, the object of it being to prevent the rope from twisting or untwisting; but from its dilapidated and straight condition when hauled in it was evident that instead of the swivel controlling the rope, quite the reverse had been the case.) We remained in just

the same position all day, the wind not being strong enough to drift us in the way we wished. The strain on the dynamometer was about eight tons. At 11 o'clock p.m. it was decided to pull the grapnel up again; it took three hours to do this, it being finished by two o'clock next morning. About 12 o'clock noon to-day, the *United Kingdom* from New York to Glasgow passed, and obligingly took a packet of letters for England from the *Great Eastern.*

"*Tuesday, August* 14*th.*

"The wind was very strong from the E.S.E. all day, we had to keep our head against the wind, and nothing was done towards letting the grapnel down again.

"*Wednesday, August* 15*th.*

"To-day the weather was much calmer, but to make up for the absence of wind we had a thick fog all day. However, it was considered to be fine enough to make another attempt at grappling, and at 12.30 noon, the grapnel again went down. It reached the bottom by 2 o'clock, after 2,200 fathoms of rope had been paid out. At about 2 o'clock both the *Medway* and *Albany* came alongside; after some consultation the former was sent to grapple 2½ miles west of us, and the latter was ordered to stand by buoy.

"At six p.m. our strain was such as to induce us to believe the cable was hooked, and at 8 o'clock we commenced hauling in. By 10.15 600 fathoms had been pulled in, and we were preparing to buoy the cable, when the splice which connected the buoy rope and grapnel rope drew, and the grapnel rope rushed with great violence away over the bows. While this was going on, we discovered, by hearing terrible bumps against our side, that one of the buoys already laid by the *Albany* was alongside and doing its

best to damage our paddle wheel. After many fruitless efforts to hook and secure it, it drifted away astern. All the evening the fog was very thick; we sometimes could not see half a boat's length before us.

"*Thursday, August* 16*th.*

"To-day the weather was splendid, and most favourable for our grappling operations. The morning was spent in obtaining an accurate knowledge of our position, and by noon we had steamed into a suitable situation for grappling. Within two hours our grapnel was let go, it reached the bottom in three hours more; after drifting to the N.N.E. our strain indicated that the cable was hooked. By 9 p.m. (ship's time) or 11.40 (Greenwich) 100 fathoms were hauled in, but as it was too late to complete the hauling in, we let the 100 fathoms out again, and hung on until daylight next morning.

"*Friday, August* 17*th.*

"Very early this morning we recommenced heaving in, and by 7 o'clock half the rope had been secured; the strain at that time was 10·4 tons. By 10.30 the 2,300 fathoms had been hauled in, and there remained but the three fathoms of chain. In fifteen minutes the grapnel appeared with the cable actually hanging to it. Then arose a shout of exultation, the men in the *Terrible's* boats began to secure the cable, the testing instruments were got ready, but before anything effectual was done, the sudden fall of the dynamometer told us that the cable had snapped at the grapnel; one of the boats had been washed heavily against it by a wave. Silent amazement and disappointment appeared on every countenance for some minutes until we were sufficiently recovered to talk about our next proceeding. It was then decided to steam up to a position between the

Albany and *Medway*, both which ships were grappling. In three or four hours the grapnel was let down again, but for some reason or other, it was hauled in again before night.

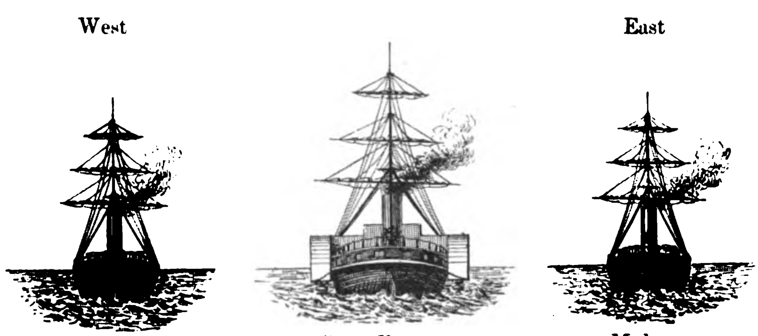
"*Saturday, August* 18*th.*

"We were, to use Mr. Clifford's expression, 'lolloping about' all day, the only thing done was to launch a buoy, No. 5, to mark the place where the cable broke. This was done at 7.30 p.m. (ship's time).

"*Sunday, August* 19*th.*

"The weather was tolerably fine to-day; starting from No. 5 buoy, we steamed five miles to the S.S.W., and at 8 a.m. let go our grapnel, finished by 9, from 9 to 3 drifted to the N.N.E. At 4 the strain went up to 10½ and sometimes touched 11; we then immediately began to haul in, and after getting up 1,300 fathoms, it was resolved to buoy the cable, the sea being too rough and the day too far gone, to risk bringing the cable to the surface; accordingly our monster-buoy, No. 6, was again got ready and this time safely launched, with the grapnel rope and cable hanging to it.

"The position of the three ships to-day while grappling was thus:—



Albany.	*Great Eastern.*	*Medway.*
Lat. 51.25	51.25	51.25.30
Long. 38.41	38.38	38.34.30

No. 5 buoy being: Lat. 51.30; Long. 38.40.

"The *Albany* and *Medway* were both unsuccessful.

"*Monday, August* 20*th.*

"The weather was tolerably fine, but the wind was too rough for us to do anything to-day.

"*Tuesday, August* 21*st.*

"This morning about 10 we perceived one of the buoys adrift. We immediately started in chase of the runaway, and soon came up to it, lowered a boat, secured the buoy and hauled it on deck. It proved to be No. 4 buoy, broken loose by the snapping of the chain from its moorings. The sea is too rough for us to grapple for the cable; next to this, a buoy hunt is the best thing to pass away the time.

"*Wednesday, August* 22*nd.*

"The sea and wind were much quieter to-day, and having got into position for grappling, we let go our grapnel at 11.28 a.m., but presently we discovered that we were drifting the wrong way, so after some hours we ignominiously hauled in our grapnel again. The *Medway* and *Albany* had been stationed, the former west, the latter east, to grapple. The *Medway* informed us in the afternoon that she had hooked the cable, but in an hour or two afterwards she discovered she had made a mistake; thus another fine day passed without any practical results.

"*Thursday, August* 23*rd.*

"The grapnel was let out to-day about 9 a.m., the sea being tolerably calm; our drifting not being satisfactory, we hauled up again; this completes the account of to-day's operations.

Friday, August 24*th.*

"The weather was rather dirty to-day and the sea

rough, and all we did was to launch another mark buoy about 7 p.m.

"*Saturday, August 25th.*

"To-day the weather was very fine and the sun out brilliantly all day. We dropped the grapnel no less than three times; the first time after a hundred or two fathoms of rope had gone out, it was found that some repairs were necessary, so it was hauled in again. This was at 6.30 a.m. At 9.30 the grapnel was let out again, but after several hours we discovered that we were drifting the wrong way, so the rope was again pulled in. At 7 p.m. the grapnel went down for the third time. By 2 o'clock Sunday morning, the strain had gradually gone up to 10½, and we all thought the cable was hooked. All the hands were called up, the engine got ready, and we were about to haul up, when suddenly the strain went down to about seven, where it remained. When the grapnel came up, some of the prongs were very much bent, so probably we hooked a piece of rock instead of the cable.

"*Sunday, August 26th.*

"The weather continued propitious all day; we let go the grapnel about 1.30 p.m. Shortly afterwards the *Medway's* engineers came on board and reported that they had broken the cable, and set the bight buoy adrift. As it seemed useless for us to grapple for a loose bight, we hauled in at 7.35 p.m.

"*Monday, August 27th.*

"Early this morning, Mr. John Temple came on board from the *Albany* and reported that he had hooked the cable, raised it to the surface, cut it and buoyed the two ends; as a proof of his success he brought a piece of the cable which he had cut off. It was then resolved that we should bring our stern round to the buoy, and from there bring the

cable on board. For about four hours we were vainly endeavouring to do this, when the Captain having said he could not do it, we changed our tactics, and after some difficulty brought our head to the buoy, with the intention of picking up from that end of the ship. We soon had the end of cable on board; there could be no mistaking it, but the strain on the dynamometer sufficed to show that we were hauling in only a short piece. The two ends were taken into the testing room. The following are the results of the tests:—

"No. 1 end, even Bridge

4·2
res. 1,470 S.U.
350 miles

"No. 2 end. About the same (showing the instruments to be out of order).

"Insulation.

No. 2 line, slide reading 9,814 = 200 S.U. for the whole line.
No. 1 " " 9,791 = 210 S.U. for the whole line.

No. 1 end. Copper resistance, Bridge $\frac{10}{100}$.

70 cells Z to L 227 S.U.
10
4·2) 2,270
541 miles.

"No. 1 end then brought in-board, so this end was laid aside altogether.

"No. 2 end connected on.

Copper resistance 100 cells C to L $\frac{10}{100}$
27
10
4·2) 270
64 miles
Do. 100
10
Out of range with 2,700 S.U.
Do. 100
100

71 units	Z to line	$\frac{100}{100}$		62 S.U.
Do.	C „	„		71 „
Do.	Z „	„		59 „
Do.	C „	„		61 „
Do.	Z „	„		60 „
Do.	C „	„		60 „
Do.	Z „	„		53 „
			7)	426
			4·2)	61
				14·5 miles.

"The next result was 1 unit, when it was announced that the end had just come in.

"Altogether the length hauled in was 1·8 miles.

"N.B.—Mr. Smith had the two ends of the cable.

"It was then resolved to bear down to the bight buoy, and secure what might be hanging to it. We did so and brought the grapnel rope on board, and began to haul in; but the strain on the dynamometer (five tons) told us that the cable, which undoubtedly had been left suspended to the buoy, had either broken or slipped off. It being apparently of no use to grapple any more in the same ground, it was decided to go fifteen miles east, and try our luck there; this was accordingly done, and by 8 a.m. on

"*Tuesday, August 28th,*

the grapnel was again let down, but an hour or two sufficed to show to our navigators that we were about fourteen miles from our proper position, in consequence of the drifting of the buoys. The grapnel was hauled in again.

"In the afternoon, the *Albany* proceeded to launch two more buoys. At 7.15 p.m. having placed ourselves in what we considered a suitable position, we let down the grapnel once more. We drifted to the E.N.E. by the help of one of our paddle wheels.

"*Wednesday, August 29th.*

"We continued to drift till 6 this morning, when the angle of the rope hanging over the bow, and the strain induced us to believe that the grapnel had not touched the ground, but had been floating. We accordingly hove in; about 8 p.m. Captain Commerell came on board from the *Terrible* to take leave previous to his departure to St. John's for coal and provisions. Immediately after he left, we sailed off for a spot 80 miles east of our present position to try to grapple there; the *Albany* remaining to pick up the two buoys now floating, and the *Medway* accompanying us.

"*Thursday, August 30th.*

"By 7 a.m. we had run by calculation 80 miles; but when we took an observation we found we had gone twelve miles too far east. We retraced our steps and somehow managed to go another twenty-five miles out of our way, making altogether forty-nine miles steaming more than necessary. The remainder of the day was spent in repairing the grapnel ropes; while the *Medway* dropped a buoy. The weather was tolerably calm, but there was a heavy swell resulting from a breeze yesterday.

"*Friday, August 31st.*

"At 10 a.m. having placed the ship about fifteen miles from the supposed line of cable, we dropped the grapnel with 2,150 fathoms of rope—the depth being 1,900 instead of 1,600. From that time until 11.50 p.m. we drifted slowly to the southward, and then the dynamometer strain indicated that the cable was hooked. We at once began to haul in. The *Medway* informed us that she also had hooked the cable, but had lost it owing to the breaking of the fluke of the grapnel.

"*Saturday, September 1st.*

"We stopped heaving in at 5.20 this morning, after about 1,300 fathoms had been hauled up. We then launched our large buoy with the cable suspended, and proceeded two miles east to grapple again. We let down the grapnel at 8.45 a.m. with 2,150 fathoms of rope. We drifted till 3.45 p.m. when the strain on the dynamometer told us that the cable was again hooked, we at once began to haul in. The *Medway* who was grappling two miles west having informed us that she too had hooked the cable, we told her to break it, so as to give us an end for hauling in. This she accordingly did. By 12.50 (midnight) the bight of the cable was above water; it was at once secured by strong stoppers, and after some time the end slowly came on deck. By 3.15 (ship's time), or 5.35 (Greenwich) the end was brought into the testing room.

"The following were the tests, &c. made:—

Insulation 100 cells. Z to line

Slide reading after 1 min. 20 secs. = 4,990,000

multiplied by 1,000 say

4,990,000,000 S.U.

5.30 a.m. .	sent three .	20 secs. reversals.
5.40 " .	" .	" "
5.45 " .	" .	" "

"When we received from Valentia, 'Understand, Query,' there was at once a burst of cheering in the testing room, which was repeated from one end of the ship to the other." (In one of the two illustrations here given, which may be considered authentic as they are taken from pictures painted for me by Mr. R. Dudley, who was present at the time and made sketches of the incidents, is shown the recovered cable hanging at the bows of the *Great Eastern.* In the other, the interior of the test room at the moment when the first signal was received from Valentia, and I involuntarily started a cheer which, lustily and heartily taken up

by all present, passed through the ship, telling more plainly and quickly than words could have done that all was right electrically. Our hopes had been ascending and descending with the grapnel for the past three weeks, during which period the beam of bright light on the scale of the mirror galvanometer at Valentia had been carefully watched; great therefore must have been the delight of the patient watchers when they at last saw it move to the ship's call, as it indicated that the lost was not only found, but that it was in a healthy condition.) "The weather throughout the day was beautifully fine and calm, just suitable for our operations.

"*Sunday, September 2nd.*

"It was decided this morning that the *Albany* should leave at 8 o'clock for England, which she accordingly did, having orders to pick up our last bight buoy. The picked up cable having been spliced to that in our main tank, and the bight passed from bow to stern, we commenced paying-out; the engines starting at 9.22 a.m., by noon we had paid out 29 miles. The weather during the day was not pleasant, a stiff breeze and heavy rain prevailed nearly all day.

"*Saturday, September 8th.*

"The following table gives the daily distance run and the cable paid out during this week."

Date.	Daily Distance run.	Total Distance from Splice.	Daily Cable paid out.	Total Cable paid out.	Remarks.
Sept. 2	23	23	29	29	Strong gale from N.N.E.
" 3	94	117	120·6	155·6	Foul flake in the morning.
" 4	109	226	129·3	284·9	Sunny day—occasional wind.
" 5	126·4	352·4	133·37	418·27	Sun shining brilliantly all day.
" 6	118·6	471	137·11	555·38	Do.
" 7	134·8	605·8	143·43	698·81	Arrived in 150 fathoms.

"On Friday morning we dispatched the *Medway* to look after the *Terrible;* and in the evening about 8 o'clock we sighted them both. The *Terrible* soon after sent a boat to us with the letters from England; in company with the *Terrible* was the *Margaretta Stevenson*, whose captain, Mr. Kerr, came on board to pilot us up the Bay.

"This morning early we were joined by the *Lily* and the *Hawk* bringing the Governor and a large party from St. John's.

"About 6 o'clock occurred the only fault which has troubled us since leaving England. A few simple tests, however, served to show that the fault was in-board, so the cable was cut and joined to another length in the after tank, and in the course of an hour or two paying-out recommenced."

(It was, I think, well that this fault did occur, as it decided two important points. Firstly, that the electrical system worked well, as the fault was discovered while in the coil and the ship was only stopped while the splice was being made; secondly, it showed how the faults in the last year's cable were probably caused, for, on careful examination, it was found that a broken wire on an outgoing flake had by some means got one of its ends bent so that it penetrated the turn of the cable beneath it. It is supposed that the pressure caused by the tread of the cable hands forced this wire into contact with the conductor.)

"We came in sight of Heart's Content Harbour about 11 o'clock. The cable was at once cut, and handed over to the *Medway* to splice to the shore end. The *Great Eastern* then steamed into her former position in the Harbour and dropped anchor. By 4 p.m. the *Medway* had completed the laying of the shore end, and soon afterwards

the end was brought ashore by the *Terrible's* boats. There was the usual amount of excitement when the end made its appearance, and a good deal of cheering while the "Jacks" carried the end up to the Telegraph House. Messrs. Canning, Clifford and Field were successively chaired and applauded. The end was brought into the operators' room in presence of the Governor and Bishop of Newfoundland and others, and the cable was soon ascertained to be perfect. It was then given up to Mr. Laws to test on behalf of Mr. Latimer Clark. He remained on shore all night taking tests.

(After the official tests had been made and the test messages sent, the cable was handed over to the Anglo-American Telegraph Company, and thus terminated the expedition, which forms a most important epoch in the annals of submarine telegraphy. The data for this cable when handed over was:—

Length laid	1,896 knots.
Average depth	1,900 fathoms.

Mean temperature by resistance of copper conductor 41° Fahrenheit.)

"*Sunday, September 9th.*

"All last night it blew almost a gale, affording us a prospect of but poor weather for our start to-day. However we managed by 3 o'clock p.m. to weigh anchor, and bid farewell to Heart's Content, steaming out of the Harbour amidst the cheers of the *Terrible* and the *Medway*. Mr. Field when he left the *Great Eastern* came in for three hearty cheers from our crew. The wind had somewhat quieted, but the sea was still rough."

It was agreed that the *Great Eastern* should go to Liver-

pool to be cleaned on the "gridiron," and on our way thither several entertainments were arranged for our evening's amusement; one of these took the form of a theatrical performance. The play was entitled "Contentina," and will be found in extenso in Appendix D.

On our arrival in England all the "cable layers" were fêted and made much of. At a banquet given to them in Liverpool it was announced by Lord Stanley (now Earl Derby) who presided, that Her Majesty would confer the honour of knighthood on Messrs. Glass, Canning, Thomson and Anderson; and a baronetcy on Mr. Daniel Gooch and Mr. Curtis Lampson.

On the 19th February, 1867, I received the following letter:—

"American Chamber of Commerce,
Liverpool, *February 18th*, 1867.

"Dear Sir,—The American Chamber of Commerce of Liverpool being desirous of commemorating the successful completion of the Atlantic Cable between England and America, resolved in September last to present Gold Medals to yourself, Sir Samuel Canning, Sir James Anderson, and Mr. Cyrus W. Field, as representing the enterprise.

"The Medals are now ready, and it is proposed that they should be presented at a banquet to be given by the Chamber at Liverpool on the 14th of March next.

"I have ascertained that this day will suit the convenience of Captain Sir James Anderson and Mr. Cyrus W. Field, and I shall be obliged if you will let me know as early as possible whether you will be able to honour the Chamber with your presence at the time proposed, or if not, what

other day in that week will suit you, as Sir James Anderson and Mr. Field leave England in the following week.

"I remain,

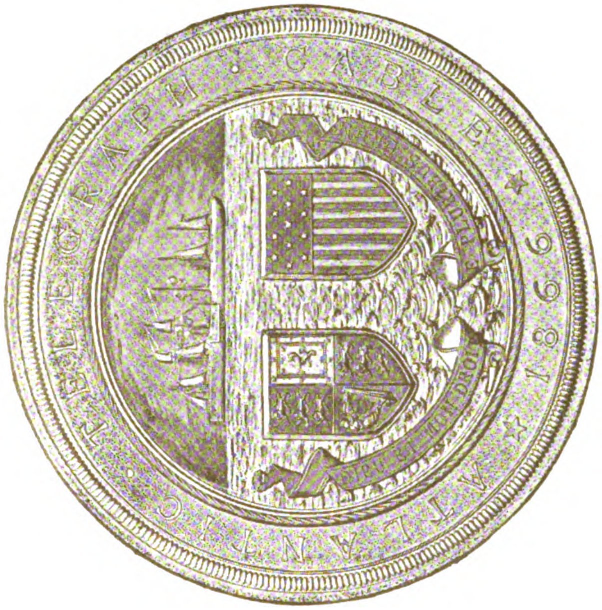
"Yours truly,

"HENRY W. GAIR, President.

"WILLOUGHBY SMITH, Esq.,
"Anglo-American Telegraph Co.,
"London."

And at the banquet, Gold Medals specially designed were presented to Mr. Cyrus Field, Captain Sir James Anderson, Sir Samuel Canning, and myself.

Engravings of both sides of this medal, are here given, and also a reduced facsimile of the illuminated address presented by the Liverpool Chamber of Commerce.


ATLANTIC TELEGRAPH CABLE
1866


PRESENTED BY THE AMERICAN CHAMBER OF COMMERCE, LIVERPOOL
TO
WILLOUGHBY SMITH

To

Cyrus W. Field, Esqre. — Professor William Thomson

Samuel Canning, Esqre. — Willoughby Smith, Esqre.

Henry Clifford, Esqre. — Staff Commander Moriarty, R.N.

Captain Anderson.

And the other Executive Officers connected with the successful laying of

THE ATLANTIC CABLES

The President and Council of the Chamber of Commerce

Beg to convey to you, on behalf of the entire Mercantile [illegible] congratulations upon the success of the great undertaking [illegible] England and America by the Atlantic Telegraph Cables.

They desire to convey their profound admiration of the [illegible] undaunted perseverance which, in spite of difficulty, discouragement [illegible] every obstacle, and brought to a successful conclusion one of the grandest [illegible]

Liverpool is especially concerned in your success. [illegible] Empire, her wealth and importance are closely connected with the [illegible] Trade with America.

She esteems it, therefore, a happy circumstance that the Community [illegible] interested in your labours should be the first to welcome you on your return to England [illegible] express those feelings of admiration which your services have so richly earned.

It is her fervent hope that the increased facilities of [illegible] secured may not only multiply the [illegible] augment the wealth of both, but by bringing the [illegible] of prejudice and misconception may bind them together [illegible] reciprocal goodwill.

Signed on behalf of the Liverpool Chamber of Commerce.

Liverpool, 20th September, 1866.

To

Cyrus W. Field, Esq^re. Professor William Thomson.
Samuel Canning, Esq^re. Willoughby Smith, Esq^re.
Henry Clifford, Esq^re. Staff Comd^r. Moriarty R.N.
Captain Anderson.

And the other Executive Officers connected with the successful laying of

THE ATLANTIC CABLES

The President and Council of the Chamber of Commerce

Beg to convey to you, on behalf of the entire Mercantile Community of Liverpool, their heartfelt congratulations upon the success of the great undertaking in which you have been engaged of uniting England and America by the Atlantic Telegraph Cables

They desire to convey their profound admiration of the nautical skill, scientific ingenuity, and undaunted perseverance which, in spite of difficulty, discouragement, and failure, have triumphed over every obstacle, and brought to a successful conclusion one of the grandest enterprises of modern times

Liverpool is especially concerned in your success. Pre-eminently among the Cities of the Empire, her wealth and importance are closely connected with the maintenance and expansion of the Trade with America.

She esteems it, therefore, a happy circumstance that the Community which is most vitally interested in your labours should be the first to welcome you on your return to England, and to express those feelings of admiration which your services have so richly earned

It is her fervent hope that the increased facilities of intercourse which your exertions have secured may not only multiply the Commercial Relations between England and America, and so augment the wealth of both, but by bringing the Nations into closer contact and removing the causes of prejudice and misconception, may bind them together by the enduring ties of mutual respect and reciprocal goodwill.

Signed on behalf of the Liverpool Chamber of Commerce,

Charles Ed: Rawlins Jr

VICE PRESIDENT

Liverpool, 20th September, 1866.

CHAPTER XIV.

"Hooper's Core"—Avlona Cable lifted—Death of Col. Stewart—Malta and Alexandria Repairs—Comparison of B.A. and Siemens' Units—Cable for Persian Gulf—1865—Behring Sea Cable—Diagram—Working of Submarine Cables—Valentia—Experiments at Malta—Letters on the Subject —1866—Business slack—Presentation—Mr. Hooper's Patent—Proposed Purchase—Hooper *v.* Elliot—Placentia and Sydney Core—Capt. S. Osborn—1866 Atlantic Cable—Broken and Repaired—Data for Placentia Core—S.S. *Chiltern*—Data for Cable when laid—Atlantic Cable again Broken—Cable in West Indies—Death of Seven Members of Staff—Atlantic Cable Repaired—Mr. Huxley's Report on Piece of 1851 Dover and Calais Core.

My wish to give an uninterrupted account of these two expeditions has caused me once more to carry my readers somewhat too far ahead of other subjects worthy of note. I must therefore ask them to retrace their steps and to be patient while I enter into further particulars.

In "Hooper's Core" the conductor was of tinned copper, around which were lapped tapes of pure india-rubber, over which again were lapped tapes of india-rubber containing a certain quantity of oxide of zinc, and called the "separator." Over the separator were lapped tapes of india-rubber containing a known proportion of sulphur, and this last covering was called the "jacket." When a certain length was completed it was coiled in a cylinder and vulcanised in the usual way, the object of the separator being to prevent the pure rubber from becoming vulcanised. It was said by many recognised authorities that the inductive capacity of this core, as compared with that of gutta percha, was 35 per cent. lower, while its insulation was as 1 to 50 higher;

also, that it was unaffected by a temperature that would cause gutta percha to become plastic and flow like tar; therefore it was the only known core suitable for warm climates, while its high insulating qualities were invaluable, as they enabled minute faults to be detected should they occur during the manufacture of the cable. In tensile strength it was lower than gutta percha, and had only been manufactured in comparatively short lengths; in fact, it was a new and untried core, and, like all rubber cores hitherto tried, pressure and age did not improve its insulation; still its many good qualities warranted the attention it was receiving.

On June 8th, 1864, Mr. Hooper presented a letter from Mr. Glass to the Manager of the Gutta Percha Works, requesting him to assist Mr. Hooper in every way to test his wire under pressure; consequently, Mr. Hooper sent two lengths of his core, wound on two iron reels, for experiment.

The lengths were said to be as follows:—

No. 1 . . 2,289 yds. No. 2 . . 1,686 yds.

They tested well under all sorts of conditions and varied temperatures, and on the 24th June I informed Mr. Glass that the resistance of Hooper's wire was very high, and that I thought they should direct their attention more to the durability of the material when made into a cable than to its electrical qualities, which in its then state were all that could be wished. I also called his attention to the fact that the 20 knots of core made by Messrs. Hall and Wells, covered by Henley with iron wires, and sent by Government about two years since to the Persian Gulf, was now lying there in a very faulty state, the rubber having become semi-fluid. A sample of this core which I had in my pos-

session appeared to be as good as when first made, but a piece of the same core, bound with tarred yarn as serving and with iron wires, showed evident signs of decay between the copper and rubber.

It was thought a great thing in the annals of submarine telegraphy when, in September, 1864, the news arrived that Mr. Henley had lifted and repaired the Avlona cable in 565 fathoms.

I should mention that Colonel Stewart, a man well known in connection with the Persian Gulf cable and the Indian lines, died January 17th, 1865, at Constantinople.

In February, 1865, 50 knots of old core, of all sizes and in every condition, were supplied to Mr. Henley to make into a cable to repair the Malta and Alexandria line, and in the July following a cheap core, made by using the common gutta percha, was manufactured at the Gutta Percha Works for 100 knots of cable, also to repair this same line.

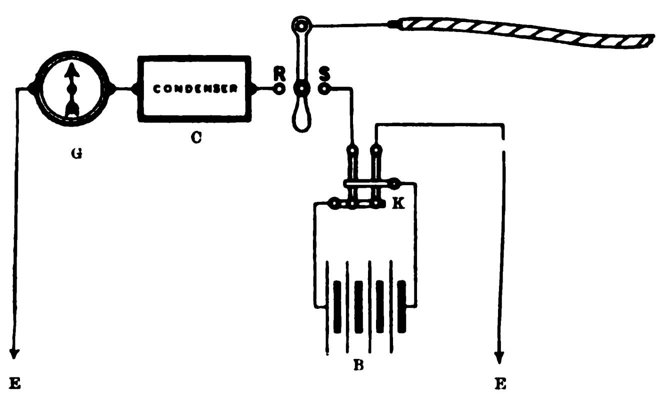
In March, 1865, while Mr. Sabine was at the Gutta Percha Works testing 160 knots of core for Messrs. Siemens & Co., of Charlton, he compared the B.A. unit with one of Siemens', and made it ·046 higher.

In October, 1865, 170 knots more cable were made for the Persian Gulf, the conductor being a solid wire and not segmental.

The failure of the attempt in 1865 to lay a cable across the Atlantic revived a scheme for laying one across the Behring Sea, consequently 560 knots of 14 strand wire, doubly covered to No. 1, were made at the Gutta Percha Works, and Mr. Henley covered it in the usual way with hemp serving and iron wire. Mr. J. R. France, who was then engineer to the Submarine Telegraph Company, superintended the making of this cable. It was coiled on board the sailing ship *Egmont*, and left for its destination in

March, 1866; but owing to the great success attending the Atlantic expedition of that year it was not laid, and after an absence of three years was returned to Mr. Henley's Works, looking, mechanically, none the worse for the many vicissitudes it had experienced; its electrical condition, however, was not so healthy as when it was first manufactured.

On my return from Heart's Content, in 1866, I arranged the working of the cables in the way shown in the following diagram:—



In which C shows the condenser, the electrostatic capacity of which was equal to 75 knots of the cable, G receiving galvanometer, S switch, K ordinary reversing key, and B battery of ten Menotti cells.

The arrangements were the same at each end of the cable. When not working, the switch S at each station was turned to the contact marked "receive," so that each end of the conductor would be connected to a condenser. The operator at either station wishing to speak, would "switch over" to the stud marked "send," and commence sending

reversals by the key K, to represent the usual call signal; then "switch over" and wait until he received the reply to his call, when he would again "switch over," and send what he had to communicate. A room in the cable house at Foilhummerum, Valentia, was occupied by the representatives of the Telegraph Company, who used to send the messages from there to London by what was called "a land line," and a Morse instrument. On one occasion during my stay at the cable house all had been at a standstill, owing to a break down somewhere on the American side of Heart's Content, and in consequence of this, one evening a special messenger arrived at the cable station there with a large batch of accumulated messages. Here was a good opportunity for a trial of systems and speeds in sending and receiving, of which the operators were not slow to avail themselves, being justly proud of their skill, while each warmly upheld the superiority of his own system.

The distance from Valentia to London was only about one-fourth of that of the length of the cable from Valentia to Heart's Content; but still the race was on equal terms, and in sporting phraseology the mirror won in a canter, the contrast between the systems being as great as if a good cart horse were entered for the Derby with an idea that he could beat the thoroughbreds.

On my return from Valentia, the Malta and Alexandria cable having given some trouble, I was requested to proceed to Malta to ascertain whether my system as used on the Atlantic cables could be applied in working this cable from there direct to Alexandria. I therefore sent my able assistant, Mr. J. May, to Alexandria, and I on the 1st December presented the following letter to Mr. Gibson at Malta:—

"TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY, 20*th November*, 1866.

"GEORGE GIBSON, ESQ.

"DEAR SIR,—

"This will introduce you to Mr. Willoughby Smith, this Company's electrician, who comes out for the purpose of making some experiments with a view to working the Malta and Alexandria line in one unbroken length. I will therefore thank you to place the line in his hands at such times and for such periods as Mr. Smith may desire, and also to instruct the staff to follow out any instructions he may give.

"I am, dear Sir, yours truly,

"GEORGE ELLIOT,

"*Managing Director.*"

For the information of the Directors of the Telegraph Construction and Maintenance Company, I on the 8th December wrote to Mr. Shuter, the Secretary, as follows:—

"MALTA, *December* 8*th*, 1866.

"MY DEAR SIR,—

"The break in the line off Res-sem was repaired yesterday, when Mr. Saunders informed Mr. Gibson that he thought it best to start at once for Alexandria for coals, and also to get a more accurate test of the fault still in the line about 240 miles from Alexandria.

"As B.G. could not work to AX with ordinary battery, I instructed them to increase battery to twenty cells, which power enabled them to work the Morse.

"The line was put direct through from here to AX for two hours last evening, and we worked first-rate with ten cells, the sigs. being quite equal to those on the A.T.C.

"I learn from Mr. Gibson this morning that the line is

opened to the public, and as the clerks have been on duty all night they are not in good condition for further experiment with the new system to-day, but I will endeavour to get them to practise this evening. There are only two clerks at this station, Brown and Stevenson, two very good men.

"I am much pleased with the result of my experiments, and am sure there would not be any difficulty in working a line of much higher resistance direct between here and Alexandria. From what I learn here I feel confident the present line will always be giving trouble between B.G. and AX owing to the nature of the bottom, &c.

"I have no authority to give instructions for the new system to be adopted here, therefore I assume that after I have completed my experiments, and satisfied Mr. Gibson that the line can be so worked, I can return home.

"Yours very truly,

"WILLOUGHBY SMITH."

On December 14th I wrote the following letter to Mr. Shuter:—

"MALTA, *December* 14*th*, 1866.

"MY DEAR SIR,

"Mr. Gibson's telegram will have informed you of the break in the cable which occurred on Sunday last, about 230 miles from Alexandria. I have been busy experimenting with Tripoli and B.G. They were working direct with B.G. yesterday at the rate of seven words per minuté with a cell constructed for the occasion, equal in tension to 0·012 of an ordinary Siemens' cell as used here for working the Morse. In fact, the greatest difficulty I had was to get B.G. to reduce the tension to give readable signals. There being no mirror gal. at B.G., I could not

work to them by the same means, but Smith at Tripoli has constructed a mirror gal. and they have been sending to and receiving from him to-day at a good speed, with the tension mentioned above.

"I hope the cable will soon be through to AX, as there are a few more experiments I wish to make direct with that station before I return home.

"Mr. Gibson and the clerks here are much taken with the simplicity of the new system.

"I have not been able to communicate with Saunders yet, and therefore do not know his views upon the subject, but I suppose he saw May at Alexandria, who would explain all to him.

"I can but again remark, that there would be no difficulty in working a line at a good speed direct between here and Alexandria, with a much smaller conductor than that of the present cable. A new section, with a core something like the old 'Red Sea' cable, joined to the present cable at a suitable point between Tripoli and B.G., and laid in deep water to Alexandria, would ensure, I think, permanent communication. Tripoli could still be retained as a station. All the old cable could be recovered, the core of which would be worth, to the Company, about £70 per mile. As recovered the cable could be cut into yard lengths, and the core withdrawn and stowed away in bundles, while the iron could be thrown overboard or sold here. Labour is cheap, and when the line is perfect the *Hawk* would have nothing to do. I offer these suggestions as I fear the present B.G. and AX section has suffered too much from constant repairs and the wash of the sea ever to remain long in working order.

"Yours very truly,

"WILLOUGHBY SMITH."

On my return from Malta, early in the following January, I found business very slack at the Gutta Percha Works, and at the City office all appeared dull and gloomy, contrasting sadly with the jubilant spirit prevailing before I left, owing to the success of the Atlantic expedition.

On January 11th, 1867, the men and boys engaged at the Gutta Percha Works were each presented with a sovereign, and a Bible containing the following inscription :—

Presented to

————————

by

HENRY BEWLEY AND HENRY FORD BARCLAY

On the occasion of the Transfer of the

Gutta Percha Company's Works

to

The Telegraph Construction and Maintenance Company (Limited),

1866.

About this time rumours were being circulated among the staff of the Telegraph Construction and Maintenance Company, to the effect that Mr. George Elliot was endeavouring to persuade his co-directors to purchase Mr. Hooper's patent and plant, while admitting him as one of their colleagues, and this rumour was received by many members of the staff with expressions of a decidedly unparliamentary character.

On February 12th, 1867, I was at Valentia making experiments, and in a letter I sent from there to Mr. Chatterton, the Manager of the Gutta Percha Works, in reply to one I had received from him, I said, "I think you thoroughly know my views, and when speaking upon the subject can safely affirm that I endorse all you say. I do not agree with Thomson when he states that it required the experience of 1866 to prove the superiority of gutta percha over india-rubber. It appears from Bircham's

letter (Mr. Bircham was solicitor to the Company, and Mr. Chatterton had sent me his letter with a copy of Sir William Thomson's report on Mr. Hooper's cables), that the Company have agreed to take the patent and Hooper's stock, and the only question to settle is the amount of pay for the same. I fear that anything we may say will have but little influence in the matter."

Experience would seem to have taught Sir William Thomson to speak more approvingly of gutta percha; at least that was the impression I gleaned from the report above referred to, and from the evidence which he gave before the arbitrators on behalf of Mr. Elliot in the case of Hooper *v*. Elliot.

At Valentia good tests of the electrical condition of both cables were obtained with very satisfactory results. The gutta percha resistance, after ten minutes' electrification, was in each case 14,000,000 B.A. units per knot.

My experiments terminated abruptly, as I was recalled to give evidence in the case of "Hooper *v*. Elliot," and there I heard what seemed to me extraordinary statements. Mr. Hooper, in his evidence, said that Mr. Elliot was first introduced to him by Mr. Cyrus W. Field in the summer of 1863, when he told him that although Glass, Elliot and Co. were the largest customers of the Gutta Percha Company, that firm would not allow them a larger discount than they did to others; therefore they had lost the contract for the Persian Gulf cable, and intended to bring the Gutta Percha Company "to book" by entering into an agreement with Mr. Hooper to use his core. Able counsel argued on both sides, experts were examined, and the inquiry lasted thirteen days, but I have forgotten, if I ever knew, how the arbitrators settled the case; however it may have been, Mr. Hooper never was a director of the Telegraph Con-

struction and Maintenance Company, and that Company never supplied his core.

On March 8th, 1867, the core of a cable to be laid from Placentia to Sydney was commenced at the Gutta Percha Works, and about this time Captain Sherard Osborn became the Managing Director of the Telegraph Construction and Maintenance Company.

On May 17th, 1867, the Atlantic Cable broke, about three miles from Heart's Content; it was suggested that an iceberg had grounded and severed it, and this solution did seem as feasible as many that were propounded. The Telegraph Construction and Maintenance Company's S.S. *Chiltern* left on June 4th to repair the mischief, arriving at her destination on June 16th, and on the 19th the cable was repaired, and the following message sent through it:—

"COLLETT TO DEANE.

"Have put in 616 fathoms new shore end, 123 fathoms picked up taper. The splice to main cable made in taper. Picked up altogether about 420 fathoms taper. Faulty part picked up is about 20 fathoms small taper all crushed together."

It was announced in the *Times* of July 22nd that the 1866 Atlantic cable had again broken about 50 knots from Heart's Content, and about this time Mr. C. F. Varley strongly advised the use of Hooper's core instead of gutta percha for Indian cables.

The S.S. *Chiltern* left Greenwich, August 12th, 1867, with the Placentia and Sydney cable; owing to there not being sufficient gutta percha in stock from which to select the electrical qualities necessary, much trouble was caused, and Messrs. Bright and Clark, who tested the cable on behalf of the American company for whom it was made,

rejected many coils and joints on account of their low resistance.

The means per knot of the core were as follows:—

Conductor	150 lbs.
Gutta percha	230 „

Values per knot after 1′ at 75°.

Resistance of Conductor	8,958 B.A. units.
Resistance of gutta percha	455,000,000 B.A. units.
Inductive Capacity	·356 microfarads.

It left Greenwich in two sections, 154·515 knots and 166·886 knots respectively, but being dry in the tanks and the men at work fitting the eye of each, it was impossible to get reliable tests.

On August 27th, 1867, the *Chiltern* arrived at Placentia. Sir Samuel Canning laid this cable, the laid values of which were recorded as follows:—

	Placentia to St. Pierre.	St. Pierre to Cape Breton.
Total length of cable laid	112	189 knots.
Average depth	100	170 fathoms.
Mean temp. by copper resistance	42°	41½° F.

Electrical Values per knot after Laying.

Copper resistance	8·324 ohms.
Gutta percha resistance	5,278 megohms.

Sir Samuel Canning then went to repair the 1866 Atlantic cable. After the completion of the repairs to this cable in June last, the average copper resistance for the entire length (1,852 knots) was 7,238 units, which divided by the length, gives 3·908 units per knot. Therefore, if we divide the average of the first test (6·940 units) by 3·908, it will place the break 1,776 knots from this end, or 76 knots from Heart's Content. By the same reasoning the second test would place the break 1,793 knots from this end, or 59 knots from the other end, but I believe the first test to be the most reliable.

About this time Mr. Webb was laying for the India Rubber and Gutta Percha Company a cable in the West Indies, but it does not appear to have been a success, for the certificate was withheld, and seven of the staff died of fever. Two of the electrical staff, Messrs. Crooks and Medley, I knew well; they were young men who took far above the average interest in their work, and if death had not prematurely interrupted their career, they would certainly have excelled in their profession.

On September 10th, 1867, Mr. Lambert, one of Messrs. Bright and Clark's staff (who represented the company) tested the Atlantic cable from the Valentia end, and there commenced to watch for ship. The *Chiltern* arrived at Heart's Content on the following day, but the weather was too rough for her to proceed to the grappling ground. The distance of the break, as tested at the Heart's Content end was 81·9 knots; this would locate the injury at about the entrance to Trinity Bay. On this spot, when laying the cable, those on board the *Great Eastern* could not understand the erratic movements of the ships that were supposed to be showing the way, more especially as it was a dark night and their lights could only be seen at intervals, as they appeared to be moving round the "Big Ship" in preference to entering the harbour. It is fair to suppose that in consequence of this behaviour a lot of slack laid anyhow would be found at that spot. The cable was repaired on September 20th, but, owing to the tension put on the splice, the cable parted, one of the ends going overboard; this was soon recovered and the work completed, when the electrical conditions of the cable proved satisfactory.

On November 27th, 1867, Mr. J. R. France gave me a piece of the core of the Dover and Calais cable laid in 1851

in which a small white insect, not unlike a maggot, with many legs and prominent black eyes, had bored through the serving and the gutta percha in several places down to the copper; the serving was very rotten and of anything but an agreeable odour. Mr. Huxley's report on the subject was as follows:—

"JERMYN STREET, 14*th December*, 1867.

"MY DEAR CAPTAIN OSBORN,

"I am sorry to have very bad news for you. The animals contained in the little bottle which you left with me belong to the crustaceous genus *Limnocia*, the only species of which at present known, is famous for its power of devouring and destroying wood. It gave Stevenson infinite trouble when he was building the Bellrock Lighthouse. Its occurrence at so great a depth as 30 fathoms is a fact at present, I believe, unknown to naturalists. The grooves in the gutta percha are just such as the *Limnocia* makes. The most are superficial, but one I have examined goes vertically in, and the bottom of it is not a fortieth of an inch (at a guess) from the copper wire; a few hours' more work would have destroyed the insulation of the wire pretty effectually. Many means of prevention against the ravages of these animals have been suggested, among the rest white paint is said to be perfectly effectual. But I suppose the Company will lose no time in making some experiments upon this point. If you are getting up any more cable in this condition please to have a lot of the *Limnocia* put into a bottle of sea-water for me; they will live for several days.

(Signed) "M. HUXLEY."

The piece of core was found about two knots from the South Sand Head Lightship. I have never heard that the

cable has since been similarly attacked there or at any other place, nor have I heard of or seen anything like it in the experimental wire laid from Dover to Cape Grisnez in the previous year. As the iron wires had gone in parts, perhaps it was the tar and grease in the hemp that attracted this minute mischief-maker.

CHAPTER XV.

1868—Cable from England to New York—Death of Mr. Stewart—Anglo-Mediterranean Company—Cuba Cable—Cable from Malta to Alexandria—Cable Completed—Particulars of Laying, &c.—1866 Atlantic Cable—Induction in Land Wires—Specifications for French Atlantic Cable—Coverings of Cores—Tests—Reduction of Resistance—Improvement by Age—First Section—Brest to St. Pierre—Laying Commenced—Shore Station—Fault—Cable Cut and Buoyed—Discussion about Supposed Fault—Reduction of Battery Power—1′ Readings of Insulation—Laying Completed—Official Tests—Data for this Section—Summary of Laying—Section St. Pierre to Duxbury—Temperature—Earth Currents.

In January, 1868, the Anglo-American Company made experiments with a view to laying a cable direct from England to New York, should the Atlantic Telegraph Company succeed in their endeavours to take the Atlantic cables from them. The two cables joined as one, equalled a length of 3,900 knots, and gave about three words per minute, working as they then did; but, by attending to minor details, I estimated that a good commercial speed could be obtained, and that a minimum of nine words per minute through 3,000 knots of cable, which was the length required, could be relied on.

Mr. Stewart the Managing Director of the Anglo-American Company, died suddenly on February 19th, 1868, in the board room of that Company. He was a well-intentioned man, but lacked experience in telegraphy, and therefore, without doubt, his work was the more laborious to him, especially as at that time the Atlantic Telegraph Company was worrying the Anglo-American Company. Sir Richard Glass was his successor.

The Malta and Alexandria cable having given so much trouble, the Anglo-Mediterranean Company was formed in 1868 to lay a cable in deep water direct from Malta to Alexandria, and a core for this was commenced at the Gutta Percha Works.

On July 14th, 1868, it was rumoured that Sir Charles Bright had failed to lay the Cuba cable.

On August 3rd, 1868, the 1866 Atlantic cable again broke about the place were it was last repaired.

After the great success which had attended the Atlantic expedition of 1866, it might be supposed that the Telegraph Construction and Maintenance Company would bask in the sunshine of prosperity, but it was not so; dark and ominous clouds soon appeared to be gathering along their path, and for two years all was gloom and anxiety. Now, however, it seemed that brighter days were in store for them. They had sent their S.S. *Hawk* to repair the Atlantic cable, and their S.S. *Chiltern* to Malta with the shore ends of the Anglo-Mediterranean cable, which they had in hand; but more important still, they had just entered into a contract to make and lay the "French Atlantic Cable," for which work they would again employ the *Great Eastern.*

On September 26th, 1868, the laying of the cable for the Anglo-Mediterranean Telegraph Company commenced at Malta from the S.S. *Scanderia* and the S.S. *Chiltern*, accompanied by H.M.S. *Endymion;* Sir Samuel Canning had charge of the expedition, and I of the electrical department, in which I employed a similar system to that used in the 1866 Atlantic expedition. Sir Charles Bright represented the Company as both engineer and electrician.

When 620·77 knots had been very successfully laid a

truth in the report that serious faults had been found in it at Mr. Henley's Works.

I give the specifications for the French Atlantic cable in full, as I think they will be better understood than if they appeared in an abbreviated form.

SUBMARINE TELEGRAPH CABLE

BETWEEN

FRANCE AND THE UNITED STATES OF AMERICA.

SPECIFICATION No. 1

FOR THE

MANUFACTURE OF THE CABLE BETWEEN BREST AND ST. PIERRE.

Description of Cables to be laid.

The following description of Cables will be required, made to the undermentioned Specification :—

MAIN CABLE A.

CABLE A

	lbs.	lbs.
1. Core.—Copper 7-wire strand, weighing per knot	400	
Gutta percha and compound „ „	400	
	800	800
2. Serving.—A good and sufficient serving of jute yarn, well tanned		
3. Outer Covering.—10 galvanized homogeneous iron wires, of the aggregate weight of . . .		1,568
Each homogeneous wire to be enveloped in strands of Manilla or New Zealand yarn, steeped in tar, as hereafter specified, weighing in all not less than		1,450

4. The outer diameter not to exceed 1·1 inch.

SHORE END CABLES.

5. Shore ends next the Main Cable to have the same core as Cable A, covered with 12 B.B. galvanized iron wires ·238 inches diameter. The total weight of iron per knot to be not less than 11,160 lbs. CABLE B

6. The whole to be covered with two layers of hemp and asphalte, laid on as hereafter specified.

7. Heavy shore end laid next the landing-places. To have the same core as Cable A, covered with 12 B.B. galvanized iron wires, ·19 inches diameter, served with a sufficient quantity of tarred yarn to form a bedding for 12 strands, each formed of 3 galvanized iron wires, ·230 inches in diameter. The total weight of iron per knot to be not less than 38,000 lbs. CABLE C

8. The iron wire to be used in Cables B and C is to be of the quality known as best-best, free from inequalities, galvanized and annealed; a margin of 10 per cent. will be allowed in weight in any portion of the Cable, provided the average weight is as specified above. The wire to be capable of being bent round itself, and unbent without breaking. No wire of brittle quality shall be put into the Cables, and the Engineers or their assistants shall have power to reject any hanks which break in the closing machine, or which are of unsatisfactory quality. No weld shall be made in any of the iron wires or joint in the homogeneous iron wires within 12 feet of any other weld. Iron Covering.

9. Cable B is to be covered, after the iron wires are laid on, and before being coiled into the tanks, with two coatings of mineral pitch, and silica, in the proportions of 60 and 40 parts respectively, with sufficient mineral tar to give the requisite consistence, and with two servings of tarred hemp yarn, laid alternately, the first coating of the yarn being next the wires, then a serving of compound, then yarn again, and lastly compound. The compound to be applied hot, and the yarn is to be laid over immediately after its application. Such special precautions are to be taken against injury to the core, in case of the machinery stopping, as the Engineers shall direct. The yarn is to be everywhere covered by the compound, and the outside is to be smooth and regular. Asphalte Compound.

10. The wire used in the deep sea Cable (A) to be of the best quality of homogeneous iron, galvanized, having a tensile strength of not less than 750 lbs., to elongate not less than three per cent. before breaking, and to be equal in every respect to that used in the Atlantic Cable of 1866. The joints in the homogeneous iron wires to made by scarfing the ends, binding them with fine wires and soldering them. Homogeneous Iron for Cable A.

Serving round Wires of Cable A. 11. Each wire is to be served with the best quality of Manilla or New Zealand hemp, steeped in tar, and laid on in such a manner that the served wire shall have a strength equal to that of the Atlantic strand of 1865.

Strength of Cable A. 12. The completed Cable is to be capable of bearing on any portion of its length a weight of at least 7 tons, vertically suspended by it, without injury to the core between the fastenings or points of suspension, and shall not break with a less weight than 7¾ tons.

Taper Cable. 13. Each shore end to be finished off with a taper not less than ¾ of a knot in length for splicing on to the deep sea Cable, to be arranged to the satisfaction of the Engineers to the Company.

Conductor. 14. The conductor to consist of a strand of 7 wires of annealed copper of the best quality and manufacture, the resistance per knot at 75° Fahrenheit (24 Cent.), to be not greater than 3·25 B.A. units.

15. The interstices of the strand to be completely filled up with Chatterton's compound.

Insulator. 16. The Insulator to consist of the best quality of gutta percha used for the insulation of Cables, put on in four concentric layers or coverings of as near as may be equal thickness. Chatterton's compound to be laid on between the conductor and the first covering of gutta percha, and also between each of the coverings of G.P. in such a manner as to unite the G.P. coverings to the metallic conductor, and form a solid core, free from roughness and air-bubbles.

17. The resistance of the insulator at 75° Fahrenheit (24 Cent.) to be not less than 250 millions of B.A. units per knot fourteen days after manufacture, and after one minute's electrification.

18. The core when finished shall be capable of resisting the passage of water along the conductor when pressure of 600 lbs. per square inch is applied at one end of a specimen six inches long. This test shall be applied at the Contractor's expense whenever the Engineers may desire.

Joints in Core. 19. The JOINTS in the core are to be made by experienced workmen. Chatterton's compound is to be used next the conductor, between the layers of gutta percha and outside all. In every case one joint-maker is to be employed to join the conducting wire, and another to apply the insulating covering. No joint in the completed core at the Cable works is, under any circumstances, to be made except in the presence of inspectors, who will be appointed for this duty, and who will test and pass each joint. Sufficient time is to be allowed by the Contractor for this operation.

20. The joints, after they have been made six hours, shall test to the entire satisfaction of the Engineers.

Serving. 21. To consist of a good and sufficient serving of jute yarn, well tanned and applied wet; extreme care to be taken in its application.

22. The CORE shall be delivered for testing in lengths of not less than one knot. While being tested at the Gutta Percha Works, the core shall be immersed in water at the temperature of 75°, and shall have been previously maintained at that temperature for 24 hours. The lengths and weights of each coil shall be given. A margin of 5 per cent. over and under the specified weights shall be allowed, but the mean weight of the whole must be at least equal to the specified weight. **Testing and Inspection.**

23. All coils approved of by the Engineer shall be redelivered for further manufacture.

24. All coils shall be numbered, labelled, and registered, and the Engineers shall be kept cognizant of the portion of the Cable into which each knot of the core is inserted.

25. A separate and convenient room for testing the core and Cable, and suitable space for batteries, is to be provided by the Contractor, both at the Gutta Percha Manufactory and Sheathing Works, and all connections with the testing-rooms to be made at the Contractor's expense. The Contractor shall also provide a man to be in attendance on the Electricians testing the core or Cable.

26. During the covering of the core, and after the completion of the Cable, it may be tested by the Engineers at all reasonable times to be agreed upon.

27. Free access to the Contractor's Cable works shall be given, at all times, to the Engineers or persons whom they may appoint to inspect the manufacture of the Cable, and full liberty for examining and testing every part of the materials or manufactured Cable; all materials shall be liable to rejection.

28. The CORE shall be coiled on drums, and shall be kept under water until serving is begun. The drums to be carefully protected. The core when served to be coiled in water-tight tanks. **Storage of Core and Cable.**

29. The water is to be withdrawn by the Contractor from the tanks, and replaced if and so often as required by the Engineers.

30. The tanks and other parts of the manufactory where the Cable is manufactured or stored are to be roofed over.

31. Correct INDICATORS are to be attached to each closing machine, showing the exact amount of Cable manufactured, and the completed Cable is to be marked at every nautical mile in the usual manner. **Indicators.**

32. Every facility is to be provided by the Contractor for the shipment of the Cable, and no vessels are to be moored off his works during the shipment, in such manner as to interfere therewith. **Facility for Shipping.**

33. Any ADDITIONS or ALTERATIONS in the manufacture of the Cable, as described in this Specification, which may be required at any time by the Engineers during the progress of the work, are to **Alterations**

be made by the Contractor upon terms to be then agreed upon; or, in the event of difference, the price of such alteration is to be determined by arbitration in the usual manner.

Insurance. 34. The Contractor shall, at his cost, INSURE the Cable against risk of damage by fire to the full amount of the advances made; the policies to be effected in the name of the Concessionaires or of the intended Company and placed in their hands.

Time of Manufacture. 35. The MANUFACTURE SHALL COMMENCE twenty-one days after the date of the order to begin work and payment of the first instalment of the Contract sum.

Lengths of Cables. 36. The following is the approximate length of Cables that will be required; but these lengths may be modified from time to time by the Company or their Engineers, under Clause 33, provided due notice of the same be given to the Contractor.

Cable A.	2,643	Knots	Main Cable.
Ditto B.	127	,,	Shore Ends.
Ditto C.	18	,,	
Total	2,788	Knots.	

37. The foregoing includes a quarter of a mile of Taper Cable at the junctions of the Thick Cables with those of smaller diameter.

SUBMARINE TELEGRAPH CABLE

BETWEEN

FRANCE AND THE UNITED STATES OF AMERICA.

SPECIFICATION No. 2

FOR THE

MANUFACTURE OF THE CABLE BETWEEN ST. PIERRE AND THE UNITED STATES.

Description of Cables to be laid. The following description of Cables will be required, made to the undermentioned Specification:—

MAIN CABLE D.

CABLE D

	lbs.	lbs.
1. Core.—Copper 7-wire strand, weighing per knot	107	
Gutta percha and compound, „ „	150	
	257	257
2. Serving.—A good and sufficient serving of jute yarn, well tanned		
3. Outer Covering.—10 B.B. galvanized iron wires ·165 inches diameter, weighing per knot about . .		4,254
4. Outer Protection.—To be hemp and asphalte, laid on in two coatings		

SHORE END CABLES.

CABLE E

5. Shore ends next the main cable. To have the same core as Cable D, and to be covered externally with 12 B.B galvanized iron wires, ·238 inches diameter, the total weight of iron per knot to be not less than 11,160 lbs.

6. The whole to be covered with two layers of hemp and asphalte as hereafter specified.

CABLE F

7. Heavy shore end laid next the landing places. To have the same core and iron covering as Cable D, served with a sufficient quantity of tarred yarn to form a bedding for 12 strands each formed of 3 galvanized iron wires, ·230 inch in diameter; the total weight of iron per knot to be not less than 38,000 lbs.

Iron Covering.

8. The iron wire to be used in Cables D, E, and F is to be of the quality known as best-best, free from inequalities, galvanized and annealed; a margin of 10 per cent. will be allowed in weight in any portion of the Cable, provided the average weight is as specified above. The wire to be capable of being bent round itself, and unbent without breaking. No wire of brittle quality shall be put into the Cables, and the Engineers or their assistants shall have power to reject any hanks which break in the closing machine, or which are of unsatisfactory quality. No weld shall be made in any of the iron wires within 12 feet of any other weld.

Asphalte Compound.

9. Cable B is to be covered, after the iron wires are laid on, and before being coiled into the tanks, with two coatings of mineral pitch, and silica, in the proportions of 60 and 40 parts respectively, with sufficient mineral tar to give the requisite consistence, and with two servings of tarred hemp yarn, laid alternately, the first coating of the yarn being next the wires, then a serving of compound, then yarn again, and lastly compound. The compound to be applied hot, and the yarn is to be laid over immediately after its application. Such special precautions are to be taken against injury to the core,

in the case of the machinery stopping, as the Engineers shall direct. The yarn is to be everywhere covered by the compound, and the outside is to be smooth and regular.

Taper Cable. 10. Each shore end to be finished off with a taper not less than $\frac{1}{4}$ of a knot in length for splicing on to the deep sea Cable, to be arranged to the satisfaction of the Engineers to the Company.

Conductor. 11. The conductor to consist of a strand of 7 wires of annealed copper of the best quality and manufacture, the resistance per knot at 75° Fahrenheit (24 Cent.) to be not greater than 12·15 B.A. units.

12. The interstices of the strand to be completely filled up with Chatterton's compound.

Insulator. 13. The Insulator to consist of the best quality of gutta percha used for the insulation of Cables, put on in three concentric layers or coverings of as near as may be equal thickness. Chatterton's compound to be laid on between the conductor and the first covering of gutta percha, and also between each of the coverings of G.P. in such a manner as to unite the G.P. coverings to the metallic conductor, and form a solid core, free from roughness and air bubbles.

14. The resistance of the Insulator at 75° Fahrenheit (24 Cent.) to be not less than 250 millions of B.A. units per knot 14 days after manufacture, and after one minute's electrification.

15. The core when finished shall be capable of resisting the passage of water along the conductor when pressure of 600 lbs. per square inch is applied at one end of a specimen 6 inches long. This test shall be applied at the Contractor's expense whenever the Engineers may desire.

Joints in Core. 16. The JOINTS in the core are to be made by experienced workmen. Chatterton's compound is to be used next the conductor, between the layers of gutta percha and outside all. In every case one joint-maker is to be employed to join the conducting wire, and another to apply the insulating covering. No joint in the completed core at Cable Works is, under any circumstances, to be made, except in the presence of inspectors, who will be appointed for this duty, and who will test and pass each joint. Sufficient time is to be allowed by the Contractor for this operation.

17. The joints, after they have been made six hours, shall test to the entire satisfaction of the Engineers.

Serving. 18. To consist of a good and sufficient serving of jute yarn, well tanned and applied wet; extreme care to be taken in its application.

Testing and Inspection. 19. The CORE shall be delivered for testing in lengths of not less than one knot. While being tested at the Gutta Percha Works, the core shall be immersed in water at the temperature of 75°, and

shall have been previously maintained at that temperature for 24 hours. The lengths and weights of each coil shall be given. A margin of 5 per cent. over and under the specified weights shall be allowed, but the mean weight of the whole must be at least equal to the specified weight.

20. All coils approved of by the Engineers shall be redelivered for further manufacture.

21. All coils shall be numbered, labelled and registered, and the Engineers shall be kept cognizant of the portion of the Cable into which each knot of the core is inserted.

22. A separate and convenient room for testing the core and Cable, and suitable space for batteries, is to be provided by the Contractor, both at the Gutta Percha Manufactory and Sheathing Works, and all connections with the testing-rooms to be made at the Contractor's expense. The Contractor shall also provide a man to be in attendance on the Electricians testing the core or Cable.

23. During the covering of the core, and after the completion of the Cable, it may be continually tested by the Engineers.

24. Free access to the Contractor's Cable works shall be given, at all times, to the Engineers or persons who they may appoint to inspect the manufacture of the Cable, and full liberty for examining and testing every part of the materials or manufactured Cable; all materials shall be liable to rejection.

25. The CORE shall be coiled on drums, and shall be kept under water until serving is begun. The drums to be carefully protected. The core when served to be coiled in water-tight tanks. **Storage of Core and Cable.**

26. The Cable, when completed, is to be coiled under water in suitable water-tight tanks, so situated that it can be afterwards, at all tides, coiled on board vessels drawing twenty feet of water. The water is to be withdrawn by the Contractor from the tanks and replaced, if and so often as required by the Engineers.

27. The tanks and other parts of the manufactory where the Cable is manufactured or stored are to be roofed over.

28. Correct INDICATORS are to be attached to each closing machine, showing the exact amount of Cable manufactured, and the completed Cable is to be marked at every nautical mile in the usual manner. **Indicators.**

29. Every facility is to be provided by the Contractor for the shipment of the Cable, and no vessels are to be moored off his works during the shipment, in such manner as to interfere therewith. **Facility for Shipping.**

30. Any ADDITIONS or ALTERATIONS in the manufacture of the Cable, as described in this Specification, which may be required at any time by the Engineers during the progress of the work, are to be made by the Contractor, upon terms to be then agreed upon; or, **Alterations.**

n the event of difference, the price of such alteration is to be determined by arbitration in the usual manner.

Insurance. 31. The Contractor shall, at his cost, INSURE the Cable against risk of damage by fire to the full amount of the advances made; the policies to be effected in the name of the Concessionaires or of the intended Company, and placed in their hands.

Time of Manufacture. 32. THE MANUFACTURE SHALL COMMENCE twenty-one days after the date of the order to begin the work, and payment of the first instalment of the contract sum.

Lengths of Cables. 33. The following is the approximate length of Cables that will be required; but these lengths may be modified from time to time by the Company or their Engineers, under Clause 30, provided due notice of the same be given to the Contractor.

Cable D,	700	Knots.
Ditto E,	54	„
Ditto F,	22	„
Total .	776	Knots.

34. The foregoing includes a quarter of a mile of Taper Cable at the junctions of the thick Cables with those of smaller diameter.

SUBMARINE TELEGRAPH CABLE
BETWEEN
FRANCE AND THE UNITED STATES OF AMERICA.

SPECIFICATION No. 3
FOR THE
SHIPPING, TRANSPORT, AND LAYING OF THE CABLE BETWEEN BREST AND ST. PIERRE.

Destination. 1. The Cables described in the Specification No. 1 of equal date with this, shall be shipped from the Contractor's works, conveyed to the neighbourhood of BREST or ST. PIERRE, and laid between such points of the coast as may be hereafter selected by the Engineers.

Shipping. 2. The Cables shall be shipped from the Contractor's works with such machinery and in such manner as shall be approved of by the

Company's Engineers, or, in case of difference with the Contractors, Mr. John Penn to decide. The Cable B shall receive, at the same time, a thorough coating of chalk and water.

3. The Contractor to supply, at his own expense and risk, the necessary steam tonnage, including coals, crew, and all supplies and wages, and fit the steamer or steamers out with all necessary approved machinery and appliances (including all electrical instruments and batteries) for laying the Cable, buoying it, picking it up, &c., &c. The machinery and appliances to be approved by the Company's Engineers or, in case of difference, shall be such as shall be approved by Mr. John Penn. Steamers for laying, &c.

4. The steamers to be fitted up with good and sufficient water-tight Cable tanks, thoroughly secured.

5. No Cable shall be shipped until the fitness of the hold shall have been certified by the Engineers or their Inspector. Every knot of Cable when put on board shall be carefully marked with a tally on which the number of the knot shall be stamped.

6. Previous to the departure of the Expedition, the Engineers of the Company, and of the Contractor shall mutually agree upon the course over which the several Cables shall be laid, and the positions in which the different sized Cables shall be placed. After such decision is come to, no deviation shall take place without the mutual consent of the above-named parties. Course over which Cable is to be laid &c.

7. The Engineers of the Company to select the several landing places, in conjunction with the Contractor's Engineer or Agent. Landing Places.

8. During the laying the Engineers of the Company shall be consulted by the Contractor's Engineer as to the proper amount of slack to be laid, and the retarding strain to be put upon the Cable; also the speed of paying-out, and all other incidental questions that may arise during the process of paying-out the Cable or hauling back, should such latter be found necessary; but the ultimate decision shall remain with the Contractor's Engineers. Such agreement or acquiescence of the Company's Engineers is in no way to relieve the Contractor of any responsibility. The Engineers to have the right of having communication with the shore forwarded through the Cable at reasonable times during the laying. Laying.

9. During the laying an accurate log must be kept by the Contractor's Engineer, on a form to be approved of by the Company's Engineers, and copies of this log to be at all times open to the inspection of the Company's Engineers, who shall be furnished with all necessary information for filling up a similar log during the progress of paying-out.

10. The position of the ship shall be accurately determined by observations as often as possible during the paying-out of the

Cable, and the course marked down on the best published chart of the Atlantic.

41. In four different places, to be mutually agreed to by the Engineers of the Company and Contractor, about 3 knots of slack shall be laid, in a zig-zag course, to facilitate the picking-up and testing of the Cable, should such ever become necessary.

Acceptance of Cable.

12. The Cable shall, on its completion, be handed over to the officers of the Company for their use and inspection.

Testing.

13. Every facility shall be afforded to the Engineers and their assistants to test every part of the Cable during shipment and transport. During the laying, the testing shall be in the hands of the Contractor, but shall be open to the continual inspection of the Engineers or their assistants on board ship and on shore. The principle of testing to be the same as adopted in laying the Atlantic Cable of 1866, or any improvement that may be agreed upon. The condition of the Cable when laid shall be such, that the tests of the conductor and insulator shall give no reasonable ground for believing that any deterioration or defect exists. The decision of the Engineers to be binding, with an appeal to Sir William Thomson in case of disagreement.

14. Should the Contractor fail to complete the Line, or should the tests of the Line when completed be unsatisfactory, the Contractor shall hand over all spare Cable remaining after the failure or abandonment of the Expedition.

Rejection.

15. The Engineers may decline to allow any portion of the Cable to be laid which is in their opinion damaged or unfit for use, and the Contractor shall replace any Cable damaged during shipment or transport.

Accommodation for Staff.

16. The Contractor shall provide accommodation and victualling for the Company's Engineers and staff (not exceeding ten) on board the ship laying Cable. This obligation shall extend over the whole time during which any of the vessels shall be employed in laying the Cable.

General Disbursements.

17. All disbursements whatsoever, necessary for carrying out the present Specification, shall be at the charge of the Contractor (unless where exceptions are specifically named), and he shall not be entitled to claim any allowance on account of delays, whether these arise from unavoidable causes or otherwise.

Insurance.

18. The Contractor shall, at his own cost, insure the Cable against risk by sea and fire during transport, and the policy shall be effected in the name of the parties of the first part, or of the intended Company, and placed in their hands.

Surplus Cable.

19. Any surplus Cable shall be delivered to the Company at some one station or stations to be agreed upon before the sailing of the

expedition from Brest, or, in case of difference, to be settled by Arbitration. The Contractors may ship, at their own risk, such lengths of Cable as they think fit, in addition to the specified lengths, and in case any of such additional Cable is paid out with the consent of the Company's Engineers, it shall be paid for in cash on completion of the Section, at the rate of £220 a mile, up to the sum of £20,000.

20. The Contractor shall, at his own expense and risk, at each landing place bury the Cable in a good and sufficient trench, if required, to the extent of 200 yards from high-water mark, in such a position as shall be pointed out by the Company's Engineers. **Land Connections and Stations.**

21. All further land connections shall be made at the expense and risk of the Company by their Engineers.

22. During the thirty days' tests, after the completion of the whole Line, the Contractor shall keep a suitable vessel for such repairs as may possibly be required. **Eventual Repairs after laying.**

23. Any additions or alterations to the contract for laying and transporting the Cable, or any alteration in the destination or length of the Cable, which may be required at any time during the progress of the work, shall be made upon terms to be then agreed on. **Alteration.**

SUBMARINE TELEGRAPH CABLE

BETWEEN

FRANCE AND THE UNITED STATES OF AMERICA.

SPECIFICATION No. 4

FOR THE

SHIPPING, TRANSPORT, AND LAYING OF THE CABLE BETWEEN ST. PIERRE AND THE UNITED STATES.

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1. The several Cables described in the Specification, No. 2, of equal date with this, shall be shipped from the Contractor's works, conveyed to the neighbourhood of St. Pierre, or the Coast of North America, between 40 and 45 degrees of N. latitude, and laid between such points of the coast in those neighbourhoods as may be hereafter selected by the Engineers. **Destination.**

Shipping.

2. The Cables shall be shipped from the Contractor's works with such machinery and in such manner as shall be approved of by the Company's Engineers, or, in case of difference with the Contractor, Mr. John Penn to decide. The Cable D shall receive at the same time a thorough coating of chalk and water.

Steamers for laying, &c.

3. The Contractor to supply at his own expense and risk the necessary steam tonnage, including coals, crew, and all supplies and wages, and fit the steamer or steamers out with all necessary approved machinery and appliances (including all electrical instruments and batteries) for laying the Cable, buoying it, picking it up, &c., &c. The machinery and appliances to be approved by the Company's Engineers, or in case of difference shall be such as shall be approved by Mr. John Penn.

4. The steamers to be fitted up with good and sufficient watertight Cable tanks, thoroughly secured.

5. No Cable shall be shipped until the fitness of the holds shall have been certified by the Engineers or their Inspector. Every knot of Cable when put on board shall be carefully marked with a tally on which the number of the knot shall be stamped.

Course over which Cable is to be laid, &c.

6. Previous to the departure of the Expedition, the Engineers of the Company and of the Contractor shall mutually agree upon the course over which the several Cables shall be laid, and the positions in which the different sized Cables shall be placed. After such decision is come to, no deviation shall take place without the mutual consent of the above-named parties.

Landing Places.

7. The Engineers of the Company to select the several landing places, in conjunction with the Contractor's Engineer or Agent.

Laying.

8. During the laying, the Engineers of the Company shall be consulted by the Contractor's Engineer as to the proper amount of slack to be laid, and the retarding strain to be put upon the Cable; also the speed of paying out, and all other incidental questions that may arise during the process of paying-out the Cable or hauling back, should such latter be found necessary, but the ultimate decision shall remain with the Contractor's Engineers; but such agreement or acquiescence of the Company's Engineers is in no way to relieve the Contractor of any responsibility. The Engineers to have the right of having communications with the shore forwarded through the Cable at reasonable times during the laying.

9. During the laying an accurate log must be kept by the Contractor's Engineer, on a form to be approved of by the Company's Engineers, and copies of this log to be at all times open to the inspection of the Company's Engineers, who shall be furnished with all necessary information for filling up a similar log during the progress of paying out.

10. The position of the ship shall be accurately determined by observations as often as possible during the paying out of the Cable, and the course marked down on the best published chart of the Atlantic.

11. The Cable shall, on its completion, be handed over to the officers of the Company for their use and inspection. Acceptance of Cable.

12. Every facility shall be afforded to the Engineers and their assistants to test every part of the Cable during shipment and transport. During the laying, the testing shall be in the hands of the Contractor, but shall be open to the continual inspection of the Engineers or their assistants on board ship and on shore. The principle of testing to be the same as adopted in laying the Atlantic Cable of 1866, or any improvement that may be mutually agreed upon. The condition of the Cable when laid shall be such, that the tests of the conductor and insulator shall give no reasonable ground for believing that any deterioration or defect exists. The decision of the Engineers to be binding, with an appeal to Sir Wm. Thomson in case of disagreement. Testing.

13. Should the Contractor fail to complete the Line, or should the tests of the Line, when completed, be unsatisfactory, the Contractor shall hand over all spare Cable remaining after the failure or abandonment of the Expedition.

14. The Engineers may decline to allow any portion of the Cable to be laid which is in their opinion damaged or unfit for use, and the Contractor shall replace any Cable damaged during shipment or transport. Rejection.

15. The Contractor shall provide accommodation and victualling for the Company's Engineers and staff, not exceeding ten, on board the ship laying the Cable. This obligation shall extend over the whole time during which any of the vessels shall be employed in laying the Cable. Accommodation for Staff.

16. All disbursements whatsoever, necessary for carrying out the present Specification, shall be at the charge of the Contractor (unless where exceptions are specifically named), and he shall not be entitled to claim any allowance on account of delays, whether these arise from unavoidable causes or otherwise. General Disbursements.

17. The Contractor shall, at his own cost, insure the Cable against risk by sea and fire during transport, and the policy shall be effected in the names of the Concessionaires or of the intended Company, and placed in their hands. Insurance.

18. Any surplus Cable shall be delivered to the Company at some one station or stations to be agreed upon prior to the sailing of the expedition from Brest; or, in case of difference, to be settled by arbitration. Surplus Cable.

knot length when first manufactured and immersed at 75° after 1′ electrification equalled :—

December	2	118,000,000 B.A. units.
„	3	167,000,000 „
„	5	201,000,000 „
„	23	236,000,000 „
„	30	251,000,000 „
January	1	262,000,000 „
„	19	267,000,000 „
„	23	268,000,000 „
February	23	322,000,000 „

Things did not go smoothly at Mr. Henley's Works; he had erected furnaces for the purpose of drawing rods and iron wire, thus making the place anything but suitable for the manufacture of submarine cables. A new test room had to be constructed, but still the constant movement of large masses of iron so affected the galvanometers that it was with difficulty that reliable data could be obtained.

This section was made in eight lengths and coiled in iron tanks placed above ground in the yard, and some of these tanks not being water-tight, it was no easy task to keep the cable immersed.

The faults which occurred during its manufacture were numerous, and the re-coiling and cutting caused thereby gave much anxiety and occupied much time.

The S.S. *Scanderia* and *William Cory* took this section, and on June 10th, 1869, the latter left for St. Pierre direct, while the former remained behind to accompany the *Great Eastern.*

The cable was coiled in the tanks on board the *Great Eastern* as follows :—

Fore tank	720 knots;	3·3 knots in each flake.
Main tank	1,114 „	7·25 „ „
After tank	921 „	4·25 „ „

Making a total of 2,755 knots.

On June 12th, 1869 the *Great Eastern* left the Medway for Portland, there to take in coal, &c. She was under the command of Captain Halpin, who on the former expeditions had been chief officer under Sir James Anderson, the latter gentleman accompanying us this time on behalf of the French Company.

On the eve of the departure of the *Great Eastern* from Portland, when those who were to take part in the expedition came on board, it was found that the engineers for the French Cable Company were represented by Messrs. Latimer Clark, Hockin, Fleming Jenkin, C. F. Varley, and M. Bertsch, together with their assistants.

The contractor's staff, with the exception of Mr. J. C. Laws, who, by permission of Mr. Latimer Clark, was to assist me in the electrical department, consisted of almost the same men as were employed on the 1866 expedition.

The shore end of the cable having been laid by the S.S. *Hawk* and *Chiltern* from a cable house erected by the sea, in close proximity to Port Minou, about ten miles from Brest, the *Great Eastern* proceeded to the buoyed end of the cable off that place.

In 1867 the *Great Eastern* had been engaged to carry passengers from France to America, on the occasion of the Orleans Exhibition, but the undertaking not having been a success, it was reported that if the vessel went to France most likely she would be seized for debt; she was therefore kept well out to sea and no visitors were allowed on board, although many came from Brest to inspect her.

Although the same system as that adopted in the 1866 Atlantic expedition was to be used, and I had every confidence in Mr. Joseph May, who was in charge of the shore station, I was sorry I could not visit it, as, by so doing, I could have understood at one glance more than could be

conveyed to me by any other means. On this occasion, especially, it was more than ever a matter of regret that I could not visit the shore station, as I had been informed that Sir William Thomson was not only to be umpire in case of dispute, but was to act there on behalf of the French Cable Company. This statement required explanation, for it was no secret that Messrs. Thomson, Varley, and Jenkin were in partnership and receiving royalties for working the mirror system. Whenever opportunity offered I had always spoken well of the mirror galvanometer, and given Sir William Thomson the fullest credit for its introduction, but I could not give the same credit to Mr. Varley for the condenser, as he certainly did not invent it, and was not the first to apply it in the working of submarine cables. As regards Mr. Jenkin, I could not at all see where he came in, unless under the assumption that union is strength. At any rate I should have liked to talk the matter over with Sir William, for it seemed to me, that according to the specification, the contractors were entirely in the hands of Messrs. Thomson, Varley, and Jenkin, and that to them they gave great power without the least responsibility.

Paragraph 8, Specification 3, says:—"Such agreement for acquiescence of the Company's engineers is in no way to relieve the contractors of any responsibility." Again in Paragraph 13 of the same document it says, "During the laying, the testing shall be in the hands of the contractors, but shall be open to the *continual* inspection of the engineers or their assistants on board ship and *on shore*. The decision of the engineers to be binding, with an appeal to Sir William Thomson in case of disagreement." (The italics are mine.) But enough of this! The shore end had been spliced to the main cable and paying-out commenced; no sooner, however, had shore begun to send signals to ship

through the 2,755 knots than confusion was caused by two signals being received for each one sent. This was found to be caused by the way the cable was coiled in the main tank, for there, attached to the bottom end of the coil, 869 knots in length, which would be the last coil paid out, was the ship's receiving galvanometer. On the top of this coil was one, 245 knots in length, from which paying-out was then going on. The top end of this latter coil was in connection with the instrument on shore. The consequence was that the first signal ship received was due to induction caused by the coils being one on the other, and the second signal was the true one that had passed through the entire cable. There was an appreciable time between the two signals. As the cable on the top coil was paid out, the amplitude of the induction signal gradually diminished, but did not entirely disappear until the last turn was removed. Taken as a whole the weather was not favourable, for during the entire expedition the wind and sea were at times very high, and the *Great Eastern* rolled sometimes to an extent that made testing almost an impossibility. Her course being east and west, when she rolled the coils of cable passed through the terrestrial magnetic line at their strongest point, and produced, by induction, a current which was sufficient to cause the beam of light, at the insulation galvanometer, to leave the scale as though a fault had occurred. This was the more to be regretted as several faults did occur which were found to proceed from punctures in the gutta percha similar to those which wrought such mischief in the 1865 Atlantic expedition. One of these faults developed itself in the midst of a gale in which it was found impossible to manœuvre the *Great Eastern* in the required way, and there was only just time to let shore know we were going to "cut and buoy" ere

it was done. The attendant ships, *Chiltern* and *Scanderia*, appeared to be having a very bad time. The former lost her life-boat, which was swept away; and both ships seemed more or less damaged. For two days the *Great Eastern* did nothing but steam about in the vicinity of the buoy, but on the morning of the third day the weather had sufficiently moderated to allow her to recommence operations. The cable and fault were soon regained and paying-out proceeded with.

On one occasion, after a longer time than usual had been occupied in sending and receiving, a marked difference was found to exist in the resistance of the gutta percha taken by the different currents. Mr. Jenkin insisted that this denoted a fault, consequently paying-out was stopped and a long and protracted discussion ensued. I objected to picking up as the insulation was high with either current, and there was no indication of a fault in the true acceptation of the term, although it was probable there soon would be if the ship held on the cable much longer; I maintained further that several causes might be assigned for the discrepancy noticed, independently of a fault. The testing and discussion had extended to nearly midnight, and the time for a final decision had arrived; when it was discovered that Sir Daniel Gooch had retired for the night. On going to his cabin he requested me to do what I thought best in the matter; therefore laying was recommenced under a protest from Mr. Jenkin, who spoke as "The Engineers."

There are times, and this was one of them, when it is desirable for those on whom a great responsibility rests, to concentrate all their thoughts on the testing, and in consultation with each other. Here such abstraction was found to be impossible; nothing could be said or done in

the test room without one of the Company's staff, note book in hand, demanding to know what was going on; a running comment upon its policy was kept up. Not only was this done, but frequent complaints were made by me, both to Mr. Jenkin and Mr. Varley, of the way in which they interfered in the test room during my absence.

As it was decided to continue to lay the cable Mr. Jenkin requested that the testing battery should be reduced to 20 cells, and not so frequently reversed "for fear of opening out the fault." This was agreed to, but as the laid length increased, the deflection became so low owing to the difference in temperature, that it was feared an incipient fault might pass unnoticed; it was therefore suggested that the battery power should be increased to 40 cells. Mr. Varley "would not object to 100 if necessary, but he did not think it was"; Mr. Clark "would meet me half way and say thirty," but Mr. Jenkin "would not consent to any increase," although the gutta percha resistance of the cable per knot was now 2,538 megohms, and messages were being sent and received at a speed of five and a half words per minute.

Soon after this, strong vibrations of the deflection on the insulating galvanometer took place, and I was informed that the fault, of which I would not admit the existence, had begun to show itself in a more marked form. Investigation, however, showed the vibrations to be caused by the battery altering its potential each time the sea struck the ship with sufficient force to give them a tremulous motion. It was found that the vibrations could be produced at will by merely tapping the shelf on which the battery stood. With precautionary arrangements this kind of vibration vanished and never reappeared.

Mr. Varley at this time informed Sir Daniel Gooch that

he had calculated, and found the existing fault in the cable to be 2,000,000 times smaller than the last one we recovered, but Sir Daniel Gooch told him it was immaterial what was said or thought, the cable was being laid under protest and only time could prove whose theory was correct. On July 12th, before cutting the cable, very careful one minute readings of the insulation galvanometer were noted with the slide of 350, and as this record will give some idea of how the beam of light wandered from the rolling of the ship, and other causes, I give it in full:—

Left.	Zero.	Right.
55	"	88
35	"	64
45	"	55
50	"	50
12	"	65
54	"	85
52	"	51
85	"	25

According to this the resistance per knot of the gutta percha was 5,381 megohms.

The weather being too foggy to give any hope of finding the buoy attached to the shore end, it was supposed that the *Great Eastern* had overrun the distance by four knots, and at 12.43 Greenwich time, having laid 2,552·66 knots, the cable was cut and buoyed, the *Great Eastern* groping her way into Placentia Bay.

On the following morning, on board the *Scanderia*, the shore end was spliced to the length of the main cable which was on board the *Great Eastern*, and that vessel laid several knots towards the *William Cory*, which was supposed to have the end of the main cable on board ready to splice. They had, however, lost the picked-up end, so the *Great Eastern* buoyed her end, and left the *William Cory*, *Scanderia*, and *Chiltern* to complete the work, while she

steamed to anchorage in Placentia Bay, just below the cable house. At 11.30 p.m. ship's time, on July 13th, the laying of the cable was completed and electrical communication established between the cable house near Brest and that at St. Pierre.

At 2.30 p.m. on the following day the official tests were commenced, in the presence of Messrs. Laws, Jenkin, Varley, Hockin, Bertsch, Willey, Theophilus Smith, Williamson, Fothergill, Betts (six of whom had notebooks), and myself. Messrs. Jenkin, Varley, and Hockin were busy tracing connections and entering them in books. A diagram of these connections had been offered to them, but had been refused, on the ground that they preferred tracing them themselves. I regretted that Mr. Latimer Clark was not present, as he was familiar with the behaviour of long cables. Sir William Thomson and staff were at the Brest end.

What are designated "earth currents" were interfering with the tests, but the most reliable, taken with 100 cells zinc to line, were as follows:—

Minutes.	Resistance per knot. B. A. units.	
1	2,202	approximate.
2	4,675	
3	4,905	
4	5,921	
5	8,142	and decreasing.
6	7,480	very steady.
7	4,144	
8	7,544	3 seconds before time.
9	7,415	good.

Mr. Latimer Clark came in later, but did not take part in the tests. At 9 p.m. Messrs. Jenkin, Clark, and Varley consulted together, and then said that the message to the Emperor might be sent, but Mr. Jenkin interrupted the message to send one as follows:—

"Jenkin to Thomas,

"We wish you to make two tests, one with copper and one with zinc to line for fifteen minutes each, after some messages have been sent."

The Emperor's message was then continued, and Messrs. Clark, Jenkin, and Varley left to walk to the town of St. Pierre, promising to return at daylight to resume tests. In a few minutes Mr. Jenkin returned to request that if the fault should develop we would discontinue using the cable; he also said that he had left Mr. Hockin to record all that was done. The night was principally passed in sending and receiving messages, but on the return of Mr. Jenkin late on the following morning he said he had had sufficient testing and was going to experiment as to speeds, so at 11.19 a.m. he sent the following message:—

"Jenkin to Thomson or May,

"Please send regular dots for one minute at sixty per minute; note battery and condenser."

About noon Sir James Anderson came in and said that the experiments must be terminated as the whole expedition was being kept waiting, but Messrs. Jenkin and Varley continued for over one hour longer before the cable was handed over to the company.

My notes concerning the data of this cable are as follows:—

Means of the core per knot after twenty-four hours at 75° and 1′ electrification.

Conductor	3·16	ohms.
Gutta percha	240·5	megohms.
Inductive capacity	·419	microfarads.
Weight	804	lbs.
Total length laid	2,584	knots.
Average depth	2,100	fathoms.
Mean temperature by copper resistance	40·5°	F.

Resistance after 1′ electrification at 75° when laid.—

Conductor	2·93 ohms.
Gutta percha	2,881 megohms.

Present working speed ten and a half words per minute.

I was unwell when I joined the *Great Eastern* at Portland, and felt worse day by day; but I suppose it was the excitement that had kept me going, for on giving up charge of this section of the cable, it was impossible for me to proceed farther; Mr. J. C. Laws acted for me in laying the other section, and I returned to England with Sir Daniel Gooch in the *Great Eastern*, which started two hours after the expedition.

The following is a summary of the laying of this section:

French Atlantic Cable, St. Pierre to Duxbury.

Thursday, July 15th, 1.12 p.m. Greenwich time, started paying out shore end.

July 16th, 12.30 a.m.—We had to stop testing for a short time, as through the bursting of the valve of the bilge pipe the test room became flooded with froth and mud. Just at the same time one of the outer strands of the shore end broke and got foul of the machines. It rucked up for several yards, and upset the vertical supports before the ship could be stopped. It was, however, soon put right, and the ship started again.

1.46.—First continuity signal received.

2.14.—Finished paying out shore end, 10·895 knots.

2.43.—Current off to take constant of instrument.

3.29.—Fogs came on about 12 o'clock.

12.45 p.m.—Changed from after to main tank. Attempting several times to speak to shore, but signals too sharp to be understood, on account of the short length in circuit.

11.59 p.m.—Heavy rain and wind all night, ship rolling heavily. During the night we ran into the *Chiltern*, smashing up one of her boats, and injuring the paying-out gear. The collision was caused by the *Chiltern* coming up too close to us while speaking.

Saturday, July 17*th.*

There was a heavy swell on all the morning, resulting from the breeze of the previous evening, and when the whole of the cable was paid out from the *Cory*, it was found to be too rough to change to the *Scanderia*, so at 11.15 a.m. the end of the cable on board the *Cory* was buoyed, and after dropping a mark buoy the three ships steamed off to find a quiet refuge behind Cape Scatari, about twenty miles north. It was also intended to repair the damage done to the *Chiltern*.

6.15 p.m.—Dropped anchor in Mira Bay, Cape Breton Island.

7 p.m.—Mr. Laws and T.W. went to *Chiltern* to test cable on board.

During the evening, the batteries and instruments from the *Cory* were removed to the *Scanderia*, and set up. The three ships left anchorage for the buoy about midnight.

Sunday, July 18*th.*

2.10 p.m.—*Scanderia* came up to buoy. The weather fine.

2.37.—End of cable on board.

3.—Cable connected to instruments. Splice commenced.

3.46.—Called shore and sent "How are signals?"

3.49.—Received "First rate."

5.—Ship started paying out from No. 1 tank.

10.23.—Changed from No. 1 to No. 4 tank.

Monday, July 19th.

In the morning varying earth currents on line. Slide reading ranging from 232 to 328.

1.9 p.m.—Change from No. 4 to No. 3 tank.

4.6.—Current off line for about an hour, making permanent joint between No. 2 and No. 3 tanks.

In the evening slight earth currents still on line, but signals very distinct and readable. Weather continuing very fine. Paying out proceeding at about seven and a half knots per hour. Testing O.K.

Tuesday July 20th.

7.9 a.m.—*Foul Flake* in tank of a very complicated character. The ship was speedily stopped and reversed, but in putting on the breaks *sharply*, the cable parted over the stern. Within five minutes a buoy was dropped overboard, and soon afterwards a second. As quickly as possible the grapnel was lowered and by 11.40 we had got the cable on board. The *Chiltern* not noticing our signals, went right on, and we were compelled in consequence to pick up the short end attached to the buoy ourselves (after paying out the cable) causing a delay of about two hours. The St. Pierre end was held by a boat until we were ready to pick it up, which was done at 2.45 p.m.

3.31 p.m.—Spoke to shore and received reply.

4.52.—Splice made and recommenced paying out. Length of cable to be deducted owing to foul flake and piece cut off cable overboard, 3·567 knots. Weather all day very fine and calm.

Wednesday, July 21st.

The *Chiltern* being still out of sight we reduced our speed towards evening, continually firing off rockets and blowing the whistle in the hope of attracting the *Chiltern's* attention.

Thursday, July 22nd.

10.22 a.m.—Having paid out all our cable, and the *Chiltern* not being in sight, we buoyed the end, and after dropping another buoy as a mark, we began to steam to the eastward of the buoy. This continued for about two hours, when the masts of the *Chiltern* were discovered in the distance, and we at once turned back. We fired a gun to attract attention, and in about an hour the *Chiltern* was alongside. The instruments were at once taken off the *Scanderia*, and fitted up on the *Chiltern*. Sea rather rough.

1.10 p.m.—The cable was hauled on board the *Chiltern*. Calculation of resistance of total length of cable from resistance of ship and sea portions:—

		Slide.	Absolute.
Ship portion	= 120·5 knots	230	= 3,016,000
Sea „	= 619·4 „	130	= 5,390,000

$$\frac{5{,}390{,}000 \times 3{,}016{,}000}{5{,}390{,}000 \times 3{,}016{,}000} = 1{,}934{,}000 \text{ or } 1{,}431 \text{ per knot.}$$

6.14 p.m.—Actual resistance of total. Length, 739·9 knots = 2,080,000 or 1,539 per knot.

6.10.—*Chiltern* started paying out cable, the *Scanderia* being told to pick up mark buoy and then follow us.

Friday, July 23rd.

The deep sea portion of the cable was completed off Cape Cod at 11.20 a.m. Total paid out to that time 721·4 knots. The splice was then made between deep sea and intermediate portions, and at 12.45 we commenced paying out again.

First fourteen minutes slide reading:—

After splice = 137 Z to L = 3·852 per knot.

Length in circuit = 753·7 knots.

After paying out the thirty-one knots of intermediate cable we commenced upon the heavy shore end (4.45 p.m.), and at 6.30 we had arrived at our anchorage opposite the landing place. The hands at once commenced to coil the

end into a boat, and in about three hours the end was conducted into the cable house on shore. The instruments were taken at the same time from the *Chiltern*, and set up on shore exactly as on ship. Total length of cable:

Cory	173
Scanderia	446·5
Chiltern	129·6
	749·1

Saturday, July 24th.

Finished testing, and certificate handed over to Mr. Laws, by Clark.

N.B.—On board the *Cory* and *Scanderia*, one of the Company's representatives was always in the test room (except during sending or receiving of private messages) keeping a copy of our Diary, but the test room of the *Chiltern* being very small, the practice was discontinued.

When it was first ascertained that temperature affected the resistance of gutta percha it was attributed to every imaginable cause, whereas, perhaps, even a little thought and investigation would have shown the fallacy of such conclusions and would probably have taught valuable lessons for future guidance. Now it appeared also to be the custom to attribute every unknown phenomena, whether in short or long laid lengths of cable, to "earth currents."

There can be no doubt that by some means or other more or less electromotive force travels along the conductors of laid cables, and causes in some instances much trouble and annoyance, while in others, it is so low as to be scarce recognisable. Much appears to depend on the direction in which they are laid; time of day and the state of the atmosphere also affects them, but still I think the currents due to such causes have been much magnified and their doings exaggerated. I remember a case when, during

the official tests of a laid cable of considerable length, my attention was called to the fact that the readings were negative. The conclusion drawn was that the "earth currents" were flowing out of the cable with sufficient force to oppose that of the 100 cells in circuit for testing the insulation of the cable, consequently the tests were abandoned until the following day. But were earth currents really so strong as was imagined? I thought not, but that they were very slight, for it was only after long electrification that they interfered. To illustrate my meaning more plainly. Suppose a pair of ordinary scales to be delicately suspended, and precisely the same weight placed in the pans, under these conditions the index attached to the centre of the beam will remain at zero, but the slightest addition to the weight in either pan will destroy the balance: but it would not be correct to assert that the addition was of more weight than all that was in the opposing pan. Now this is precisely what takes place during the test for insulation of the cable: the galvanometer represents a very sensitive index, while the battery represents one pan, and a charged cable the other. Now if the potential in both were the same (and the longer the current is applied the nearer they approach to it) the galvanometer would remain at zero, but it would indicate the slightest alteration on either side, and there are several cases in which this difference can occur and which are remediable. For instance polarisation of the battery, loose connections, defective earth, &c., may cause a negative result which it is incorrect to attribute to so-called "earth currents."

Too much care cannot be bestowed on these points, and I could instance numerous cases in which the neglect of the same has led to disastrous results, more especially in the case of defective earths.

CHAPTER XVI.

Report of Mr. Hooper's Cables—Sir W. Thomson—Insulation—Inductive Capacity—Values of Different Coatings — Joint Making — Mechanical Hardness—Effect of Tinning—Remarks—Indian Government—Cable for Persian Gulf—Faults—Cable from Bombay to Aden—Down Red Sea to Suez—Tasmanian Cable—Data—Improved Core—Cable Malta to Sicily—Data—Pressure Tank—Resignation of Sir R. Glass—Bombay and Aden Section commenced—Data for both Sections—Insulation and Speed highly Satisfactory.

I WILL now return to note some of the things that occurred in the cable world during the manufacture and laying of the "French Atlantic Cable," leaving further remarks anent that expedition to follow in due course.

In the arbitration case already referred to between Messrs. Hooper and Elliot in 1867, it transpired that in May, 1864, Professor Sir William Thomson gave to Mr. Elliot the following—

REPORT ON MR. HOOPER'S CABLES.

At the request of Mr. Elliot, I undertook an examination of the qualities of Mr. Hooper's insulated wires about the end of last September.

I arranged to test especially the following particulars:—

1. Insulating quality of covering, and its durability under water.

2. (For speed in long submarine cables) inductive capacity.

3. Separate values as to each of the above, particulars of

the three materials, "pure rubber," "separator," "jacket," which are used together by Mr. Hooper.

4. Practice of joint making.

5. Mechanical hardness of the manufacture.

6. Effects of tinning on the conductivity of the wire.

At the end of November I gave, in a letter to Mr. Elliot, a provisional report, to the effect that I had found the results of observations which I had made on each of those points so far very satisfactory; and that I considered the excellence of the manufacture sufficiently proved to justify an experiment on a large scale, to consist of the laying of a submarine cable of considerable length for practical telegraphic work.

I have continued the investigations especially to SSSS 1, 2, and 3 up to the present time, and I still keep a large number of the specimens hitherto experimented on in proper circumstances for testing their durability. I shall report further results on this, the most important point of all, from time to time.

The details of the laborious investigations which I have already gone through are all minutely recorded, and shall be produced at any time desired, with full explanations to any person who may be appointed to take charge of the manufacture, or of practical testing in connection with it. They would be too voluminous for the present report, in which I propose to give a summary of the practical results and conditions.

This I shall do under the six heads numbered above.

SS 1 Insulation.—I have tested for insulation upwards of forty specimens of Mr. Hooper's manufacture, comprising lengths of cable from two to three feet up to 1,003 yards; specimens of two or three years' age, and of inferior manufacture to that now adopted by Mr. Hooper; short

specimens with one or more joints each, and with joints imperfectly "cured" by heat in the manufacture; and long and short pieces which I subjected to violent mechanical strain. In the course of many hundred tests made on these specimens from the commencement of last October to the present time, I have, with only the one exception of an apparently failed joint, noted below (SS 4), found in every case a degree of insulation very much superior to that of gutta percha. The worst insulator was in the cases of a specimen marked No. 2 RX, given to me by Mr. Hooper at Betley Hall in the beginning of October (which, before I tested, he told me he knew to be of inferior manufacture), and a length of 457 yards of the same manufacture (green), which I tested at Mitcham on the 29th October, and of a length of 1,003 yards, then two years old, which I tested at Mitcham on the same day. In each of those cases the loss was about 4 per cent. per minute, corresponding to loss "from charge to half charge" in 16 or 17 minutes. It is right to observe, however, that even this insulation is four times as good as that of the best gutta percha cables ever made.

I advised that the 1,003 yards length should be cut and tested for a fault or faults, as it would be important to find whether the comparatively poor insulation which it presented was owing to inferior manufacture on the whole or to some imperfect joint, but I was not able to undertake this investigation at the time myself, as I was obliged to return to Glasgow for my University duties.

The best insulation which I found in the great lengths was in the following cases:—

Tested Oct. 29th, 1863, at Mitcham.

Cable No. 1	500 yards	Loss per cent. per minute	·19
Cable No. 2 Made May, 1863	500 "	" " "	·18

The nearly equal insulation in these two cases is about 100 times as good as that of the best gutta percha cables. It corresponds to loss of 5 per cent. in about half an hour, or fall from charge to half charge in seven hours, but as the rate of loss goes on diminishing from hour to hour, I have no doubt but that considerably more than seven hours would pass before one of these cables would lose half of any charge left in it after several minutes' electrification.

The best insulation of all the specimens which I tested was that of No. 2 ("jacket" above) of a set of four experimental cables prepared for me at the beginning of November by Mr. Hooper. In every test it was found to insulate remarkably well. For instance, during twenty hours, December 8 and 9, it lost from charge = 220 to charge = 158, being at the rate of rather less than $\frac{1}{10}$ per cent. per minute. This is about 700 times as good insulation as gutta percha, and compounds to loss from charge to half charge in 47 hours. It is, I believe, much the highest insulation that has yet been recorded of any india rubber or other submarine cable.

As to durability, I have not yet found any falling off in the insulation of any of the specimens. It certainly remained very constant during the first two months of the investigation in each case, and in the few specimens I have been able to test recently I have found no sensible change since last October.

Thus three short specimens given to me by Mr. Hooper at Betley Hall in the beginning of October have been tested since the beginning of the present month (May), and found to be rather better than they appeared on the 10th October when I first tested them, and as nearly as possible the same as on the 21st and 26th, when each was tested a second time. The apparent improvement is owing to a better

method of preparing the ends, which I adopted after the early tests.

One of these specimens had two joints. Another, before the end of October, was twisted and wrenched to a great extent, and with great violence, so much so as to cause the outer jacket to crack and peel off in many places. The third was the best insulator of all that I had then tried. It is very satisfactory to find that not one of them has shown any loss of insulation, or any appearance whatever of decay or deterioration during six months that they have kept in an open glass jar of water, exposed to light.

No. 2. INDUCTIVE CAPACITY.—I compared the electrostatic capacities of equal lengths of the Persian Gulf Core and Mr. Hooper's ordinary manufacture, and found the former to be 1·595 times the latter. The diameter of the wire was found in each case to be ·106 of an inch, the outer diameter of the insulating cover was ·38 of an inch in the Persian Gulf, and ·46 in Mr. Hooper's. The Naperian logarithms of the ratios $\frac{\cdot 38}{\cdot 106}$ and $\frac{\cdot 46}{\cdot 106}$ are 1·243 and 1·467, and therefore if the *specific* inductive capacity of the insulating materials were the same, the capacity of the Persian Gulf Core would be $\frac{1\cdot 467}{1\cdot 243}$ or 1·18 times that of Mr. Hooper's. But its capacity by electric measurement was 1·595 times, and therefore the specific inductive capacity of the gutta percha of the P.G. cable is $\frac{1\cdot 595}{1\cdot 18}$ or 1·35 times that of Mr. Hooper's insulator.

In the recent specimens of Mr. Hooper's "ordinary manufacture" the outer diameter was 3·848 times the diameter of the wire, the corresponding ratio in the Persian Gulf being only 3·5. I find that with Mr. Hooper's insulator

an outer diameter of 2·84 times that of the wire would give one or two per cent. more speed than an outer diameter of 3·848 times the wire, with gutta percha. That is to say, rather less than half, $\frac{1}{2 \cdot 1}$ of the quantity of insulator actually used by Mr. Hooper would give the same speed as a gutta percha cable of the dimensions he uses, and this speed would be about 10 per cent. above that of an equal length of the Persian Gulf cable. Hence it is safe to rely upon something less than half the quantity of insulator actually used by Mr. Hooper to give a speed equal to that of the best gutta percha cable supplied up to the present time. And, generally speaking, with the *proportions* of copper and gutta percha at present approved of for long submarine lines, we may reckon (whatever is the absolute gauge of the conductor, and whether strand or round wire) that about half the bulk of india rubber insulator will give the same speed. This is a most important result as regards the economy of the manufacture. I would strongly advise, in connection with it, that specimens should be prepared with smaller quantities of the insulator, but with the same arrangement of coatings as that adopted by Mr. Hooper, in order that the convenience and the security of the manufacture and the joint making may be tried with the thinner layers, and that these specimens be carefully tested for insulation especially, to make sure that there is no increased liability to faults with the thinner covering, and that its hardness be also tested mechanically.

No. 3. Separate Values of the Different Coatings used together by Mr. Hooper.—At my request Mr. Hooper prepared for me in the beginning of November a number of specimens—(1) coated with "separator" alone, (2) "jacket" alone, (3) pure india rubber, (4) ordinary

manufacture, the conductor in each case being similar to that of the Persian Gulf, for the sake of greater ease and accuracy in the electric comparisons.

The insulation of each of these specimens was remarkably good. That of the "jacket" was best of all, being the case of best insulator ($\frac{1}{40}$ per cent. per minute of loss) referred to above (SS 1). The "separator" also stands high, being above that of the pure india rubber considerably. The inductive capacity of the "jacket," on the other hand, stands very high, being nearly as great as that of the Persian Gulf gutta percha ($\frac{1}{1\cdot09}$ is the ratio I have found). The pure rubber stands as nearly as may be in the same relation to gutta percha as the compound of three layers used in Mr. Hooper's ordinary manufacture ($\frac{1}{1\cdot35}$ being the ratio, agreeing within one per cent. with my measurement for the ordinary manufacture). The "separator" seems to have *less* inductive capacity than the pure rubber, but one measurement (that of the outer diameter of the separator cable) is accidentally wanting to allow me to give the number. I shall take an early opportunity of supplying it. It will be important to compare the four specimens as regards permanence. All I can say yet is that all of them having been kept together under water and exposed to light since the middle of November, none of them show any sign of deterioration or change.

It must be borne in mind, however, that none of these substances, separately laid on, are in the same condition after the curing by heat which they undergo together in Mr. Hooper's finished cable, for each of them undoubtedly causes some chemical influence on the other. The excellence of Mr. Hooper's manufacture probably depends to

some extent on their mutual influence during the application of the heat, especially the permanent soundness of the inner pure india rubber. It will, however, be worth while to try, by making and testing specimens with different proportions of the coatings, whether it may not be advantageous, as regards speed, to diminish the thickness of the "jacket," and as regards insulation to diminish the thickness of the inner layer of pure rubber, making up the whole thickness required by an increase in the "separator."

No. 4. Practice of Joint Making.—I examined carefully the process of insulating a joint, and went through it with my own hands. It seems to be reduced to a perfectly practical form, and I see no reason why it should cause difficulty or risk in any circumstances in which the requisite time can be given. To test whether a *hurried* covering of the insulator round a joint could give good results, I had a number (18 in all) prepared all in the same way in the first place, but *cured* in different times by the steam heater, one only in ten minutes with the heat applied suddenly to the highest degree, others at all intermediate degrees, up to the ordinary process, which is gradually from steam at atmosphere pressure, increasing to 40 lbs. during an hour, and then kept at 40 lbs. during half an hour. One of these, No. 6, cured only 15 *m.* at 50 lbs. pressure steam, had lost insulation when I last tried it. As soon as I have an opportunity I shall examine it to ascertain *how* it has gone wrong. The others are all still good, they will be examined from time to time, and tried severely by induction coils, &c., and I shall report results.

No. 5. Mechanical Hardness.—Besides experiments, such as those referred to above (SS 1), on the short specimens given me by Mr. Hooper in the beginning of October, in which the most violent twisting and straining

was found to produce no injurious effect in the insulation, even though the outer covering was cracked, and though the specimens have been wet with common and sea water, and left about carelessly exposed, and finally kept in an open glass jar of water exposed to light and air for six months, I had a length of twenty yards prepared by Mr. Hooper of his ordinary manufacture covering a strand of nearly the same gauge as that adopted for the Atlantic. I coiled this back and forward many times on rough ground in the open air, twisted it and filled it with kinks and pulled them straight and then broke the cable (after stretching it many feet) by the aid of levers, and examined the mechanical bearing of the wire and india rubber. I could find nothing that seemed dangerous as regards use for a deep sea cable. I then tested the insulation of each part, and found it perfect throughout.

No. 6. Effect of Tinning upon the Conductivity of the Wire.—I made accurate tests on this point, and, to my surprise, I found that the tinning seemed to exercise a slightly beneficial effect. To make sure of no mistake, I had one half of a piece of solid wire tinned by Mr. Hooper's ordinary process, and I still found (the weight of each part being taken probably would account) a slight advantage in favour of the tinned wire. It is quite safe, therefore, to rely upon there being no injurious effect on the conductivity produced by the metallic coating which Mr. Hooper applies. The mechanical quality of the tinned wire seemed quite similar to that of the plain copper wire.

William Thomson.

London, *May 27th*, 1864.

P.S.—If there is any subject embraced in the preceding report on which additional information is desired, I am

ready to give all particulars, so far as my observations have already been carried.

W. T.

This report, which is dated May 27th, 1864, reads curiously, for while it was in hand it will be observed that it says therein, "At the end of November I gave, in a letter to Mr. Elliot, a provisional report, to the effect that I had found the results of observations which I had made on each of those points so far very satisfactory, and that I considered the excellence of the manufacture sufficiently proved to justify an experiment on a large scale, to consist of the laying of a submarine cable of considerable length for practical telegraphic work."

But be it remembered that at the date of this provisional report Messrs. Glass, Elliot & Co. were using their best endeavours to come to terms with the Gutta Percha Company, so that they might amalgamate the two companies and form the Telegraph Construction and Maintenance Company, Limited; therefore, perhaps the bringing the Gutta Percha Company "to book" was to be done in a way little anticipated.

I have no doubt but that such a character as given in the above report, emanating as it did from so recognised an authority, induced the Indian Government to lay, in the Persian Gulf, a long cable containing Hooper's core, more especially as Mr. C. F. Varley was also advocating its use in warm climates. Mr. Hooper manufactured this core, and Mr. J. C. Laws tested and generally superintended its manufacture on behalf of Mr. Latimer Clark, who acted as engineer for the Indian Government.

To my knowledge seven faults occurred during its manufacture, but if they were the only ones that did occur,

they were not so many as were discovered in the St. Pierre and Duxbury section of the French Atlantic cable. It was not so much their number that attracted attention as their novel and unexpected way of appearing and disappearing; in fact they were as puzzling as tricks played by a conjuror who can at will conceal or reveal. In one case the battery power employed was sufficient to burn the rubber at the fault, and thus it was discovered by its odour and the discolouration around the surface.

This cable was coiled on board two sailing ships, the *Tweed* and the *Calcutta*, and in each length a fault developed while shipping. The fault on board the *Tweed* was supposed to be about 69 knots in the coil, but that on board the *Calcutta* was said at the time not to have been localised. Of the further history of this cable I have no record. It is said that to know the cause of the disease assists very much in its cure, but in this case there appeared to be nothing by which to fix a clue.

At this time also Mr. Henley was manufacturing for the Telegraph Construction and Maintenance Company an ordinary iron coverèd cable to be laid across Cook's Straits, to be called the "Tasmania Cable." This was taken out and laid by S.S. *Investigator*. The following particulars refer to it: —

1868. TASMANIAN CABLE.

Copper	107 lbs.
Gutta percha	150 „
Total length	180 knots.
Commenced testing	October 28th.
Finished „	December 16th.

Means of the core per knot after 24 hours at 75° and 1′ electrification.

Conductor	12·555 ohms.
Gutta percha	492· megohms.
Inductive capacity	·362 microfarads.
Weight	255·1 lbs.

The only real advantage to be gained from the use of Hooper's core instead of gutta percha was its low inductive capacity. I therefore turned my attention to this point, and on February 4th, 1869, I informed Captain Sherard Osborn that by a slight alteration in the preparation of gutta percha its inductive capacity could be reduced 20 per cent. The Company requested me to at once cover one knot on my proposed plan, and to ascertain what the real difference was between this and the material we were then using. For this purpose a knot length the same size as the Brest and St. Pierre core was covered, and Mr. George Preece found it to be 19 per cent. lower in inductive capacity than that of the mean of the batch of coils he had last tested.

At this time a company was about to be formed to lay a cable from Bombay to Aden, and thence down the Red Sea to Suez. For the section from Bombay to Aden (2,000 knots, to insure twelve words per minute), I had given the proportion to be 180 lbs. copper, and 240 lbs. gutta percha per knot. For the other section (1,500 knots) 101 lbs. copper and 135 lbs. gutta percha per knot, but it was thought that this was too small for mechanical requirements, so it was altered to copper 120 lbs., and gutta percha 175 lbs. I now informed Captain Osborn that if my improved gutta percha were used, the proportions in the long section could be reduced to equal proportions of 160 lbs., but opposition to its use now sprang from an unexpected source, and its adoption was denounced in language unmistakable. It was asserted that it could only be produced in small quantities, that the mechanical properties of the material would be destroyed, &c., &c. We know that when doctors disagree it is difficult to know who shall decide, and so it appeared to be in this case. Those

who did not understand the subject considered it better to bear the ills they had than fly to others that they knew not of.

On my return to business, after an absence of two months through illness, I found that during my absence my opponents had been active in their endeavours to convince the Managing Director of the absurdity of my proposed scheme. In consequence of these objections, I not only gave practical illustration of its working, but placed one knot length of my improved core at the disposal of Sir William Thomson, and Messrs. Latimer Clark, H. C. Forde, Hockin, Fleeming Jenkin, and C. F. Varley, so that they might report on both its electrical and mechanical qualities. Specimens were also sent to Dr. Matthiessen for chemical analysis, and in all cases the report was favourable, so much so that the Company ordered the core of the cable to be laid from Malta to Sicily to be of this material.

The following are the particulars of this cable:—

Copper . . .	73 lbs.	
Gutta percha . .	119 „	S.6

Means of the core per knot after 24 hours at 75° and 1 electrification:—

Conductor 17·39 ohms	=	93·9 per cent. pure copper.
Gutta percha		286 megohms.
Inductive capacity		·260 microfarads.

This cable proved highly satisfactory, and so far so good, but the high additional prices charged per knot for this material prohibited its use except in some long lines; consequently it was long before it was universally adopted. In future reference to this material I shall designate it S.6, that being how it was distinguished in the factory.

In October, 1868, the Anglo-American Telegraph Company removed their station from Foilhummerum to the buildings they had erected at Knightstown. The subterranean lines to the cables consisted of two taped gutta percha covered wires, laid in iron tubes, and it was found that the induction, caused by the close proximity of these wires, prevented the two cables being worked simultaneously; to remedy this another wire was laid on the opposite side of the road.

In February, 1869, Mr. Reid removed his pressure tanks from the Gutta Percha Works to those of Mr. Hooper.

In March, 1869, Sir Richard Glass resigned the chairmanship of the Anglo-American Telegraph Company.

On the 27th April, 1869, the core for the Bombay and Aden section was commenced in the presence of the Directors of the British India Telegraph Company and those of the Telegraph Construction and Maintenance Company.

In May, 1869, the Telegraph Construction and Maintenance Company removed their offices from 54 to 38, Old Broad Street.

On November 5th, 1869, Mr. Laws was engaged by the Telegraph Construction and Maintenance Company to take my place in cable laying expeditions, so as to give me more time to attend to important home duties, as contracts for long submarine cables were now coming in from all directions. Mr. Laws was to proceed overland to join the *Great Eastern* at Bombay, for which place she left on the following day, November 6th, under the command of Captain Halpin, who was also to lay this cable in place of Sir Samuel Canning, who did not accompany this expedition.

The following data refers to this cable:—

1869.

BOMBAY AND ADEN.

Conductor	180 lbs.
Gutta percha	240 „
Total length	2,050 knots.
Commenced testing . .	May 26th.
Finished „ . .	September 29th.

Means per knot of the core after 24 hours at 75° and 1′ electrification :—

Conductor . .	7·0216 ohms.
Gutta percha . .	276·35 megohms.
Inductive capacity .	·321 microfarads.
Weight . . .	419·5 lbs.

WHEN LAID.

Total length of cable laid .	1,818 knots.
Average depth . . .	1,700 fathoms.
Mean temp. by copper resistance	39 F°

ELECTRICAL VALUES.

Conductor	6,524 ohms.
Gutta percha after 1′ electrification	2,240 megohms.

ADEN AND SUEZ SECTION.

Conductor	120 lbs.
Gutta percha	175 „
Total length made . . .	1,150 knots.
Commenced testing . . .	June 4th.
Finished „ . . .	November 10th.

Means per knot of the core after 24 hours at 75° and 1′ electrification :—

Conductor . . .	10·4121 ohms.
Gutta percha . .	336·79 megohms.
Inductive capacity ,	·3354 microfarads.
Weight	292·9

Total length laid . . .	1,460 knots.
Average depth . . .	500 fathoms.
Mean temp. by copper resistance	74° F.

ELECTRICAL VALUES.

Conductor	10·260 ohms.
Gutta percha after 1′ electrification	568 megohms.

Four ships were engaged in laying these two sections, viz.:—The *Great Eastern*, S.S. *Hibernia*, S.S. *William Cory*, and the S.S. *Hawk*. Captain Robert Halpin had sole charge of the expedition, but Mr. Henry Saunders laid about 360 knots from the *Hawk* and *William Cory*, from Suez towards Aden, to meet the *Hibernia*.

These two sections may be taken as similar to those just laid for the French Atlantic Telegraph Company, but under what different circumstances! It might be supposed that the French Company followed the maxim that in the multitude of counsellers there is wisdom, while the British Indian Telegraph Company held the opinion that too many cooks are apt to spoil the broth. Of course, the Red Sea and Indian Ocean are as a rule more suitable for cable laying than the Atlantic Ocean, but be that as it may, the comparatively few engaged in this expedition were in every way united, and success crowned their efforts.

Mr. J. May was in charge of the shore station at Bombay during the laying, and on March 21st Mr. Laws reported that the insulation and speed were highly satisfactory. Later on he reported the same of the Aden and Suez section.

CHAPTER XVII.

Singapore to China Cable—1869—S.6—Reduction of Standard—Letter to Capt. Osborn—Syphon Recorder—Signal Station for Passing Ships—Falmouth and Malta Cable—Data British Australian—Batavia and Singapore Section—Engineer's Report—Data for British Indian Extension Cable—Data for British Australian Cable—Singapore and Batavia Section—Particulars concerning it—Banjoewangie to Port Darwin—Particulars—Repairs 1872.

On December 9th, 1869, for 1,500 knots of core for the cable from Singapore to China, I guaranteed 15 words per minute, with proportions per knot of 107 lbs. copper and 140 lbs. gutta percha if S.6 were used, but Mr. Chatterton asserted that it was impossible to *treble* cover such proportions.

On December 21st I received instructions to reduce the standard of the core for the Falmouth and Gibraltar Cable to 150 megohms per knot.

On February 15th, 1870, I wrote the following letter:—

"Captain Osborn, C.B.

"Dear Sir,—

"In the event of the British Australian Cable being laid direct from Raby Straits to Buck Town, which in round numbers would be 2,000 knots, to insure a speed of 12 words per minute the core must be C.W. 150, G.P. 200, that is supposing my improved material be used, but for ordinary material about 17 per cent. must be added to the above weights.

"Yours, &c.,

"W. S."

On February 19th Mr. Clifford showed me a fault taken from No. 12 section of the Malta and Gibraltar Cable, in which a piece of zinc adhering to one of the iron wires had pressed with the serving through the gutta percha.

On April 11th, 1870, Sir William Thomson was introducing his ingenious instrument the "Syphon Recorder" for working submarine cables.

About this time 55 knots of cable were laid from the shore to a ship moored in mid-channel, the object being to make her the signal station for passing ships, but owing to the great difficulty in keeping up communication the scheme was abandoned. It was a cause of comment at the time that Major Knapp Barrow, being a soldier, should have charge on this occasion.

Mr. Henley made, for the Telegraph Construction and Maintenance Company, about one-half of the Falmouth and Malta cables. The resistance of the gutta percha in some of the lengths decreased in a remarkable way. At first it was thought this was due to imperfect joints, but after a good deal of time had been spent and trouble taken to find the cause, Mr. Henley admitted that he was using coal-tar in the outer covering, and this proved the key to the whole mystery. To show how the resistance was affected, No. 5 section was cut into 5 lengths and re-coiled into other tanks, each length varied in its insulation, the minimum being 104 and the maximum 400 megohms per knot worked to the first minute at 75° F. The worst lengths were rejected, and replaced with some of the cable then being made for the British Indian Extension Company. Most of the staff were detained on their way from the British Indian Expedition to lay this cable, Sir Samuel Canning being in charge, while Captain Halpin returned home in command of the *Great Eastern.*

The data before and after laying these sections was as follows :—

1869-70.

FALMOUTH AND MALTA.

Copper	120 lbs.
Gutta percha	175 „
Total length laid . .	2,456 knots.
Commenced testing . .	November 12th, 1869.
Finished „ . .	March 2nd, 1870.

Means per knot of the core after 24 hours at 75° and 1′ electrification :—

Conductor	10·508 ohms.
Gutta percha	214·4 megohms.
Inductive capacity . .	·3479 microfarads.
Weight	296·5
Manufactured T.C. and M. Co.	1,182 knots.
„ Henley, Woolwich	1,274 „

FALMOUTH AND MALTA.

	Falmouth to Lisbon.	Lisbon to Gibraltar.	Gibraltar to Malta.
Total length of cable laid . .	823	340	1,120 knots.
Average depth	1,750	620	780 fathoms.
Mean temp. by copper resistance .		65°	58° F

ELECTRICAL VALUES AFTER LAYING PER KNOT.

	Lisbon to Gibraltar.	Gibraltar to Malta.
Conductor	10·353	10·149 ohms.
Gutta percha after 1′ electrification	1,419	1,527 megohms.

On August 21st Captain Halpin and Mr. J. C. Laws left for Batavia to lay a cable for the British Australian Telegraph Company. The data for these cables before and after laying was as follows :—

1870.

BRITISH AUSTRALIAN, BATAVIA AND SINGAPORE SECTION.

Copper	107 lbs.
Gutta percha	140 ,, S.6
Total length	579 knots.
Commenced testing	April 14th.
Finished „	June 21st.

Means per knot of the core after 24 hours at 75° and 1′ electrification:—

Conductor	11·908	ohms.
Gutta percha . . .	194·7	megohms.
Inductive capacity . .	·2926	microfarads.
Weight	248·3	lbs.

Manufactured T.C. and M.Co. . .	283 knots.
" Henley, Woolwich .	296 "
Total length of cable laid . .	557 "
Average depth	30 fathoms.
Mean temp. by copper resistance .	83° F.

ELECTRICAL VALUES AFTER LAYING PER KNOT.

Conductor	12·111	ohms.
Gutta percha after 1′ electrification	323	megohms.

Messrs. Clark and Forde were the Company's engineers, and the latter accompanied the expedition. The following extracts are from their report on this cable:—

"When the cable was all coiled on board, careful final tests of it were taken by us on your behalf.

"As a rule the contractors allow us too little time to take these tests as accurately as we should wish, owing to their anxiety to get their ships away as soon as possible after loading, and this was more or less the case in this instance. However, in consequence of our representations on this head, they now allow us one clear day for these tests, which is the minimum of time that should be allowed.

"Mean insulation resistance per knot reduced to 75° Fahr. at end of 1′ 317 megohms, or 17 per cent. improvement over the final tests taken on board ship previous to leaving England, and 111 per cent. better than the contract standard. The copper resistance, when reduced to the standard temperature, showed about the same results as when the cable left England.

"Nothing could be better and more uniform than the polarisation of the cable both separately and combined with both copper and zinc currents, and there was every indication of a perfectly sound and healthy cable.

"The tests during paying out were continuous, with the exception of speaking with shore for a short time when sending noon positions, and also on one occasion when the tests were interrupted for six hours in consequence of heavy rain getting into the test-room and temporarily damaging the instruments.

"We think it well to remark here that sometimes the Telegraph Construction Company does not pay sufficient attention to providing proper accommodation for the electricians on board their ships. Had the above accident happened when paying out a long cable in deep water the six hours' suspension of tests might have been most prejudicial to the success of the undertaking.

"The mean result of the minute insulation test at the temperature of the sea we found to be 128 megohms per knot, which, reduced to the standard temperature of 75° Fahr., gives 230 megohms per knot.

"This latter figure is 53 per cent. improvement on the contract resistance of 150 megohms per knot, and 18 per cent. improvement on the mean insulation resistance found by testing the whole core at the actual temperature of 75° Fahr. at Wharf Road, viz., 194 megohms per knot.

"It is, however, lower than the results obtained when taking final tests on board ship in England and at Batavia; therefore, in the absence of any other indication of an imperfect cable, Mr. Forde, after due consultation with Mr. Lambert and Mr. Laws, came to the conclusion that the falling off in insulation as compared with the final tests on board ship was due to a general change in the insulating

property of the gutta percha, possibly due to the high temperature of the water in which it lies. Mr. Forde consequently handed to Captain Halpin a letter dated the 18th November, 1870, informing him of the general results of the official tests, and soon after the cable was opened for the purposes of traffic.

"The cable was opened to the public on the 19th November, but the official thirty days' tests were continued on the 20th November, and on that day we found decided indications of an electric fault in the cable, of which Captain Halpin and Mr. Laws were immediately informed.

"The fault, however, did not interfere with the working of the cable, and we devoted considerable time to testing for the fault (in order, if possible, to localise it), especially at night when the cable was not required for messages.

"It was desirable not to use much battery power or break down the fault, therefore a series of delicate tests were taken to approximately localise it, and the first results placed it about 90 knots from Singapore.

"On the 26th December Captain Halpin and staff, accompanied by Mr. Forde and Messrs. Lambert and Fisher, proceeded in the *William Cory* to repair the cable, but after two days' unsuccessful dredging, in about 22 fathoms of water, we were obliged to return to Singapore, in order to proceed with the laying of the British Indian Extension Telegraph Cables.

"The cable was repaired on the 31st of January last, and the faulty piece of core was sealed up by Mr. Laws and our representative, Mr. Lambert, and then forwarded to the Telegraph Construction and Maintenance Company."

The data for the British Indian Extension Cable was as follows:—

1870.

BRITISH INDIAN EXTENSION.—SINGAPORE, PENANG AND MADRAS.

Conductor	120 lbs.
Gutta percha	175 „
Total length	1,756 knots.
Commenced testing	February 3rd.
Finished „	May 18th.

Means per knot of the core after 24 hours at 75° and 1′ electrification :—

Conductor	10·569	ohms.
Gutta percha	234·9	megohms.
Inductive capacity	·3403	microfarads.
Weight	294·7	lbs.

	Madras to Penang.	Penang to Singapore.
Total length of cable laid	1,408	400 knots.
Average depth	1,400	30 fathoms.
Mean temp. by copper resistance	46·6°	84·2° F.

ELECTRICAL VALUES AFTER LAYING PER KNOT.

Conductor	9·929	10·686 ohms.
Gutta percha after 1′	1,314	261 megohms.

It would have been considerably to the advantage of not only the contractor, but also to the cable companies, had the just remarks of Mr. Forde concerning accommodation and time been permanent in their effects, but, unfortunately, at this time new cable companies were springing up in all directions and clamouring for cables, which were produced in such hurry and confusion that they did not redound to the credit of either parties.

The Australian Telegraph Company extended their cables from Java to Sumatra, and from Java to Port Darwin. The following particulars refer to them :—

1870-71.

BRITISH AUSTRALIAN, SINGAPORE AND BATAVIA SECTION.

Copper	107 lbs.
Gutta percha	140 „ S.6
Total length	1,192 knots.
Commenced testing	December 17th, 1870.
Finished „	April 5th, 1871.

Mean per knot of the core after 24 hours at 75° and 1′ electrification :—

Conductor	11·885	ohms.
Gutta percha	259·6	megohms.
Inductive capacity	·2866	microfarads.
Weight	249·2	lbs.

	Java to Sumatra.	Java to Port Darwin.
Total length of cable laid	55	1,082 knots.
Average depth	—	1,000 fathoms
Mean temp. by copper resistance	—	59·75° F.

ELECTRICAL VALUES AFTER LAYING PER KNOT.

Conductor	11·461 ohms.
Gutta percha	1,140 megohms.

I took great interest in these cables as they were insulated with S.6; I will therefore go more fully into detail concerning them.

BRITISH AUSTRALIAN CABLE.

SINGAPORE AND BATAVIA SECTION.

July 26th, 1870.—S.S. *Hibernia*, Captain S. Welsh, left Greenhithe for Batavia to lay the above section. The following left London per P. and O. mail to meet the ship at Batavia :—

Captain Halpin	Engineer-in-charge.
J. C. Laws	Electrician „
H. C. Forde	On behalf of the British Australian Co.
F. Lambert	

November 1st, 1870.—S.S. *Hibernia* arrived at Batavia, having made the voyage round the Cape of Good Hope. During the voyage out tests of cable were frequently made. In all cases values obtained were satisfactory.

Mr. Laws came on board and arranged for final tests previous to splicing.

November 2nd and 3rd.—Ship coaling.

November 4th.—All cables tested by Mr. Lambert on behalf of the British Australian Company, Mr. Laws present.

November 7th and 8th.—Splices made between Type A fore tank and Type B main and after tanks.

November 8th.—The Batavia shore end landed Type A from fore tank.

11.10 a.m.—Commenced paying out of the fore tank Type A. 2 p.m.—Splice between Type A fore tank, and after tank Type B passed overboard.

November 11th, 1 a.m.—Changed from after to main tank, Type B.

November 13th, 5 a.m.—Cable buoyed, 549 knots paid out from Batavia. Ship then steamed for anchorage off Tanjong Katong cable house, Singapore.

November 14th, 12 a.m. GT.—End of 10 knots Type A from after tank landed at cable house, Tanjong Katong.

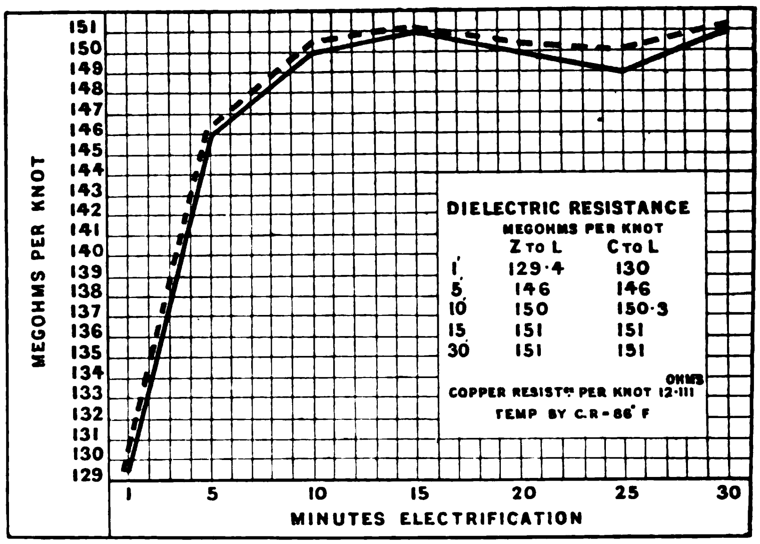
1.10 p.m.—Commenced paying out towards buoyed end of main cable (549 knots).

4 p.m.—Alongside main cable buoy, end inboard. Tested same, 5th minute zinc to line $6 = 150$ megohms per knot. Ends then passed to engineers for final splice.

7 p.m.—Final splice completed and bight of cable slipped. *Hibernia* then returned to Singapore and discharged surplus cable into lighters (which was afterwards transhipped into *William Cory* for repairs of this section). *Hibernia* returned to England with cargo *viâ* Cape of Good Hope. Staff transferred to S.S. *William Cory* to assist in laying Singapore and Penang section of the British Indian Company's cables.

First Test after Laying.

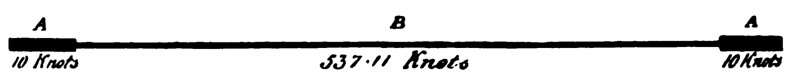
November 17*th*, 1870.



——— Zinc to line.
- - - - Copper to line.

Diagram showing types and lengths. After laying. Total length, 557·11 knots.

Batavia. Singapore.

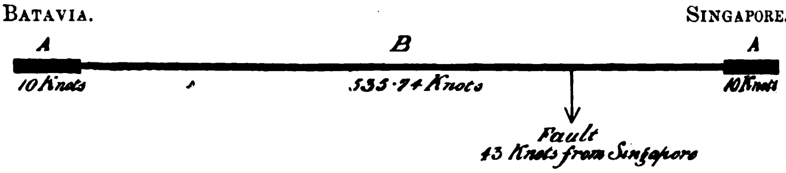


Average depth, 18 fathoms. Temp.: 86° F.
Wharf Road means obtained from Clark Forde.

Copper resistance	. .	11·87 ohms per knot.
Dielectric „	. .	—

Diagram showing types and lengths. After removal of fault, January, 1871.

Batavia. Singapore.



During the thirty days' tests after completion, a minute fault appeared (on the 20th inst., six days after completion), approximate distance by tests 65 knots from Singapore. This fault was removed by the S.S. *William Cory*, January 31st, 1871.

January 25th, 1871.—S.S. *William Cory* left Singapore for grappling ground.

January 28th.—Cable hooked about 77 knots from Singapore. Bight of cable cut, tested. Cable to Batavia O.K., end 480 knots buoyed. Singapore side faulty, went on picking up towards Singapore.

First cut .	. 3 knots inboard tested O.K.	.	(Fault overboard)
Second „	About 5 „ „ „	.	„ „
Third „ .	. 10 „ „ „	.	„ „
Fourth „ .	. 10 „ „ „	.	„ „
Fifth „ .	. 5 „ „ faulty	.	(sea portion O.K.)

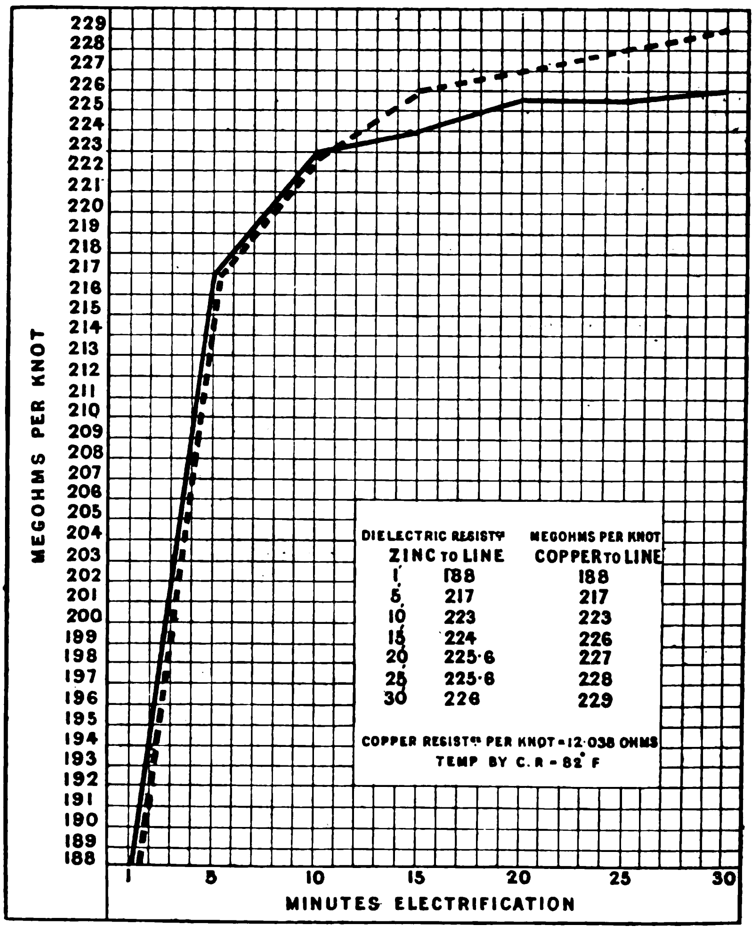
Buoyed the sea portion about 42 knots from Singapore.

January 30th.—Testing and joining up pieces picked up.

January 31st.—Picked up the Batavia end, which had been buoyed on January 28th. Tested O.K., 1st minute=167 megohms per knot. Splice then made to cable on board. Length in circuit from Batavia to ship, 519·5 knots. 8.40 a.m.—Commenced paying out towards Singapore, end buoyed. 6.34 p.m.—Alongside buoy, and tested cable to Singapore, about 42 knots. 1st minute=132 megohms per knot. 6.55 p.m.—Ends passed to engineers for final splice. 7.30 p.m.—Splice completed and passed overboard. Length is now 555·74 knots. *William Cory* then returned home with cargo *viâ* Suez Canal, staff remaining at Singapore awaiting the arrival of the China Submarine Cable.

First Test after Removal of Fault.

February 2nd, 1871.



——— Zinc to line.
- - - - Copper to line.

BRITISH AUSTRALIAN CABLE, 1871 and 1872.

BANJOEWANGIE TO PORT DARWIN. Length 1,802 knots.

August 3rd, 1871.—The S.S. *Edinburgh*, Captain Cato, and the S.S. *Hibernia*, Captain S. Welsh, left Portland for Port Darwin, to lay the above section. Captain Halpin was engineer in charge; Mr. T. Brown, electrician in charge, and Messrs. Hockin and Lambert represented the British Australian Company. Both ships also took out spare cable to transfer to S.S. *Investigator*, the repairing ship.

October 24th, 1871.—The S.S. *Edinburgh* arrived at Port Darwin, 82 days out from Portland.

October 27th.—The S.S. *Hibernia* arrived at Port Darwin, 85 days out from Portland.

From October 27th to November 7th at anchor off Port Darwin. Messrs. Brown and Hockin took final tests before laying, and the cables were then spliced up in readiness for the paying out.

November 7th, 10 a.m.—Shore end, Type A, landed at Port Darwin, from No. 2 Tank, S.S. *Hibernia*. Commenced paying out at noon. 3 p.m.—Splice between A and B paid out. Immediately after this splice passed overboard the insulation decreased, and the readings became unsteady. 9 p.m.—Informed Captain Halpin that he had better pick up to splice between A and B.

November 8th, 4 a.m.—Cable picked up to splice. Splice cut out and cable then tested O.K. The twenty knots laid cable $1'=163$ megohms per knot. 10 a.m.—Cable respliced, commenced paying out again. 9.30 p.m.—From Tank 2 to Tank 3.

November 11th.—*Hibernia's* cable all paid out. Length 376·971 knots. 6 a.m.—Changed to *Edinburgh.* Length in circuit, 1,162·39 knots. 8.30 a.m.—Commenced paying out from No. 2 Tank, *Edinburgh.*

November 13th, 8 a.m.—Changed to No. 3 Tank.

November 16th, 2 p.m.—1.060 knots paid out and buoyed. Ship then steamed into Banjoewangie.

November 19th, 8.30 a.m.—Banjoewangie shore end landed from Tank Type A, *Edinburgh.* 9.15 a.m.—Commenced paying out to buoyed end of main cable. 3.30 p.m.—Alongside buoyed end of main cable on board and tested:—1,060 knots, 5th min.=867 megs. per knot. Shore end, 23 knots, 5th min.=325 megs. per knot. 6 p.m.—Final splice made and let go. Length=1,082 knots.

December 3rd.—S.S. *Edinburgh* proceeded to Sourabaya for cargo, *en route* for London *viâ* Suez Canal. Staff on board.

December 20th.—S.S. *Hibernia* left for Singapore, *en route* to London *viâ* Suez Canal.

Repairs, 1872.

In June, 1872, a fault appeared in the Port Darwin and Banjoewangie section. Estimated distance from Banjoewangie, 220 knots.

July 15th, 1872.—S.S. *Investigator*, Captain Tidmarsh in charge, left Banjoewangie for the fault. Mr. T. Brown electrician in charge.

July 17th.—Arrived in position. Grapnel lowered.

July 18th.—Picked up grapnel. Mark buoy let go, and sunk, the moorings being too heavy. Returned to Banjoewangie for two large buoys.

July 20th.—Ship left Banjoewangie for position of fault.

July 22nd, 12.40 p.m.—Ship in position, let go grapnel.

July 23rd.—Still grappling.

July 24th.—Still grappling.

July 25th.—Still grappling.

July 26th.—Blowing too hard for work.

July 27th.—Grappling.

July 28th.—Grappling.

July 29th.—Grappling.

July 30th.—Blowing too hard for work.

August 1st, 10 p.m.—Ship anchored in Banjoewangie.

August 6th.—*Investigator* started for Sourabaya to await instructions, and more grappling rope from England. Ship remained until the arrival of Captain S. Welsh to make repairs of cable.

October 12th.—*Investigator* arrived at Banjoewangie from Sourabaya, and left at midnight for grappling ground. Captain S. Welsh on board in charge. Mr. T. Brown electrician in charge.

October 14th.—*Investigator* on grappling ground and commenced work.

October 17th.—Cable at bows. Banjoewangie end tested, found to be O.K. and buoyed. Port Darwin end faulty, picked up to fault (break) 9·334 knots, end inboard.

October 18th.—Cable hooked, but parted when 400 fathoms from surface. 10.45 p.m.—Port Darwin end hooked, and picked up. Cable tested and found to be O.K.

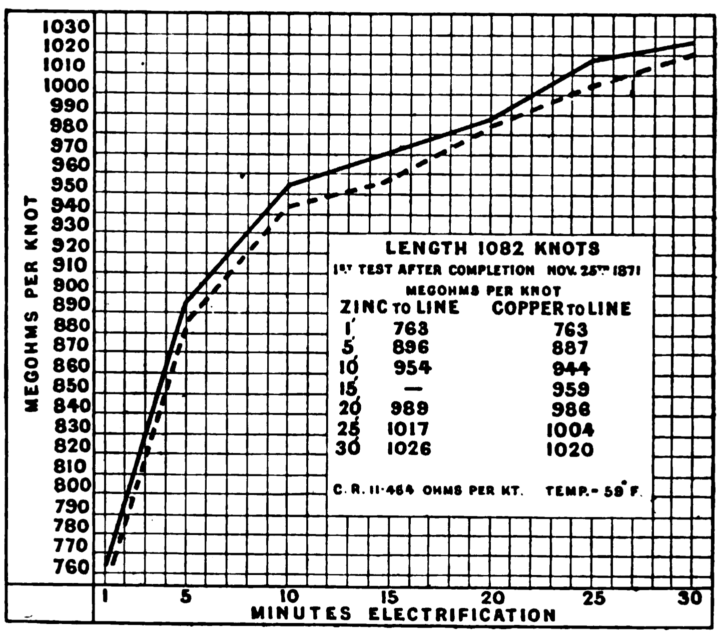
October 19th, 10 a.m.—Spliced on to cable on board, and commenced paying out to the buoyed Banjoewangie end. 3 p.m.—Alongside buoyed Banjoewangie end. 7 p.m.—Final splice made and let go. Length after repairs, 1,098·7 knots. *Investigator* then returned to Banjoewangie for final tests after repairs.

Cable after Repairs.

Length, 1,098·7 knots.

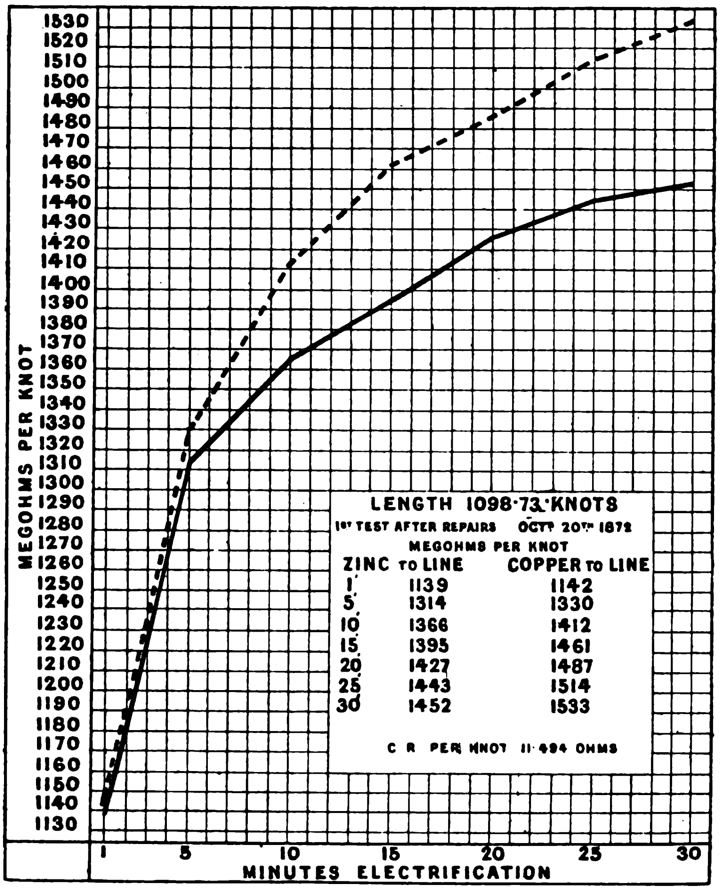
Cable Laid in for Repairs.

18·951	new cable.
8·248	relaid.
27·199	knots.



——— Zinc to line.

- - - - Copper to line.



—— Zinc to line.
- - - - Copper to line.

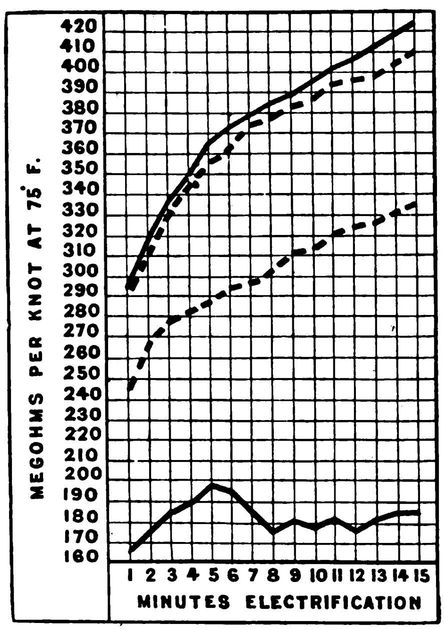
CHAPTER XVIII.

Faulty Lengths—China Cable—Section Seven—Singapore and Hong Kong Cable—Data—Siemens' Black Sea Cable—Marseilles and Algiers—Channel Islands—Beachy Head to Cape Antifer—Algiers and Malta—Balearic Islands—North German Cable.

THE following data will show how faulty lengths were manipulated in those days by the Telegraph Construction and Maintenance Company :—

SECTION 7.—CHINA CABLE.

15*th December*, 1870.



Section 5. Copper to line.
Section 5. Zinc to line.

Section 7. Zinc to line.

Section 7. Copper to line.

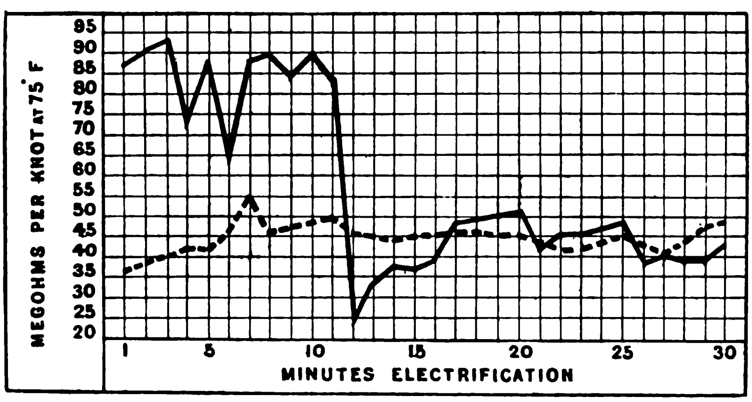
FOR COMPARISON.

Section 5 = 151 knots,	Insulation Resistances 1′ at 75° F. .	C to L = 295 megohms Z to L = 291 ,,
Section 7 = 143 knots,	Insulation Resistances 1′ at 75° F. .	C to L = 165 ,, Z to L = 246 ,,

The vertical column gives the insulation resistance in megohms per knot for each minute's electrification. The values obtained show the fault in Section 7 to be of very high resistance, and it is worthy of note that the copper current reduces the insulation considerably, whereas the reverse is the case with faults of low resistance. Both sections were completed and coiled at Morden Wharf.

CHINA CABLE.

Section 7 = 142·924 knots.



- - - - C to L ——— Z to L Battery 50 cells.

The insulation resistance of the above section fell on the 13th inst. from 210 to 185 megohms per knot (first minute worked to 75°), but on the following day it increased to 219. It was then subjected to quick reversals from 100

cells for about 18 hours and tested again, when the following values were obtained.

C to L = 165 per knot. 1′ at 75° F.
Z to L = 246 „ „ „

Quick reversals from 100 cells were again applied for 18 hours, and the resistance fell to 7·5 megohms per knot (first minute to 75°). But when tested a few hours afterwards the resistance had increased and the thirty minutes' electrification with each current was then as shown above.

With few exceptions the readings were remarkably steady, and only three times did sharp kicks occur, one of which caused the sudden fall from 87 to 23.

China Cable.

Section 7 = 142·924 knots.

December 20*th*, 1870.

This section is coiled in one of the iron tanks at Morden Wharf and covered with water.

The bottom end marked "A."
„ top „ „ "B."

Absolute C.R. before fault appeared on the 13th inst. was 1590·218 ohms = L

"A" end to bridge.	"B" to iron of cable.	The ends reversed	
C to L	1591	C to L	1588·86
Z „	1588·48	Z „	1587·48
C „	1588·48	C „	1587·48
Z „	1588	Z „	1587·38
C „	1588	C „	1587·96
Z „	1588	Z „	1587·38
C „	1588	C „	1587·48
Z „	1588	Z „	1587·48
C „	1587·67	C „	1587·38
Z „	1587·77	Z „	1587·19
Mean value	= 1588·34 = R.	Mean value	= 1587·607 = R′.

HOCKIN'S FORMULA.

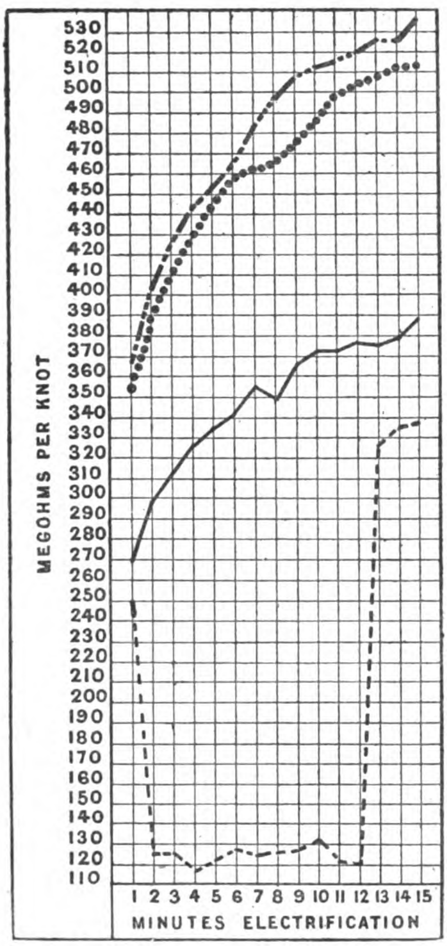
$$\frac{R(L + R') - \sqrt{R\,R\,(L - R)(L - R')}}{R + R'}$$

Places the fault 79 knots from bottom end, or 64 knots from the top end.

The loop test places the fault 69 knots from the top end.

CHINA CABLE.

December 29*th*, 1870.



Section 7 cut into two lengths.

Bottom length = 96·155 knots.
Top „ = 46·768 „

——— Z to L } Bottom length.
- - - - C to L }

—··— Z to L } Top length.
.... C to L }

N.B.—It would have been cut where the fault was localised on the 20th inst. viz., 64 knots from the top end, but only the length cut was required to coil on board the *Belgium*.

China Cable.

January 3rd, 1871.

Section 7 in two lengths.

Top length = 46·769 knots.
Bottom „ = 96·155 „
The bottom end is marked "A."
The top end of the same length "B."
Absolute C.R. = 1,061 ohms = L.

"A" end to bridge.	"B" to iron of cable.	"B" to bridge.	"A" to
C to L	1060·29	C to L	1059·38
Z „	1060·29	Z „	1059·38
C „	1060·29	C „	1060·19
Z „	1060·29	Z „	1059·00
C „	1060·19	C „	1060·38
Z „	1060·24	Z „	1059·67
C „	1060·19	C „	1060·38
Z „	1060·19	Z „	1060·38
C „	1060·19	C „	1060·29
Z „	1060·19	Z „	1060·29
	1060·235 = R		1059·934 = R′

$$\frac{R(L - R') - \sqrt{RR'(L - R)(L - R')}}{R - R'}$$

OR

$$578{\cdot}4 = \frac{1060{\cdot}235\,(1061 - 1059{\cdot}934) - \sqrt{1060{\cdot}235 \times 1059{\cdot}934\,(1061 - 1060{\cdot}235)\,(1061 - 1059{\cdot}934)}}{1060{\cdot}235 - 1059{\cdot}934}$$

$\frac{578{\cdot}4}{11{\cdot}03}$ C.R.P.K. = 52·4 knots from bottom end or 43·755 knots from the top end.

This does not agree with the test made on the 20th December, when the section was in one length. According to that test the fault would be now only 17 knots from the top end.

China Cable.—Section 7.

January 5th, 1871.

Faulty part = 96·155 knots.
C.R. by loop = 1,055·19 ohms = L.

Top end to iron of cable.		Bottom end to iron of cable.	
Z to L	1054·91	Z to L	1054·05
C „	1054·86	C „	1052·86
Z „	1054·82	Z „	1053·89
C „	1054·72	C „	1053·19
Z „	1054·67	Z „	1053·58
C „	1054·63	C „	1051·00
Z „	1054·58	Z „	1051·19
C „	1054·54	C „	1050·38
Z „	1054·53	Z „	1051·48
C „	1054·48	C „	1050·00
	1054·674 = R		1052·162 = R′

$$10 \text{ knots from R} = \frac{R(L - R') - \sqrt{R R' (L - R)(L - R')}}{R - R'}$$

The variation of the resistance of the fault no doubt interferes with the correctness of the above formula, especially for short lengths containing a fault of high resistance, as in the present instance.

The G.P.R.P.K. at present temperature is 698 megohms, or 34 worked to 75°.

The loop test still places the fault about 20 knots from the top end.

January 11th.

The first test by loop was correct, as the fault was found to be between the 69 and 70 knot mark.

The serving and G.P. was punctured by a piece of iron about half an inch in length, but bent and half the diameter of one of the outer wires. It is supposed that the piece was ripped from a flaw in one of the outer wires at the lay plate and there forced through the serving into the G.P.

The China Telegraph Company had a cable laid from Singapore to Saigong and from there to Hong Kong, to which the following data refers :—

1870.

CHINA CABLE.—SINGAPORE AND HONG KONG.

Copper	107 lbs.
Gutta percha	140 „ S.6
Total length	1,716 knots.
Commenced testing . . .	June 2nd.
Finished „ . . .	December 17th.

Means per knot of the core after 24 hours at 75° and 1′ electrification:

Conductor	11·843	ohms.
Gutta percha	200·	megohms.
Inductive capacity . . .	·2856	microfarads.
Weight	248·5	lbs.

	Singapore to Saigong.	Saigong to Hong Kong.
Total length of cable laid . .	620	975 knots.
Average depth	50	50 fathoms.
Mean temp. by copper resistance	51°	51° F.

ELECTRICAL VALUES AFTER LAYING PER KNOT.

Conductor	11·468	11·468 ohms.
Gutta percha after 1′	255	757 megohms.

It will be remembered that during the manufacture of this cable it was discovered that the tar was having an injurious effect on the insulating properties of the gutta percha, so much so that when the cable arrived at Singapore the insulation was not so high as when it left England, although the readings were very steady and uniform with each current. The climate also unfavourably affected the instruments.

The Telegraph Construction and Maintenance Company were about this time also making and laying cables of shorter lengths, among which was the core for Messrs.

Siemens and Halske's Black Sea cable. The particulars of these cables are given as follows:

1869.

SIEMENS' BLACK SEA CABLE.

Copper	107 lbs.
Gutta percha	166 ,,
Commenced testing . .	January 19th.
Finished „ . .	April 16th.
Total length	276 knots.

Means per knot of the core after 24 hours at 75° and 1′ electrification:

Conductor	12·12 ohms.
Gutta percha	279 megohms
Inductive capacity . . .	·329 microfarads.

1870.

MARSEILLES AND ALGIERS.

Copper	107 lbs.
Gutta percha	140 „ S.5
Total length	502 knots.
Commenced testing . . .	March 9th.
Finished „ . . .	May 19th.

Means per knot of the core after 24 hours at 75° and 1′ electrification:

Conductor	12·037 ohms.
Gutta percha	205·15 megohms.
Inductive capacity . . .	·293 microfarads.
Weight	247 lbs.

Manufactured and laid by Mr. Henley.

1870.

CHANNEL ISLANDS.

Total length	92 knots.
Copper	107 lbs.
Gutta percha	150 „
Commenced testing . . .	March 10th.
Finished „ . . .	March 15th.

Means per knot of the core after 24 hours at 75° and 1′ electrification :

Conductor	12·272	ohms.
Gutta percha	218·22	megohms.
Inductive capacity	·3522	microfarads.
Weight	253·15	lbs.

Manufactured by Mr. Henley.

1870.

BEACHY HEAD TO CAPE ANTIFER.

Copper	107 lbs.
Gutta percha	150 „
Total length	430 knots.
Commenced testing	April 29th.
Finished „	June 28th.

Means per knot of the core after 24 hours at 75° and 1′ electrification :

Conductor	11·922	ohms.
Gutta percha	287·8	megohms.
Inductive capacity	·333	microfarads.
Weight	259·5	lbs.

1870.

ALGIERS AND MALTA.

Copper	107 lbs.
Gutta percha	140 „
Total length of new core	214 knots.
Commenced testing	July 22nd.
Finished „	September 9th.

Means per knot of the core after 24 hours at 75° and 1′ electrification :

Conductor	11·87	ohms.
Gutta percha	178·9	megohms.
Inductive capacity	·2839	microfarads.
Weight	247·4	lbs.

Manufactured by Mr. Henley. 300 knots of Egmont cable was used to complete the length. The 300 knots here referred to formed part of the cable made in 1866 to lay across the Behring Sea. On its return to England it was coiled at Mr. Henley's Works and the Telegraph Construction and Maintenance Company utilised it as best they could. Fifty knots were coiled in half knot lengths and sent abroad to serve as a subterranean wire from the cable to the telegraph office.

1871.

BALEARIC ISLANDS.

Copper	196 lbs.
Gutta percha	358 „
Total length	90 knots.
Commenced testing . . .	April 27th.
Finished „ . . .	May 4th.

Means per knot of the core after 24 hours at 75° and 1′ electrification:

Conductor	6·536	ohms.
Gutta percha	393·8	megohms.
Inductive capacity . . .	·3465	microfarads.
Weight	552·2	lbs.

Manufactured by Mr. Henley.

1871.

NORTH GERMAN CABLE (FOUR WIRE MULTIPLE).

Copper	107 lbs.
Gutta percha	140 „ S.6
Total length	922 knots.
230·5 knots each marked 1, 2, 3, and plain.	
Commenced testing . . .	June 20th.
Finished „ . . .	August 29th.

Means per knot of the core after 24 hours at 75° and 1′ electrification :

Mark.	Lbs.	Ohms.	Megohms.	Microfarads.
1	247	11·993	185·7	·2865
2	248·4	11·985	183·1	·2866
3	249·2	11·978	181·5	·2872
Plain	248	12·002	163·8	·2872

Tested by Mr. Muirhead for Messrs. Forde and Jenkin. Manufactured by Mr. Henley.

CHAPTER XIX.

Resistance of Cables—Letter to Captain Osborn—Stockholm Tar—"Inspectors"—French Atlantic—Ship's Diary—Repairs—Cable again Broken and Repaired—Broke again 1876—1880—Particulars of Repairs, 1880—"Smartness" in Repairing.

DATA and coefficients for reducing the resistance of laid cables to Wharf Road means were all right for comparatively short lengths of core, but for long laid cables the same formula did not apply. In consequence of this I wrote the following letter:—

June 14th, 1871.

"CAPTAIN S. OSBORN, C.B., R.N.

"DEAR SIR,

"Owing to the low G.P. resistance of the China cable when it arrived at Singapore (and it has been the same with all the cables we have sent to the East) to what it was when it left England, I was induced to make an experiment with the tar we are now using for the Bright and Clark compound, supposed to be pure Stockholm, and I am sorry to inform you that this tar at a high temperature has the same effect on the resistance of G.P. as coal tar has at a much lower temperature. At a temperature of 90° in tar received from Greenwich the G.P.R. is reduced 50 per cent. in five days; I have no doubt this is the true cause of the low insulation, and unless a substitute for tar in the outer covering of cables is adopted, it will be difficult

to fix a standard for the G.P.R. of any cables to be laid in comparatively warm climates.

"Yours truly,
"WILLOUGHBY SMITH."

I admit that it did appear strange, and quite justified the remark that it was difficult to understand why I used Stockholm tar so freely in my compound for cores, and yet objected to its being used in any other part of the cable.

Fortunately the answer was simple, and could be easily explained thus. Hydrochloric acid has a great affinity to zinc, consequently it is not stored in vessels made of that material, but it will combine with zinc in certain proportions, and then it becomes "killed" and can be stowed in such vessels with impunity. It is the same with a well made compound; the Stockholm tar has combined with the gutta percha until it has become "killed," and then it can be used as it is without any fear of adverse consequences.

To show how well "Inspectors" were posted in their work in the early days of submarine telegraphy, I record the following fact. One of them objected to the use of hydrochloric acid as a flux for the joints in the copper wire, while another condemned muriatic acid, and said he would have nothing used but spirits of salts. Now, as all three were one and the same, the Gutta Percha Company had no difficulty in complying with their wishes.

In the ordinary course the contractors' thirty days' guarantee of the Brest and St. Pierre section of the French Atlantic cable would have expired on the 14th of August, 1869; at that time my health was not sufficiently restored to allow of my return to business. I cannot therefore speak

certainly of what transpired on that occasion. However, the fact that the contractors did extend their liability for two years to a certain portion of that cable, which would include that part in which the reputed fault was supposed to be, shows that the electrical condition of the cable was disputed, and thus the compromise. All appears to have gone well with this cable until October 27th, 1870, when the contractors were informed that the fault was now clearly definable about 500 knots from Brest, which placed it within their prescribed length.

I was at Brest on November 4th, and there no doubt was a fault in the cable, but as I was not allowed to localise it in my own way, I refused to make any report on the subject. The fault in no way appeared to interfere with the working of the cable.

On January 21st, 1871, Sir W. Thomson and Messrs. Hockin, Varley, and Jenkin were at the contractors' office, and took from the Ship's Diary a copy of all the insulation tests from the morning of the 23rd to the night of the 25th of June, 1869.

On May 22nd, 1872, the French Atlantic Company expressed a wish that I should accompany Mr. Varley to Brest to report to them on the electrical condition of the cable, but as Mr. Varley was to control the tests I did not comply with their wish.

In the following June it is fair to assume that the cable had ceased to work, as the Telegraph Construction and Maintenance Company were employed to repair it. The S.S. *Robert Low*, with Captain Halpin and Mr. J. C. Laws on board, was about three weeks repairing this cable, and they reported it to be in very bad mechanical condition, and the fault 218 knots distance from Brest, not 500 as had been asserted, consequently it was far on the Brest side

of the length for which the Telegraph Construction and Maintenance Company were responsible, assuming that their two years had not expired.

In the April of the next year the cable again broke, 207 knots from Brest. The repairing expedition on this occasion consisted of the S.S. *Hibernia*, Captain Welch and Mr. J. C. Laws. Mr. J. May was at the shore station. After repairs the insulation per knot of the cable at the 10th minute was:—

Zinc to line	24,450
Copper to line . . .	20,200

In April, 1876, the cable again broke about the same distance from Brest. Mr. London accompanied the repairing expedition as engineer in charge, and Mr. Laws as electrician, Mr. Brown being at the shore station. The Anglo-American Company's repairing ship *Minia* was first employed for this repair, but as she was required for some repairs on the other side of the Atlantic, she left, and in the following June the S.S. *Hibernia* was engaged in her stead. In this expedition those engaged were not able to recover more than 15 knots of the 100 knots abandoned during the last repairs, owing to the weak state of the cable; in parts the iron wire was quite gone, and the gutta percha had no protection.

The following cutting from the *Daily Telegraph*, dated June 28th, 1876, refers to this repair:—

"The Anglo-American Telegraph Company, Limited, notify that their cable, *viâ* Brest, was repaired last evening by the Telegraph Construction and Maintenance Company, with their steamship *Hibernia*, Captain Cato, thus completing the restoration of communication by both the Anglo-American lines *viâ* Brest and *viâ* Valentia."

In November, 1880, the cable again broke. I give an

account of the repairs more fully, the following being the particulars of what happened on this memorable occasion:—

1869 Atlantic Cable.—Attempted Repairs 1880.—
S.S. *Scotia.*

November 18th, 11.30 a.m.—The S.S. *Scotia*, Captain Cato, left Charlton for Brest, to there take on board Mr. T. Clark (who in company with Mr. T. Brown had previously left London for Brest) and to then attempt the repair of the above cable, Mr. F. Lucas in charge.

November 20th, 6 p.m.—Anchored in Brest harbour.

November 21st, 11.30 a.m.—S.S. *Scotia* left Brest harbour for Cable House.

Noon.—Arrived off Cable House. Mr. Clark came on board. *Scotia* then left for position of fault.

November 22nd.—Arrived on grappling ground about 220 knots from Brest. Blowing hard, and very squally.

November 24th, Noon.—Sounded in 232 fathoms, lat. 48° 38′ 30″ N., long. 9° 56′ W. 1.30 p.m.—Sounded in 380 fathoms, lat. 48° 34′ N., long. 9° 59′ 30″ W.

November 25th, 3.45 p.m.—Let go mark buoy B 3 in lat. 48° 31′ N., long. 9° 59′ 30″ W.

Until November 30th weather very unsettled, blowing hard. Soundings taken at frequent intervals.

November 30th, 1.30 p.m.—Let go mark buoy E 3 in lat. 48° 30′ 45″ N., long. 9° 56′ W. 2.40 p.m.—Commenced grappling.

December 3rd, 1.50 a.m.—Hooked cable and commenced to pick up. 2.36 a.m.—Cable at bows. 3.20 a.m.—Cable to Brest connected on to the testing room lead; spoke Brest and said:—

"Clark to Brown—Please free five minutes and then call."

Dielectric Resistance 1st min. = 2,084 megs. per knot. Sent:—

"Clark to Brown—Please put to earth for five minutes."

Copper Resistance 658·9 ohms. Sent:—

"Clark to Brown—I now put to earth five minutes for you."

Shore's value: copper resistance 662·8 ohms.

Mean value = 660·85 ohms.

$$\frac{660{\cdot}85}{3} = 220{\cdot}28 \text{ knots.}$$

Informed Mr. Lucas cable was O.K. to Brest.

4.10 a.m.—Testing room leading wire connected to the western end.

Copper resistance 15.3 ohms.

$$\frac{15{\cdot}3}{3} = 5{\cdot}1 \text{ knots to fault.}$$

4.20 a.m —The western end abandoned.

4.25 a.m.—The eastern end sealed and buoyed at 220·28 knots from Brest. 10.25 a.m.—Lowered grapnel, about six miles to the west of buoyed Brest end. 12.35 p.m.—Hooked cable. 2.10 p.m.—Cable to bows. Leading wire joined to western end.

Copper resistance 32·07 ohms.

Reported short end and commenced picking up.

2.30 p.m.—Eastern end abandoned.

4.30 p.m.—Finished picking up our western end, 1·302 knots recovered, and then the end broken at a kink came inboard. Supposed to have parted whilst picking up bight. About 14 inches of copper exposed. Iron wire broken off short. 7.36 p.m.—Lowered grapnel to the west of last position.

December 4th, 1.7 a.m.—Picked up the grapnel.

Picked up mark buoys, then steamed six knots west, let go mark buoy E 3 and recommenced grappling.

6. p.m.—Commenced to pick up grapnel, having passed line of cable. 6.55 p.m.—Grapnel at bows, with 416 fathoms of cable on prongs.

December 5th.—Grappling all the morning. 1.26 p.m.—Commenced to pick up. 2.25—Grapnel at bows, with 310 fathoms of cable on prongs. Sounding during the remainder of the day.

December 6th, 10 a.m.—Let go mark buoy B 3, six knots to the west of last position, and commenced grappling.

December 7th.—Grappling all day.

December 8th.—After taking several soundings picked up mark buoy B 3, and let it go again six miles of last position. 1 p.m.—Lowered grapnel. 7.20 p.m.—Commenced to pick up grapnel. 9.10 p.m.—Grapnel at bows with 1,276 yards of cable on prongs. Grappling all night.

December 9th, 4.5 a.m.—Commenced to pick up. 6.20 a.m.—Grapnel at bows with bight of cable on prongs.

Eastern part broke adrift. 544 fathoms picked up.

Noon.—Picked up mark buoy B 3, and let it go again six knots west of last position and commenced grappling.

December 10th, 6.10 a.m.—Commenced to pick up grapnel, having passed the line of cable. 7 a.m.—Grapnel at bows with 272 fathoms of cable on prongs in very bad condition. Grappling and sounding during the remainder of the day.

December 11th.—Picked up mark buoy B 3, and let it go again six miles to the west of last position. 10.20 a.m.—Recommenced grappling.

December 12th, 1 p.m.—Commenced to pick up grapnel.

3.14 p.m.—Buoyed the bight of cable 700 fathoms from surface. 5 p.m.—Let go grapnel to the east of the buoyed bight. 11.15 p.m.—Grapnel picked up 324 fathoms of cable on prongs.

December 13th, 8 a.m.—Commenced to pick up on bight buoy. 9.40 a.m.—Cable parted. 10.30 a.m.—Let go mark buoy E 3 six knots to the west of mark buoy B 3. 4.40 p.m.—Recommenced grappling.

December 14th, 12.10 a.m.—Commenced to pick up. Strain suddenly fell when 1,600 fathoms of rope out. 2.10 a.m.—Grapnel at bows. Standing by mark buoy all day. Weather cloudy and wind increasing.

December 15th, 7.40 a.m.—Set course for Plymouth.

December 16th, 10 a.m.—Arrived at Plymouth.

December 18th.—Left Plymouth for London.

December 19th.—S.S. *Scotia* arrived at the Victoria Docks.

1881.—French Atlantic Repairs.—S.S. *Scotia*.

June 8th, 8.30 a.m.—The S.S. *Scotia*, Captain Cato, left the Royal Albert Dock for the grappling ground, about 250 knots from Brest, to repair the above cable.

Mr. F. Lucas was engineer in charge, Mr. Brown electrician in charge, Messrs. Forde and Peake represented the Anglo-American Company, and Mr. Donovan was in charge of the shore electrical staff.

The following shows the position of cable coiled on board *Scotia*, and also the final tests before leaving Greenwich. The Wharf Road means are not obtainable.

Type.	Knots.	Weights of Core.	Description.	Final Tests at 75°. C.R.	Dielectric. 1'. Zinc.	Dielectric. 1'. Carbon.
			MAIN TANK.			
C	5·200	400/400	1877 A.A.T. Co.	3·389	Temp. 775	of Water. = 61° F. 776
,,	7·960	,,				
,,	31·014	,,				
,,	28·340	300/300	1880 ,,			
,,	37·310	,,				
,,	30·720	400/400	1878 ,,			
,,	33·246	,,				
,,	71·620	,,				
			AFTER TANK.			
C'	5·000	300/300	1880 A.A.T. Co.	3·264	Temp. 609	of Water. = 60° F. 612
C	12·000	,,				
,,	22·885	400/400	1873 ,,			
,,	21·601	,,				
,,	73·254	,,				

June 11th, 11.30 p.m.—Hooked cable and commenced to pick up. 2.45 a.m.—Cable at bows.

Tested western end, 200 cells, 2,324 knots:—

Zinc to line 5 absolute 1·68. Per knot 3,902 megohms.
,, 10 ,, 2·15. ,, 5,006 ,,

Reported O.K. to St. Pierre.

Tested eastern end for Copper Resistance = 22 ohms. approximate.

Re-tested western end, 200 cells:—

Silver to line 4' = 1,275 megs. per knot.
,, 5' = 1,466 ,,
,, 6' = 1,393 ,,
,, 7' =

4.25 a.m.—Cable being in a very weak condition, Mr. Lucas anxious to make splice to cable in No. 3 Tank, end

handed to him to start joint. 5.15 a.m.—After the joint had been commenced, again tested.

Western end, with 100 Leclanché cells, Resistance = 2,012 ohms. 2,012 ohms − 427 (resistance of cable in Tank 3) = 1,585 ohms as resistance of western end.

Informed Mr. Lucas there was a fault to the west since insulation test taken.

5.45 a.m.—Joint cut out between western end cable in Tank 3. 5.55 a.m.—Cable parted close to bows.

The length of cable picked up = 231 fathoms, tested O.K.

June 14th.—Hooked cable. Tested western end, eastern end lost.

Test of western end = 1′ − 741 ohms; = 5′ − 700 ohms.

Reported to Mr. Lucas "short length." Commenced to pick up at 7.26 a.m. 10.20 a.m.—Cable parted. Length picked up = 1·922 knots.

Memo. to Mr. Lucas:—

"Lowest resistance obtained this morning was 205 ohms, which would place fault about 70 knots from ship. I think it would be advisable if you can get western end up to seal it, and proceed to Brest and obtain tests from St. Pierre.

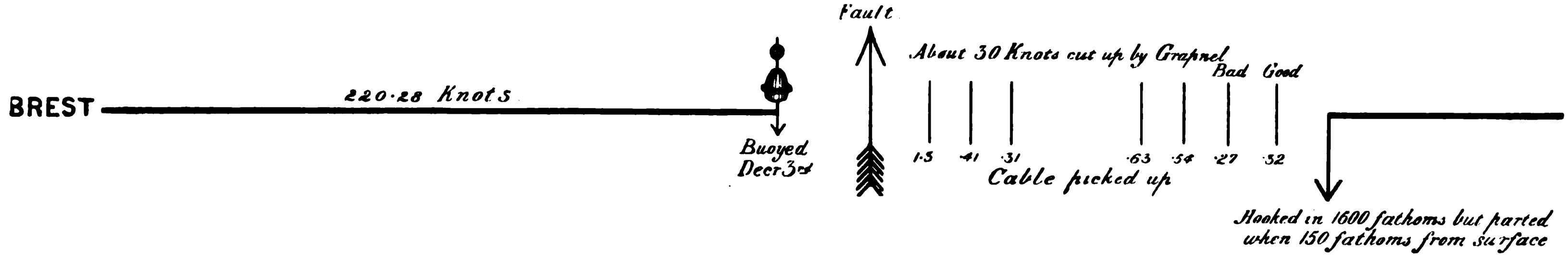
(Signed) "T. J. Brown."

June 23rd.—Hooked cable and commenced to pick up. 2.4 p.m.—Cable at bows, bight cut and eastern end abandoned.

Tested western end, Resistance = 306 ohms. Splice made between western end and 134·74 knots in after tank. 3.30 p.m.—Commenced to pay out. 6.9 p.m.—8·03 knots paid out from splice, cable cut and sealed and buoyed. Ship then started for Brest.

French Atlantic Cable Repairs, 1880.

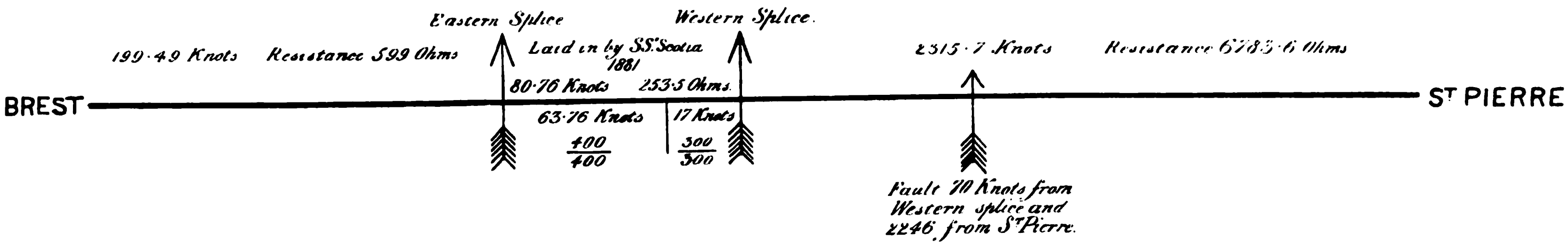
S.S. *Scotia.*



French Atlantic Cable Repairs, 1381.

June and July.

After repairs { Total length knots . 2595·42
{ ,, cop. res. ohms . 7636·13



The following handed to Mr. Lucas:—

"To-day's tests confirm those of June 14th, and show a bad fault within 100 knots from ship, though it is difficult to closely estimate distance with end sealed. If we arrange with St. Pierre to keep watch for our call, I have no doubt on our speaking him we can localise fault closely. My opinion is that the cable could be worked some time, using protecting battery and working with low power.

(Signed) "T. J. Brown."

June 24th, 7.10 p.m.—Anchored in Brest harbour, and sent following to St. Pierre:—

"Brown to Gott.—Please test soon as possible end sealed. Can you arrange look out for our call on mirror, working without condensers. Should we be unable to speak after one hour, earth and free alternately for thirty minutes."

June 26th.—Left Brest for buoyed end.

June 29th, 4.17 p.m.—Buoy lifted and cable to bows.

4.22 p.m.—Spoke to St. Pierre, signals good.

5.45 p.m.—Joint made between buoyed end and 126·71 knots in after tank.

6.47 p.m.—Commenced paying out towards the east.

June 30th, 8.24 a.m. Cable cut, 70·42 knots paid out. Cable buoyed in 106 fathoms.

July 2nd.—Grappling for Brest end. 11.45 a.m.—Brest end at bows and tested same.

Dielectric resistance = 2,300 megohms per knot.

Spoke Brest on Morse. Tested for copper resistance. = 599·02 ohms = 199·49 knots.

0.30 p.m.—Joint commenced between Brest end and 56·29 knots in after tank.

1.50 p.m.—Commenced paying out towards buoyed western end.

3.26 p.m.—Cable cut, arrived at western end; 2·31 knots paid out. Buoyed western end, picked up and brought inboard. Spoke St. Pierre, and said, "Now going to make final splice. Call B. R. in one hour with eight cells."

4.48 p.m.—Final splice completed and let go.

Tests after completion, July 10th.—Tests commenced with end free for Brest to test for two minutes, then end free at Brest for St. Pierre to test and so on for thirty minutes; the same arrangements were then repeated, only with the ends being earthed instead of freed.

Test from Brest.		Test from St. Pierre.	
End Free.	End Earthed.	End Free.	End Earthed.
1,162 ohms	1,192 ohms	6,735 ohms	6,720 ohms
—	1,188 "	6,730 "	6,710 "
1,208 "	1,188 "	6,700 "	6,710 "
1,231 "	1,196 "	6,700 "	6,710 "
1,195 "	1,191 "	6,770 "	6,705 "
1,244 "	1,188 "	6,770 "	6,710 "
1,188 "	1,182 "	6,730 "	6,700 "
Mean. 1,202	Mean. 1,189	Mean. 6,733	Mean. 6,709

In the following May the cable was found to be faulty, but I think further notice on the subject superfluous, as I hope sufficient has been given to show that the less cables are pulled about the better, and if the grapnel must be used let it be in suitable weather. I know that it is thought a great achievement to repair a deep sea cable in tempestuous weather, but I am sure that if the consequences of doing so were foreseen the rejoicing would be shortlived. It may be true that cases have occurred in which

the medical practitioner gained credit for removing the ailment for which he was consulted, although in doing so he used remedies which sowed the seeds of diseases which, developing later, caused much more trouble than the original one. Be that as it may, I fear something similar does now and then occur in submarine telegraphy, when, to gain credit for "smartness," in removing a known fault, little heed is paid to what mischief is being done, a mischief which, unfortunately, time is only too sure to develop.

CHAPTER XX.

Malta and Alexandria Duplicate—Data—1865 Cable broken 1870—Repaired following Year—Fault taken from Cable between Singapore and Penang—Insulation of Anglo-American Cables Decreasing—"Test Box"—Cable from Valentia to Heart's Content—Data—1865 Atlantic Cable Broken—*Great Eastern* to Repair it—Failed to Find Cable—Recovered 1858 Core—Australian Cable Broken—Fault from China Cable—Hooper's Core—Report—Sir W. Thomson—Tests—Malta and Alexandria Cable—French Atlantic Core—Resistance—Selenium.

OWING to increase of business, the Anglo-Mediterranean Telegraph Company duplicated their cable from Malta to Alexandria. For this cable the Telegraph Construction and Maintenance Company used about 500 knots of odd lengths of various cables which they had in stock, and 518 knots of new cable. The data for the new core at the Gutta Percha Works was per knot:—

Copper	107 lbs.
Gutta percha . . .	140 „ S.6
Commenced testing . . .	July 14th, 1870.
Finished „ . . .	August 25th, „

Means per knot of the core after 24 hours at 75° and 1′ electrification:

Conductor	11·0906 ohms.
Gutta percha	183·3 megohms.
Inductive capacity . . .	·2839 microfarads.
Weight	247·06 lbs.

And for the cable when laid:

Total length	904 knots.
Average depth	1,200 fathoms.
Mean temp. by copper resistance	52° F.
Conductor	10 150 ohms.
Gutta percha after 1′ . . .	1,998 megohms.

On November 30th, 1870, the 1865 Atlantic cable was broken, it is supposed by the S.S. *Robert Low*, while endeavouring to repair the 1866 cable, which had broken about the same distance from Newfoundland. Owing partly to its being winter time, and partly from other causes, the repairs were abandoned until early in May, 1871, when the S.S. *Scanderia*, with a new length of cable on board, having Captain Halpin in charge of the expedition, started to repair them; this was accomplished in the following June.

In August, 1871, the fault recently taken from the laid cable, between Singapore and Penang, was examined in the presence of Mr. H. C. Forde and Colonel Glover; something which resembled the tooth of a fish had passed between two of the iron wires and perforated the gutta percha with such force as to bring to view one of the wires of the conductor on the other side; but it was difficult to imagine how it got there, as there were no marks of other teeth on the cable. I never saw but one similar fault, and that was taken from the original Malta and Alexandria cable in the Bengazi and Alexandria section.

In 1858 Professor Thomson had patented the use of the reflecting galvanometer "mirror" for working long submarine cables, and early in December, 1871, on his application, the patent was granted for a further period of seven years.

Early in January, 1872, Sir Daniel Gooch informed me that the insulation in both of the Anglo-American cables was daily decreasing, and the copy of the tests I saw at their office confirmed his statement. At the request of that company I went to Valentia to endeavour to localise the faults.

One of the first lines possessed by the Magnetic Telegraph Company consisted of ten unprotected gutta percha

covered copper wires, buried two feet deep in the centre of the "six foot" of the Lancashire and Yorkshire Railway, between Manchester and Liverpool. At each mile was an iron "test box," in appearance not unlike the pillar letter-boxes of the present day, only on a smaller scale. Inside, to the back of each was attached a long thick piece of gutta percha band, down the centre of which were ten metal terminals, about one inch apart, and the end of each length of wire was connected by each terminal. All sounded very correct in theory, and looked very nice in practice, but it was soon discovered that the condensation of the atmosphere caused the whole arrangement to be constantly wet, thus forming contact between the wires and destroying insulation, so much so that the whole thing was abandoned for well insulated joints.

The Anglo-American Company had built at Foilhummerum a brick hut, called a cable house. Here connection between the cables and the subterranean leading wires to their offices in Knightstown was made by terminals, boxed in a similar way to that described; condensation from the salt water charged atmosphere was causing all the mischief, for when disconnected the insulation of the cables and land lines was all that could be desired. Perhaps it would have been better if the companies had ascertained these facts, instead of publicly announcing their cables to be faulty; at least this was the opinion of interested parties on the Stock Exchange.

In April, 1872, the French Atlantic Telegraph Company ordered the Telegraph Construction and Maintenance Company to make them a cable to be laid from Brest to Halifax, and from thence to New York. The sections were to be similar to the cables laid for the same company in 1869, with the exception that the gutta percha was to be

S.6, and coal tar was not to be used in any way. Messrs. Clark and Forde were appointed engineers and electricians to the French Company, and their assistant, Mr. Hockin, tested the core at the Gutta Percha Works with 200 Menotti cells and a mirror galvanometer.

When this cable was all on board the ships were detained, as negotiations were in progress to amalgamate the French and Anglo-American Companies. At length the terms were agreed, and instead of the route being from Brest to Halifax it was from Valentia to Heart's Content. The data for this cable per knot was:—

Copper	400 lbs.
Gutta percha	400 „ S.6
Total length	2,875 knots.

Of this length Mr. Henley manufactured 498·5 knots. Means of the core per knot after 24 hours at 75° and 1′ electrification:

Conductor	3·177 ohms.
Gutta percha	254 megohms.
Inductive capacity . . .	·353 microfarads.
Weight	800 lbs.

N.B. The mean capacity of this core was 18·4 lower than that supplied to the same company in 1869.

Total length laid . . .	1,876 knots.
Average depth	1,900 fathoms.
Mean temp. by copper resistance	38° F.
Conductor	2·940 ohms.
Gutta percha after 1′ . .	6,148 megohms.

During the manufacture of the last-mentioned cable the Anglo-American Company were informed that their 1865 cable was broken about 568 knots from Valentia, and that a serious fault was fast developing in the 1866 cable. Consequently when it was arranged to lay the new cable

from Valentia to Heart's Content, instead of from Brest to Halifax, the Anglo-American Company contracted that on her way back the *Great Eastern* should try to repair the 1865 cable. After an absence of about four months the expedition returned to Sheerness, and Captain Halpin reported that he was not successful in his search for the 1865 cable, but that he had recovered a few knots of the cable laid by Sir Charles Bright in 1858. This announcement was rather puzzling, for when in 1866 the lost 1865 cable was being grappled for, Captain Moriarty said that it was impossible to grapple the 1858 cable, as that was fully 25 knots from the scene of action. It is fair to suppose that he was right, for the 1865 cable was found as I have related, but no signs of the 1858 cable manifested themselves at that time. How it was that Captain Halpin was so unfortunate can only be assumed to have arisen from his not having in his possession all the data necessary to ascertain the true position of the cable.

Captain Halpin not only commanded the *Great Eastern*, but was in sole charge of the expedition, both as regarded the laying and repairing.

With respect to the recovered 1858 cable, the core looked as new as when first made, but it was curious to see how in places the outer covering was intact, and looked as though it had just left the manufactory, while, not far from it, the wires were broken and corroded to sharp points, showing that evidently at some time or other, the cable had been under great strain.

On June 27th, 1872, the Australian cable broke, about 200 knots from Banjoewangie, in 850 fathoms, but although a repairing ship was near the place, she was four months repairing it.

In the November of the same year a fault recently

removed from the China cable was found to be caused by a sharp but small instrument, not unlike a needle, which had penetrated the gutta percha with sufficient force to mark one of the wires of the strand conductor. Such faults had been found before, both in course of manufacture, while laying, and long after they were laid; but what caused them was a mystery, for nothing had been found to give the slightest clue. In investigating the subject more vigilantly, for the effects were becoming very serious, it was ascertained that in preparing the hemp used as "serving" it was passed repeatedly over a board studded with vertical metal pins, called "hickling," and frequently the hemp carried with it one or more of them. In searching the hemp in stock at the Cable Works many were found concealed, which only required the pressure they were sure to get at the lay plate of the "closing" machine, to force them into the core. This was thought to be the solution of the mystery attending these faults, especially when it was remembered how comparatively easily the broken wires of the Atlantic cables punctured the gutta percha.

"Hooper's Core," as it was called, was coming so prominently to the front, especially for cables to be laid in warm climates, that the Telegraph Construction and Maintenance Company put themselves in a position to manufacture these cores. They had no difficulty with them until it came to the vulcanising process, but here occurred what were termed "blow-holes," which are, in fact, minute holes caused by the escape of the steam generated in the several coatings of the core by the high temperature necessary for this process. These holes are numerous, and in many cases not developed until time or favourable circumstances cause them to become electrical faults. The Telegraph Construction and Maintenance Company considered the peculiarity

of such defects totally proscribed the use of these cores for submarine cables, and they proceeded no further with the manufacture of them, feeling sure that time would prove the wisdom of their decision. The high insulation and flexibility caused them to be used for "leads," especially between ship and shore while shipping cables, but the entire length fell gradually in insulation and had to be frequently renewed. If kept for a time in a dry warm atmosphere the high insulation would return, and the length become fit for use again, which looked very much like absorption.

With these facts before me, I was rather surprised to read the following extract from a letter written by Sir William Thomson about this time:—

"Glasgow University,
"*April* 28*th*, 1874.

"It is a form of cable in which I have great confidence. The outer protection is of the general character which both Professor Jenkin and I have long advocated as being the most suitable for a deep sea cable, but it is a very great improvement indeed on anything of this kind that we ever either designed ourselves, or have seen designed by others.

"The preservative compound which Hooper has prepared and applied to the outer hemp coverings seems to me admirably adapted to keep the different strands of hemp firmly together, and to give a very complete protection, both to the hemp and to the core, against all contingencies and accidents which can be foreseen as probable or possible, previous to the submergence. Such a cable once laid in deep water would, I believe, have a better chance of long life than the ordinary form of deep-

sea cable sheathed with iron imbedded in hemp. The strength of the protection as specified by Hooper is quite sufficient to render the laying of the cable a sure and comparatively easy task, compared, I mean, with that of laying deep-sea cables of ordinary types.

"The fact of there being no iron in the protection diminishes exceedingly the liability to faults. A large proportion, I believe indeed a large majority, of the faults which have hitherto imperilled submarine cables during the laying, and which have caused total loss in a few instances, have been due to wounds in the insulating material produced by the iron of the outer sheath. In fact, it is quite certain that in many cases *the cable has been fatally wounded by its own armour*. This consideration is one of the reasons, and a strong one, for which both Jenkin and I have long been led to look to cables protected externally, not by iron wire, but by hemp or otherwise, as probably the best type for deep sea. The insulating material (Hooper's material) I have always thought well of since it was first submitted to me in 1863-64, when I tested it in my laboratory in the old College, and with special instruments which I took for the purpose to London (the telegraphic testing instruments of the day being scarcely capable of discovering at all any want of perfect insulation in even as much as a mile length of Hooper's cable). The durability of the material has been well proved since then under many and various circumstances.

"I have acted with Professor Jenkin for the Western and Brazilian Telegraph Company, and the Central American Telegraph Company, from the commencement of each undertaking, and all their cables have been of Hooper's material.

"The Western and Brazilian Company's cables from

Pernambuco to Rio de Janeiro have been successfully laid, and are, I believe, the best submarine cables in existence.

"From my own observation, both during the manufacture of all the cables for these companies, and during the laying of the section Pernambuco to Para, in the Hooper's first cable-laying expedition, which Professor Jenkin and I accompanied as engineers for the Western and Brazilian Company, I have the greatest confidence in the insulating material in respect to all practical good qualities. For a cable to be carried across the tropics, and still more for a cable to be *laid* anywhere in the tropics, the resistance to damaging influence of heat, for which Hooper's material is peculiar, is a good quality of paramount importance.

(Signed) "WILLIAM THOMSON."

Some of the original Malta and Alexandria cable, between Bengasi and Alexandria was recovered, and about three knots of the core was tested after the joints were removed. These lengths were tested under precisely the same conditions as when they were new, and the mean results per knot were:—

Conductor	3·655 ohms.
Gutta percha	127 megohms.
Inductive capacity	·437 microfarads.

The copper strand was as clean and as good as when first used. Comparing its induction with other cores of the same proportions, I should say it had increased about 5·5 per cent., which would be caused by the contraction of the gutta percha by age reducing its diameter. All gutta percha cores are affected in the same way. The great difference in its gutta percha resistance was no doubt caused by the effects of the *tar* used in the manufacture of the cable.

That the tar had combined with the gutta percha there could be no doubt, for when the gutta percha was brought to a plastic state the odour of tar was very strong, and the gutta percha rather sticky, resembling my compound in colour. If the gutta percha had not been affected by the tar, it is difficult to say what would have been its resistance.

A similar core (French Atlantic) after twelve months increased 73 per cent., and after nineteen months it had increased 130 per cent. It is not easy to fix any precise figure, but my opinion is that, had it not been for the tar, its resistance would have been about 1,000 megohms per knot. The three joints removed were of the original make; two were made at the Cable Works, and the other at the Gutta Percha Works. Their resistance, compared with the present standard, was:—

Present standard	=	1
1st Greenwich	=	250
2nd „	=	40
Wharf road	=	2·7

Much in the way of joint making was learnt from this.

As I have already stated, for my new system of testing cables during laying, it was necessary to connect a high resistance to the end of the conductor of the cable on shore. To have used ordinary resistance coils for this purpose would have been expensive, so for the Atlantic and other cables with which I was connected, I used instead a resistance composed of alternate sheets of gelatine and tinfoil. This however proved bulky, and its resistance unreliable; therefore I sought for other means, and among the many things tried was crystalline selenium. In my experiments with this substance I was at first sorely puzzled, as it varied so much in its resistance; pieces of

high resistance at night would be only half the resistance in the morning. On investigation this proved to be owing to the resistance of selenium being affected by the slightest variation in the rays of light falling upon it. These facts I communicated to the Society of Telegraph Engineers (now the Institution of Electrical Engineers) in 1873.

As the resistance of selenium appeared to remain fairly constant in the dark, I had pieces a few inches in length and about one-eighth inch in diameter placed parallel in a vertical vulcanite box, at each end of which was a row of terminals, corresponding to the number of pieces of selenium in the box, the connections between the two being made by fine platinum wire; the box was then filled with melted paraffin wax and hermetically sealed. After 48 hours the resistance of each box was ascertained, and its value marked over its outside terminal, so that the whole could be manipulated to obtain the desired resistance. Although the greatest care was taken in all the details connected with the construction of these boxes, the resistance would as a rule be found to have decreased, especially after being used in hot climates. Whether this was due to time, long electrification when in use, or both, I never knew. Suffice it that, with all its faults, selenium was the best substance I could find for my purpose, both as regarded cheapness and compactness; I therefore continued to use it. Fortunately, great accuracy in the resistance was not essential.

CHAPTER XXI.

Brazilian Submarine Telegraph Company.—Lisbon and Madeira Section—Madeira to St. Vincent—St. Vincent to Pernambuco—First Section caused Trouble—Data—Particulars—Fault—Data for other Two Sections.

EARLY in 1873 the "Brazilian Submarine Telegraph Company" was formed, and they employed the Telegraph Construction and Maintenance Company to make and lay for them a cable from Lisbon to Madeira, from Madeira to St. Vincent, and from thence to Pernambuco.

Up to this date it could be said that the contractors had been fairly successful in their undertakings, but the first-named section of this order caused much trouble and delay. The core was tested in the usual way, the data being per knot as follows:—

Copper	120 lbs.
Gutta percha	175 „ S.6
Total length	654 knots.
Commenced testing . . .	February 14th.
Finished „ . . .	April 22nd.

Means per knot of the core after 24 hours at 75° and 1′ electrification:

Conductor	10·567	ohms.
Gutta percha, 3 coverings .	296·6	megohms.
Inductive capacity . . .	·2977	microfarads.
Weight	293·8	lbs.

The cable was on board the S.S. *Seine*, and Captain S. R. Welch not only commanded her, but had charge of the

laying, assisted therein by Mr. Thomas Temple, Mr. Thomas Brown being in charge of the electrical department. On August 21st they started laying the cable from Lisbon, and on the 24th a fault developed itself, when 383 knots had been laid. The ship was stopped, cable cut and sea end passed to the picking-up machinery. Most reliable tests showed the fault to be about 200 knots from Lisbon, so they agreed to splice the cable, complete the laying, and then remove the fault. While lowering the splice, the cable fouled and parted. On September 19th, being unsuccessful in grappling the end, the cable was recovered at the bight, where it had been buoyed for *twenty-six days*. It was fortunate this was done, as it was found that the strain caused by the buoy had so squeezed the cable, that the conductor was nearly through the gutta percha.

The S.S. *Minia*, Captain Martin, joined the *Seine*, to render assistance just after the splice was successfully made.

On September 21st they completed laying the cable to Madeira, with the fault still in, but the cable working very satisfactorily, viz., twenty-two words per minute with one cell and condenser, fifty microfarads capacity, at Lisbon only. The fault was in very deep water, and with the winter fast approaching, it was deemed expedient by those probably most competent to judge, to leave the repair to a more fitting season; some of those concerned who were far from the scene of action thought otherwise, so on September 30th, 1873, the *Seine* and *Minia* left Madeira for the fault.

On October 24th the *Minia* broke the cable, and on the 30th, the supply of grapnel rope being exhausted and winter far advanced, the ships returned home.

In April, 1874, a repairing expedition started, consisting

of the S.S. *Africa*, Captain Gallilee; S.S. *Kangaroo*, Captain Lisk; engineer, Mr. Robert London; assistant, Mr. Frank Lucas; electrician, Mr. Thomas Brown; and on the 24th they commenced to grapple for the Madeira end; on May 11th they found it, and, after speaking to Madeira, they buoyed it and commenced to search for the Lisbon end, which was found on May 25th. The fault was localised as 17 knots from ship, and 2·92 knots were hove in when the cable broke at the bottom. On June 9th, 1874, the cable was again recovered, and it had to be buoyed owing to rough weather, but on the following day they were able to commence picking up; while communicating with Lisbon the cable again suddenly broke 2·34 knots from the ship. The 2·34 knots were recovered and the fault was found to be in that length. On the next day the Lisbon end was recovered, and the cable was found to be perfect electrically from ship to Lisbon. The end was buoyed, and they commenced to grapple for the Madeira end; the buoy which was attached to this end on May 11th was found on May 22nd, 10 knots out of position, with 2·02 knots of cable attached to it. On June 14th the Madeira end was recovered, the cable electrically perfect, the end was spliced to the cable on board, and the cable laid to Lisbon buoyed end 50·92 knots, and at 2.20 a.m. on the following morning electrical communication was perfect from Lisbon to Madeira.

The total length of cable after repairs was 625·897 knots. The fault was in 2,250 fathoms, 198 knots from Lisbon; tests, with a view to localise this fault, were made by different electricians at Lisbon, Madeira, St. Vincent, and on the repairing ship, and, as might have been expected, the most accurate measurements were found to be those in which the minimum resistance of the conductor was in

circuit. The final splice was in 2,400 fathoms. Although owing to unfavourable weather and other circumstances the recovery of the fault occupied *four ships* 136 *days*, the actual work was done in six days.

The fault, which occupied all this time and caused all this expenditure, was owing to the conductor becoming by some unknown means distorted in the gutta percha coverings, leaving but a *very* thin covering over it. Some of the copper in parts of the recovered cable was even rotten, and on several occasions when picking up, want of continuity was the result. The tests after completion were :—

Temp. by copper resistance .	39° F.
Gutta-percha after 10′ . .	29,658 megohms per knot.

Reduced to 1′ electrification at 75°, and allowing for the increased resistance due to pressure, the resistance would be 426 megohms per knot. The Wharf Road means per knot of this at 75° were for the first minute 295·6 megohms per knot.

The mishaps to this cable did not in any way affect the progress of the other two, which were laid without any hitch, consequently the following data is thought sufficient to give concerning them :—

MADEIRA AND ST. VINCENT SECTION.

Copper	120 lbs.
Gutta percha	175 „ S.6
Total length	1,260 knots.
Commenced testing . . .	April 23rd, 1873.
Finished „	August 14th, „

Means per knot of the core after 24 hours at 75° and 1′ electrification :—

Conductor	10·436 ohms.
Gutta percha	284·6 megohms.
Inductive capacity . . .	·2972 microfarads.
Weight	292·6 lbs.

Total length laid . . .	1,197 knots.
Average depth	2,000 fathoms.
Temp. by copper resistance .	33·5° F.
Copper resistance of conductor .	9·6 ohms.
Gutta percha after 1′ per knot .	14,859 megohms.

S.S. *Edinburgh*, Captain Manning; S.S. *Hibernia*, Captain Cato. Captain Halpin in charge of the expedition. Mr. J. C. Laws in charge of the electrical department on ship. Mr. Joseph May in charge of the electrical department at Madeira.

St. Vincent to Pernambuco Section.

Conductor	255 lbs.
Gutta percha	340 „ S.6
Total length	1,953 knots.
Commenced testing . . .	May 30th, 1873.
Finished „ . . .	March 25th, 1874,

Means per knot of the core after 24 hours at 75° and 1′ electrification:—

Conductor	4·836 ohms.
Gutta percha	312·3 megohms.
Inductive capacity . . .	·302 microfarads.
Weight	594·6 lbs.
Total length laid . . .	1,844 knots.
Average depth	2,300 fathoms.
Temp. by resistance of conductor	40·5° F.
Copper	4·5 ohms.
Gutta percha after 1′ . .	6078 megohms.

Morning of June 8th, 1874, commenced paying out at St. Vincent from the *Hibernia;* June 13th changed to S.S. *Seine;* June 18th, changed to S.S. *Edinburgh.* June 21st, completed to Pernambuco; the S.S. *Investigator* laid the Pernambuco shore end. The heads of departments were the same as on the previous expedition, with the additions that Captain Dudden commanded the *Seine*, and Captain Cole the *Investigator.*

CHAPTER XXII.

Edison—Signal Instruments—Capt. S. Osborn Promoted—1873—Loss of S.S. *Robert Low*—Death of Sir R. Glass—Resignation of Admiral Osborn—S.S. *Minia*—Formula for Resistance—Cable from Heart's Content to Valentia—Data—*Great Eastern* Broken up—Mr. J. Beer—Mr. Henley—Cable Laid from Sardinia to Obitello—Death of Admiral Osborn—Many New Cables—Details Unnecessary—Silvertown—Siemens—The *Faraday*—Faraday's Resting Place—Various Cables Examined—Hole in Serving—"Brass Tape"—Powdered Silica—Death of Mr. J. Beer—Telegraph Construction and Maintenance Company.—Mr. J. C. Laws—Mr. J. May—Mr. Henley—Death of Sir W. Siemens.

In May, 1873, Mr. Edison brought to England a high speed telegraph instrument; it resembled a Morse's in signals, but the rapidity with which it worked on short circuit, or even through a large amount of resistance, was marvellous to behold; the paper bearing intelligible signals appeared to leave the instrument at lightning speed. It was thought by Mr. Edison that the same results could be obtained through a long length of submarine cable, and for experiments 600 knots of coiled cable, the core of which consisted of 120 lbs. of copper and 170 lbs. of gutta percha per knot, was placed at his disposal, but he was not long in finding that the speed of his instrument had to be reduced to below that of an ordinary Morse before intelligible signals could be obtained. Mr. Edison, with a candour seldom possessed by inventors, admitted that he was not prepared for this "darned induction," and that he "would go back to think about it." It was really not only interesting but instructive to see with what dexterity he worked

his instrument and manipulated his connections; in fact he was thoroughly acquainted with the subject in hand, quickly realised the cause of the defeat, and, what is all-important, freely admitted it. I am not surprised therefore at the valuable work he has since done, nor that he stands forth so prominently in the front rank of "public opinion."

A few months afterwards a similar instrument was brought to England by another American, who was anxious to try it through a submarine cable. Now it almost goes without saying that the English language is made up of twenty-six signs called letters, and that the production of either a comedy or tragedy is determined by the order in which they are placed. This gentleman could handle these signs with skill and dexterity, but he evidently did not know what nonsense he was talking with them. It was difficult to conceive anything more absurd outside a lunatic asylum; so, as I was sure that coiled cables would not answer his purpose, I declined to go further into the subject with him.

In October, 1871, Captain Sherard Osborn left the management of the Telegraph Construction and Maintenance Company for about four months, during which time he was afloat on active service, qualifying himself for promotion, and in June, 1873, he was raised to the rank of Rear-Admiral.

Considering the hazardous work attending cable laying and repairing, it is surprising how few accidents there have been; but in 1873 a sad disaster occurred. Whilst engaged in repairing one of the Atlantic cables off the American coast, the S.S. *Robert Low* and all on board were lost.

In December, 1873, Sir Richard Glass died.

In January, 1874, Admiral Sherard Osborn resigned his position of Manager of the Telegraph Construction and

Maintenance Company, and was succeeded by Rear-Admiral George Henry Richards. My opinion is that in Sherard Osborn the Company lost a good and skilful pilot, and the heads of departments a true and valued friend.

In March, 1874, the S.S. *Minia* became the repairing ship of the Anglo-American Telegraph Company, and made Halifax her port of rest.

The formula in use to ascertain the resistance of the gutta percha of cores at any specified temperature was considered correct for comparatively new cores, but when applied to *old* cores, it was found to be worse than useless; for instance it was thought advisable to re-use the core that had been recovered during repairs, and for this purpose it was made into several lengths, tested at 75°, and then sent to the Cable Works, where it was again tested, at the ordinary temperature of the day, and increased to 75° by the usual formula; it was returned as being much below the specified standard. The tests were repeated with the same result, and on investigation it was proved that the age of the core was an important factor in the formula, and could not be neglected where accuracy was necessary.

When the French Atlantic Company merged into the Anglo-American Company, and the route of the new cable was changed *from* Brest to Halifax *to* Valentia and Heart's Content, it required less cable, over 1,000 knots remaining on board the *Great Eastern*. In the following year the Telegraph Construction and Maintenance Company, assisted by Mr. Henley, made a similar length of a similar cable and joined it to that on board the *Great Eastern*, and another cable was laid from Heart's Content to Valentia. The shore ends, and intermediate at both ends of this cable, were made from old core taken from recovered cable of both the French and Anglo-American Companies, conse-

quently the conductor ranged from 400 to 300 lbs. per knot. This cable was laid *from* Heart's Content *to* Valentia; the reason for so doing I know not, unless it was that the *Great Eastern* would cross the Atlantic better, with the cable on board as ballast.

The data for the cable was:—

Total length	1,835 knots.
Average depth	1,900 fathoms.
Temp. by copper resistance . .	38° F.
Resistance of conductor per knot .	2·943 ohms.
Resistance of gutta percha 1' . .	7,301 megohms.

Captain Halpin commanded the *Great Eastern*, and was also in charge of the expedition. In the electrical department, Mr. J. C. Laws was chief on board ship, and Mr. Joseph May was chief on shore. This was the last time the *Great Eastern* was engaged in cable work.

While I write, at the present time (1889) I am told that the noise of the hammers can be distinctly heard breaking her up. Alas! for that monument of Brunel's greatness, that admirable assistant in the success of deep sea telegraphy.

Although Mr. Julius Beer was so intimately acquainted with the Telegraph Construction and Maintenance Company he seldom appeared outside their board room—in fact, his work was seemingly done by stealth, and no doubt he would have blushed to find it fame. Mr. Henley occasionally manufactured cables for him, and in July, 1874, he made 120 knots, which was coiled in a tank marked in letters unmistakable, "The cable in this tank is the property of Julius Beer." This gave rise to much comment, and when in March the following year, this cable was removed from Mr. Henley's works and recoiled at those of the Telegraph Construction and Maintenance Company,

those who had before only assumed that Mr. Henley was drifting into financial difficulties now became certain that such was the case, and, in many instances, did their best, though unintentionally, to bring about the disaster they had anticipated.

In May the same year the Telegraph Construction and Maintenance Company laid this cable from Sardinia to Obitello.

In May, 1875, Admiral Sherard Osborn died.

Most of the cables I have mentioned have been duplicated, and in some instances triplicated for various reasons, repairs are constantly going on, and repairing ships have increased in number accordingly. Many new cables have been laid, so that now it might be fairly said that, with but few exceptions, the whole civilised world is in electric telegraphic communication, and Puck's record of putting "a girdle round the earth in forty minutes" has been beaten.

To enter into detail concerning all these cables would be only to repeat what I have already said.

Of course Silvertown and Siemens were not idle, but I know little of what they did, and most of that little has been gleaned from published reports which are open to all.

I read with a great deal of pleasure that Messrs. Siemens had christened their fine cable ship the *Faraday*, showing thereby the great respect in which they held the memory of so good a man, for I suppose no one was more competent to judge of what Faraday did for electric science than Sir C. W. Siemens.

"A prophet is not without honour, save in his own country." These words involuntarily escaped my lips as, on a recent visit to Highgate Cemetery, I turned away

from the final resting place of the mortal remains of Faraday. I had found the grave in an obscure spot, a prey to rust, decay, and neglect. Alas! that it should be so, when even a few shillings spent annually would be sufficient to keep so humble a place in order. If there are no relations left, I am sure that the Royal Institution, from whose anvil Faraday sent forth so many bright sparks, has among its members those who knew him intimately, revere his memory, and would willingly undertake so small a matter if it came before their notice. Perhaps it may be said with apparent truth, that Faraday's name in itself is a sufficient monument of his greatness; that may be so, but still I think it would have been better, if something of a more substantial character had been erected to mark the spot where sleeps one of the greatest men the scientific world has ever known, and I have no doubt that this thought would occur to many foreigners as well as to his compatriots, after having seen the grave in its present condition.

In December, 1878, pieces of cables containing serious faults, and which had been taken at various times from cables laid from Singapore, &c., were examined, in London. In one of these pieces the outer covering of hemp and Bright and Clark's compound appeared perfect, the iron wires the same, and close laid, yet directly beneath one of the wires was a hole in the serving, about a quarter of an inch in diameter, as though made by a master-hand; the hole extended through the gutta percha to the conductor, but as far as the assisted eyes could scan, no trace of anything to cause such mischief could be found, and the speculation was, how so big an insect as must have caused the mischief had made its entrance and exit without leaving a trace behind. Is it not possible for the hemp used as a

serving, to contain the known animalculæ, which, resembling a grain of dust, becomes alive as soon as a drop of water touches it? The cable was inspected, and all the appearance of the fault tended to this hypothesis; therefore instead of looking for one big boring insect, the discarded "dust" was the animalculæ that caused the fault, as the imperceptible mite does the decay in cheese.

It was with an idea to prevent such faults in future that the core was covered with "brass tape," but in some cases, especially when light cores were used, the remedy was worse than the disease; for, to be effectual, the metal ribbon must be wound on very tightly, and in the process adopted to accomplish this the core becomes much stretched. It may be slowly revealed, but surely time will prove that there is a destructive electrical action between the metal tape, the iron wires, and the copper of the conductor when the outer covering allows the salt water to enter and do its work. With a view to obviate these known and surmised evils of the metal tape, it was suggested that a covering of gutta percha, containing a large percentage of powdered silica, should be substituted for it, but, as far as my knowledge extends, it was never used, although I still believe it to be worth trying.

In April, 1880, Mr. Julius Beer died.

Early in November, 1881, the Telegraph Construction and Maintenance Company, ignoring the maxim that no man can serve two masters, promoted Mr. Shuter, who had been secretary to the Company ever since its formation, to the position of Manager, Admiral Sir George Richards still retaining his position as Managing Director. Mr. Edmund Dickens replaced Mr. Shuter as secretary. Mr. Shuter has since been further promoted to a Directorship, so that now the Company has two Managing Directors, and if, as is

popularly supposed, two heads are better than one, the Company ought to benefit by the arrangement.

The first time that I met Mr. J. C. Laws was in 1855, when he came from Brighton with Dr. Whitehouse, to experiment with one of Mr. Brett's cables, then coiled in the yard of the Cable Works of Messrs. Glass, Elliot & Co., at Greenwich, with a view to obtaining electrical information for an Atlantic cable. The many times I have mentioned him in these pages shows the varied and important work he did.

In January, 1881, when I was appointed sole manager of the Gutta Percha Works, in addition to being chief of the Electrical Department, it was arranged for Mr. Laws to take charge of the Electrical Department at Greenwich, so as to enable me to devote more time and attention to my new duties. Mr. Laws readily consented to this arrangement, and all went well until the following year, when it was noticed that his health was far from satisfactory, and sufficient to cause anxiety to his friends. He was strongly advised to take rest, but this at first he declined to do, asserting that "it was nothing but a passing cloud, and that the sun would soon shine again."

> "Oh! would some power the giftie gie us,
> To see oursels as others see us;"

for although early in October he went to Brighton, it was then too late, and on the 26th of that month he breathed his last, lamented as he had been respected by all who knew him.

Mr. Joseph May replaced Mr. Laws at Greenwich, and discharged his duties faithfully. By his death, which occurred after I had resigned my appointment in the Telegraph Construction and Maintenance Company, the Company lost a good servant.

The first time I saw Mr. Henley was in October, 1851, on the beach near Calais, when he was watching the landing of the cable, through which he was to try his magnetic instruments in comparison with the double needle of Cooke and Wheatstone, which the Submarine Telegraph Company were using between Dover and Calais. It might correctly be said that Mr. Henley was then first paddling on the shores of the ocean of Telegraphy. Since that time I have seen him swimming, with a strong stroke, assisted by the tide of prosperity, and I have also seen him manfully battling against the strong tide of adversity, where financial difficulties, like wreckage after a storm, sorely impeded his way. I thought him at times eccentric until I knew him better, and then I could see that there was a meaning in his eccentricities which were so puzzling to strangers. It has been well said, "it is pleasant to be foolish at the right time," but surely he was sometimes foolish out of season. I have thought his character not unlike a painted window, which, viewed from the outside, gives but a blurred mass of unintelligible combinations, but seen from within presents a whole, which skill and talent have developed into an instructive and pleasing picture. Many who knew Mr. Henley felt sorry when he was at last overwhelmed by financial difficulties. He complained bitterly that his original plant at North Woolwich fell into the hands of the Telegraph Construction and Maintenance Company, who kept it idle and allowed it to fall into decay. Mr. Henley believed that Mr. Julius Beer, of whom he was borrowing money, was acting in kindness and consideration for his interests, and was quite unprepared for his foreclosure. Mr. Henley not only imagined, but proclaimed with much energy, that he could and would do again what he had done when turned out of Enderby's; he could not realise that his working

days were well nigh over, but on the 13th of December, 1882, his exhausted frame found rest in the long sleep of death.

On November 20th, 1883, it was with regret that I heard of the death of Sir W. Siemens.

The lately published "Life" of this eminent man, containing as it does many of his scientific sayings and doings, shows his connection with submarine telegraphy and electrical work, besides his prominent position in many other branches of science.

CHAPTER XXIII.

Joints—Localising Faults—Polarisation—Electrification—Healthy Sections—Readings—Careful Tests—Good Electricians Necessary—Wharf Road Mean—Calculated Gutta Percha Resistance—Electrical Improvements—Copper Wire—Faults—Caused by Lightning—Advancement—Manufacture.

If the good advice contained in the following verse—

> "Do what you can, being what you are,
> Shine as a glow-worm if you cannot as a star;
> Work like a pulley if you cannot as a crane,
> Be a wheel-greaser if you cannot drive a train,"

had been taken and followed, that is, if the work of all had been careful and thorough, the progress of submarine telegraphy would not have been so much retarded by the brakes of ignorance.

To join the various lengths of the conductor together is an easy and comparatively quick operation, which does not require long training to accomplish; but to insulate the same is quite another matter, great care and attention, combined with long experience, being necessary to ensure success.

In the case of gutta percha covered cores, the strips of that material used must be of the right temperature, and manipulated by soft, dry hands. A man endowed by nature with moist and flabby hands never makes a good joint, and a good jointer, after his return from a cable-laying expedition, is frequently incapacitated from making a passable joint in the Works until his hands have regained

their natural condition, more especially if, during the voyage, ignorance has employed him to clean batteries and do other objectionable things, which harden the hands and impregnate them with acid, salt water, and dirt. I admit that all this is, to a stranger, difficult to understand, but many cases might be cited where "superintendents" have come to grief through disregarding it.

Want of insulation, electrical defects, or, as it is commonly called, the "fault," frequently occurs, as I have perhaps too often mentioned in this narrative, during the manufacture, laying, and at short or long intervals after laying. Many suggestions and formulæ have been published, all of which profess to be the right ones for determining the exact position of such faults. The physician who has but one prescription for all sorts and conditions of cases would, I think, soon come to grief: so would it be with the electrician who trusted to one formula for the localising of all sorts and conditions of faults. I am not speaking of a fault of a low resistance, or where it is possible to form a loop so as to have both ends under one control, as during manufacture, or in laid duplicate cables. In such cases the work is easy and localising certain, but when it is one of those incipient faults, the resistance of which is very high and changeable, with only one end of the cable to test from, and perhaps earth currents interfering, it is not so easy to speak with the same degree of certainty as to its whereabouts. The good physician will look at his patient's tongue, feel his pulse, make a thorough examination of him, and endeavour to ascertain his ways and habits, before he prescribes; so an electrician in charge (and all stations ought to possess a competent one) should interpret a fault by, figuratively speaking, examining its tongue, feeling its pulse, and

asking daily questions, until he is satisfied he can localise the disease with almost absolute certainty.

If these incipient faults appear during the manufacture, the usual practice is to keep sending into the length affected quick reversals from a comparatively high battery power, until the resistance of the fault is reduced sufficiently to allow its distance from either end to be ascertained with certainty. It is not wise to adopt this system in the case of a laid cable, for it might develop other concealed faults; besides, it might be desirable to keep the resistance as high as possible for the better working of the cable. In a properly manufactured cable correct records are kept of the resistance of the conductor, and the inductive capacity of each length, with its position in the cable. A true knowledge of this data is of great assistance in localising a fault. Occasions might be cited where, in a broken cable, the end of the conductor was drawn several inches up the gutta percha, so that its resistance was such that the negative current soon entirely sealed it, and while in this state the inductive capacity of the entire length was ascertained. A knowledge of the inductive capacity per knot enabled the distance to be accurately given.

Owing to the polarisation, as Faraday called it, but as it is more frequently known, electrification, the longer the length of cable under test, the longer the time that should be given to its insulation test. A recognition of this fact being given to its insulation test may lead to the discovery of incipient faults, which would otherwise lie dormant until an unknown quantity of time of immersion developed them. Assuming, for instance, 100 knots of a completed section to be coiled in a tank, where it has been immersed in water a sufficient time to suggest a uniform temperature, then comes the employ-

ment of a positive current from a battery, the higher the potential the better, but say 100 cells; if a sensitive mirror galvanometer be used, this should be applied for at least one hour, and during that time each minute reading should be recorded. Both ends of the section should then be put to earth for the same length of time, with a view to thoroughly discharging it, and then a negative current should be applied, and one minute readings recorded, precisely the same as with a positive current.

In what are called healthy sections, the deflections on the scale of a galvanometer will decrease gradually and uniformly with either current; but if they differ or behave in a way that only practised eyes can detect, then it is considered unhealthy, and more care and attention has to be bestowed upon it.

It is so difficult to make it understood how many things going on in the Cable Factory are likely to interfere with these tests. The moving of a small piece of iron in the vicinity of the test room has been known to vitiate them, while, if the section is not quite finished, the induction caused by the quick revolution of the closing machine makes all the electrical tests in that length of little value.

I always found it better to draw curves of the readings, as by so doing I could better understand the doings of the section. If it be essential, and I think it is, to so test sections, how much more care is absolutely necessary at what are called the "final tests," that is when the sections are joined together, and coiled on board ship in one or more tanks.

The manufacturer who allows time for such tests to be properly made is simply doing justice to the Telegraph Company for whom the cable is made; but when he thinks

all such tests are merely "fads" and objects to detaining the ship for them, he is behaving unfairly towards his employers.

It is useless for the manufacturer to say, "Oh! if high farming electrical tests are necessary, do them while the ship is on the passage out." In the first place, while the ship is lying off the Works, a very sensitive astatic mirror galvanometer can be used on *shore*, but if the ship is at sea a comparatively sluggish ironclad marine galvanometer is the only one that can be used, and interference of other currents of unknown quantity, caused by the roll of the ship, &c., renders long readings of no value. Again, the test room on many ships is inferior to the cattle boxes close by, and totally unfit for the purpose for which it is required.

If the frame-maker be employed to hang the picture, the chances are that he will put it in the best light for showing off his handiwork, regardless of the effect of that position on the gem which the frame contains. Something similar occurs when the testing of a core is neglected, and all the attention devoted to the external covering, and the quick manipulation of the same.

It is said that an intelligent boatswain can lay a cable. My experience points towards the truth of this statement, but in any case the electrician in charge should be one who has graduated in the school of experience, for his duties are of the highest importance.

In every bargain there must be two interests, and it is only natural that each party should study his own, but in fair and honest dealings he should also consider his neighbour's side of the question. I made use of the data gleaned from tests taken as soon as the cables were laid, so as to compare the then resistance of the gutta percha with what

it had been in the Wharf Road mean, as it is called. For the difference in temperature, I employed Latimer Clarke's table, which is to be found in most text books of electrical science, and for pressure I used Siemens' coefficient, which is also to be found in the same books. Of course, in laid cables, tests are not to be relied on with that amount of certainty which should be obtainable during manufacture; still, this treatment gives some idea of a cable's electrical condition, for in a healthy cable the calculations ought to be always in excess of the Wharf Road mean.

When tar was freely used to saturate the serving, and before S.6 was thought of, such was not the case, as the following figures, taken at random, will instance:—

Wharf-road means; millions Siemens' units per knot after 1' at 75°.	Calculated gutta percha resistance per knot after 1' at 75°.
200	94
336	261
203	127
276	103

But when tanned liquor was employed instead of tar, and S.6 came into general use, the results obtained were more satisfactory, as the following figures show:—

Wharf-road means; millions Siemens' units per knot after 1' at 75°.	Calculated gutta percha resistance per knot after 1' at 75°.
312	463
284	896
333	336
273	270

The gutta percha resistance of these latter examples increased about nine per cent. during the thirty days' guarantee, but in the former example they all decreased in that time, as though the tar were still having a prejudicial effect.

Great electrical improvements have been made in submarine cables. It should be remembered that in 1858 the

proportions for the core of the then Atlantic cable were 107 lbs. of copper and 261 lbs. of gutta percha per knot. It is true that Dr. Whitehouse promised a speed of five words per minute by using from induction coils a potential very high but of an unknown quantity; but those perhaps more competent to judge calculated about two words per minute as a maximum. Now, with the same amount of copper and one half the quantity of gutta percha, a similar length can be worked at the rate of twenty words per minute, with a potential not exceeding that of a few Menotti cells. The submarine cable companies themselves ought to know best what is the most suitable type of cable to use in different seas and at different depths. They have great facilities for experiments, and surely experience has taught them something.

Let it not be forgotten that the best preservative of gutta percha is salt water, and that the more light is excluded the better, so that on the deep ocean's bed it is in its element, and I think it does not want all the covering with which it is usual to surround it. Perhaps the protection is necessary when cables are laid in comparatively shallow water, impregnated with the outcome of decaying vegetable matter.

It has been said that the athlete who is content to go in a circle round the starting point can never reach the goal, and I think this saying aptly applies to submarine cable-makers, for surely the time has arrived when they should leave the trodden circle, and make a bold effort to reach the goal where a valuable prize awaits the winner.

My experience is that the copper wire, as now made, does not alter mechanically or electrically in laid cables; cores of gutta percha do break down from causes which ought to be avoided and therefore should not exist, but they never


ATLANTIC TELEGRAPH
C.V. de Sauty
C.F. Varley
Willoughby Smith
Temple
R. London
H. Clifford
S. Canning
Capt. James Anderson
R.C. Halpin
Cyrus W. Field
H.A. Saunders
W.H. Russell

APPENDIX A.

The Atlantic Telegraph.

Saturday, July 29, 1865.

OUR WEEKLY SUMMARY.

THE week just completed has been most exciting, several mishaps having occurred, but we are enabled to state that everything at the time of our going to press was most satisfactory, both as regards the ship's progress and the chief objects of her voyage across the Atlantic. On Monday the hopes of all interested in the success of the undertaking were much damped by the intelligence that all was not right with the cable. The chief engineer immediately proceeded to stop the "paying out" of the cable, and gave orders for "paying in" the same. This latter operation is very slow and unsatisfactory, and answers to the "paying out" of the pockets of the shareholders; whereas the "paying out" of the cable contributes to the "paying in" as regards the same pockets. This curious feature will be better understood by a reference to our Money Market Intelligence.

NEWS OF THE WEEK.

The steamer *Hawk* arrived from Valentia early on Monday morning, bringing a penny paper of the 17th of July.

The doctor reports that the state of health in the ship's metropolis is satisfactory. The inhabitants of the Middle District are, however, suffering from surfeit.

Foreign Intelligence.

By the kindness of Mr. De Sauty we are enabled to lay before our readers the following important telegram from Europe :—

Note by our Philosopher—
Boiled pig's cheek should not be cut too thick.
Monr. Despecher holds, however, a contrary opinion.
Man lives to eat, and eats to smoke.

Literary Intelligence.

Mr. Field has just completed his 700th letter.

The indefatigable J. D. has been obliged to occupy an extra cabin to contain the notes he has accumulated for a great work on the cable, to be completed, as at present intended, in 96 volumes folio. The accomplished author has already completed the 47th volume, and the distinguished artist employed to illustrate this work has made already no less than 350 sketches.

Scientific Intelligence.

Some curious experiments have been made on a ship's rope by striking it with the hand and measuring the time taken for the return of the wave. Professor Thomson calculated it at nine seconds and 1000·015th part of a second. Professor Varley, on the contrary, estimated it at nine seconds and 1000·014$\frac{7}{8}$th of a second. The dispute was raging at the time of our going to press.

Captain Moriarty reports a strange inconsistency in the ship's logs; that on the port side giving a speed of 177 miles in the twenty-four hours, the starboard log only showing a speed of 143 miles in the same time. This strange discrepancy may be accounted for by the grease deposited by the cable on the port side and the extra weight of cable and pigs on the starboard side of the vessel.

Dramatic, Musical, and Artistic News.

Many distinguished musical performers have appeared during the week.

On Thursday evening Captain Anderson gave a *séance* before a distinguished audience, who went away highly delighted at the skill shown by the worthy captain.

Money Market.

Money scarce. Exchange, 00.

Stock Exchange.

There has been great fluctuation in the shares of the Atlantic Telegraph and Great Ship Company's, as shown by the following quotations :—

	Paid.	Business done.
Monday, July 24.		
Atlantic Telegraph Company	£5 ...	$5\frac{1}{2}$— $4\frac{3}{8}$—3— 2 — 1
Tuesday, 8.30 A.M. ...	...	$0\frac{1}{2}$— 2 —6— $8\frac{1}{8}$—11
,, 2 P.M.	...	1 — $0\frac{1}{8}$—0000 —
,, 3 P.M.	...	2 — $3\frac{1}{2}$—9—$14\frac{1}{2}$—21
Wednesday	...	$21\frac{1}{2}$
Thursday	...	$21\frac{3}{4}$—$21\frac{7}{8}$—
Friday	...	22 —$22\frac{1}{8}$—
Saturday, 10 A.M.	...	23 very firm.
Great Ship Company, Limited,	£20	28, 26—20—18—15—22—25
Saturday, 10 A.M.	...	$29\frac{1}{8}$ very firm.

Strange Adventure at Sea.

The following anecdote was related to us by a gentleman of unimpeachable veracity :—

The ship *Medium*, in lat. 56.40 N., long. 23.15 W., observed a raft with two men on it, distant about one mile. On approaching the raft the men were found playing at ecarté. They presented a most miserable appearance, their arms and legs looking as if pieces had been bitten out of them. On inquiry, it was ascertained that the two men were the sole survivors of the crew of the French ship *La Gloire*. Ten days past she struck against an iceberg, and, the boats being crushed, the crew, twenty in all, made a raft and succeeded in getting clear of the ship. They had some water on board but no provisions, so it was agreed that they they should play at ecarté, the victor in each game having the privilege of biting out a piece of his opponent's flesh. In this way the whole of the crew had been disposed of excepting the two found on the raft; and it is conjectured, owing to their skill being so equal, that but for the timely arrival of the *Medium* no one would have been left to tell the tale.

AMUSEMENTS FOR THE DAY.

12 Noon—Luncheon and *Daily Navigator*.

5.30—Dinner.

8—Tea.

9 to 11 P.M.—Grog, possibly with whist.

From daylight till dusk—Looking out for the *Sphinx*.

(Through the kindness and liberality of the Admiralty, this interesting amusement will be open to the public free of charge.)

N.B.—The above amusements, with the exception of whist, are gratis.

FINIS.

The *Atlantic Telegraph* will be published till further notice. The price will be for the series five shillings, including the cover, and the proceeds will be devoted to such purposes as Captain Anderson shall appoint.

Communications to be addressed to the Editor, at No. 14, Lower South Avenue, Middle District

FINIS.

Published by DAY on board the *Great Eastern*.

The Atlantic Telegraph.

Wednesday, August 2, 1865.

A serious panic occurred on Saturday last at 1.30 P.M. Of course the wildest rumours were afloat as to its cause, but our reporters could obtain no reliable information. At one time it was feared that the eminent firm of De Sauty & Co. had suspended payment, and a most anxious but respectful crowd besieged the doors until long after office hours. A general hope was expressed that the suspension would only be temporary, and we are happy to say that the confidence so well merited by the firm was not misplaced. Before midnight the office doors were opened, and all liabilities were paid in full, with compound interest.

News of the Week.

The *Great Eastern* speeds nobly on her mission of towing the islands of Great Britain and Ireland to America. In less than ten days it is expected that a splice will be effected between the two countries, and long, long may it last.

Strange Effect of a Machine on Men.

At the first turn of the "paying-in" machine on Saturday the look-out were variously affected. Some rushed down to sleep, and everyone looked at it with hostile feelings. We would advise Messrs. Canning and Clifford, if they have any regard for their machine and expect to make any further use of it (which it is hoped will not be the case), to keep a strong guard around it, for there is every probability of its being thrown overboard in the present state of excitement.

Professor Thomson gave a lecture on Electric Continuity before a select audience. The learned gentleman, having arranged his apparatus,

the chief object of which was a small brass pot, looking like a small lantern with a long wick sticking out at the top, spoke as follows :—

"The lecture which I am about to give is on a subject which has ever been of great interest to the intellectual portion of mankind, and—"

(The luncheon bell ringing, the learned professor was left speaking.)

Fine Art Gossip.

Our lazy artist still complains that the wind and the smoke prevent his working. To these disturbing elements must be added Tank-observation.

The Lay of the Electricians. (*Tune*—"Over the Sea.)

1.

Under the sea! under the sea! Here's what de Sauty is saying to me,
Such testing as this is the perfectest bliss! Insulation is coming it strong,
So we'll test! test! test! with coils and rheometers! keys, galvanometers!
Test! test! test! Test each minute all night and day long.

Chorus.

Copper and zinc! acid and stink! tink-a-tank-tink-a-tank-tint-a-tank tink.
Copper and zinc! acid and stink! success to con-tin-u-i-ty.

2.

Under the sea! under the sea! Signals and currents of every degree.
Down in the sea! down in the sea! Resistance is creeping along.
So it's test! test! test! By the units of Siemens with cunning of demons
We'll test! test! test! and watch our con-tin-u-i-ty.

Chorus—Copper and zinc, &c., &c.

3.

Down in the sea! deep in the sea! lay we our coils of elec-tricity.
Under the sea! under the sea! Success to con-tin-u-i-ty.
So it's test! test! test! Come with wire and bells, with magnets and cells.
And it's test! test! test! all through our con-tin-u-i-ty.

Chorus—Copper and zinc, &c., &c.

4.

From shore-end to sea! shore-end and sea! See what Valentia is saying to me.
Mark May's strong relay, in units B.A. of millions and trillions again.
It's so grand I can hardly trust Thomson or Varley to test! test! test!
Such a lovely con-tin-u-i-ty.

Chorus—Copper and zinc, &c., &c.

5.

Ah! down in the sea! what's this I see? Home's law is playing the devil with me.
Down in the sea this moment I see a token that something is wrong.
For just as we're speaking the light that's my beacon has marched! marched! marched!
Marched off my con-tin-u-i-ty.

Chorus—Copper and zinc, &c., &c.

6.

Up from the sea! up from the sea! Coy little coiler come hither to me.
Come Clifford and Canning! Pick up, tackle manning. Haul up that cable to me.
Mind dynamometers! hang galvanometers. Haul! haul! haul!
That fault from the depths of the sea.

Chorus—Copper and zinc, &c., &c.

7.

Once upon deck! once upon deck! little for dead earth or faults do we reck
Up on the deck. Let's get hold of his neck! we'll splice him and test him again.
What a lark! lark! lark! In this immensity of watery density
Now our spark with intensity travels along.

Chorus

Rises and sinks! coilings and kinks! long life to our copper and acids and zincs.
As long as man's able we'll stick to our cable, and splice him and test him again.

W. H. R.

It is suggested that the above song be sung in the tanks when empty, and then, to use the words of William Russell (not Lord John of that ilk), "we may rest and be tank-full."

Money Market.

We are happy to report a better tone in monetary circles. A large and influential speculator having put into circulation several American notes of three cents cash, money is comparatively abundant.

Stock Exchange.

The shares of the Atlantic Telegraph Company underwent some serious fluctuations on Saturday, but at this moment are firm at 22⅛. The shares of the Great Ship Company, though necessarily affected by the fall in Atlantic Telegraph shares, are comparatively steady. This gratifying result was probably owing to the caulking of about ten yards of the upper deck planks, which important operation was performed with complete success on Saturday afternoon.

Produce Market.

Bullocks falling. The long incarceration of the sheep has so obfuscated the intellects of the sheep that the poor beasts receive kindly the advances of their greatest enemy, the two-legged wolf. Vegetables sprouting, promising an early crop of turnip-tops.

Correspondence.

To the Editor of the "Atlantic Telegraph."

Sir,

The state of the thermometer during the past week, especially at the commencement and its close, has varied in so remarkable a manner that I am induced to send you the subjoined readings from the instrument in my observatory,

Monday, at 1 P.M. it stood at 70°, with a prospect of a further rise; at 2 it fell suddenly to 34°, and gradually sunk to freezing point. On Tuesday, no change up to 8.30 A.M., when it rose at once to 44°, increasing to 60°; at 2 P.M. it fell to zero, but in less than half an hour it rose as suddenly to 100°, at which point it remained up to 1.30 P.M. on

Saturday, when it experienced a fresh fall to 9°; at 12 it rose to 60°, but at 6 A.M. on Sunday it fell to 40°, and at 8.30 A.M. it rose to 90°, with a steady aspect.

Your obedient servant,
D. G.

19, Field's Alley, Middle District.

To the Editor of the "Atlantic Telegraph."

SIR,

I peck at your office door to lodge a complaint. I see you looking at those stupid sheep and lazy oxen, and those filthy pigs with feelings of pity, and I ask you to extend the same to me. Here am I, perched near that slimy cable, day and night watching over it, and, owing to the filthy smoke of innumerable funnels, am so changed in colour, and my health is so ruined that I fear, unless the evil be remedied, I must vacate my post, with what result you may guess when you learn that the two accidents which occurred last week arose from my temporary absence for the purpose of ablution.

Pray receive the assurance of my highest consideration,

THE RAVEN.

P.S.—Just tell them to keep that dirty cat away; she troubles me.

AMUSEMENTS.

Same as last week. The public, however, in looking for the *Sphinx* are advised to keep one eye in a westerly direction, and the other eye in an easterly direction as before.

Published by DAY—on board the *Great Eastern*.

The Atlantic Telegraph.

Saturday, August 12, 1865.

The events of the last ten days have caused so much anxiety to the chiefs of this expedition, and indeed to all on board, that it appeared to us unseemly to allow our funny writer or any one in our employ to utter any ill-timed joke. That anxiety is now over; and though it be not supplanted by the exultation of success, let us accept our failure in the healthy spirit shown by the chief sufferers, and with an expression of sincere regret let us wipe from our brain what of the past is unavailing and turn to the future with that hope and confidence which are justified by the experience gained by failure. As in kingdoms they say, "The king is dead; the king liveth," so let us say, "The cable is dead; the cable liveth." All honour and glory to our new Sovereign.

DEEP-SEA FISHING.

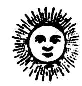
It being ascertained that the Sea Serpent was somewhere in lat. 51.30 N., long. 39 W., Captain Anderson, accompanied by Messrs. Canning and Clifford and a party of scientific gentlemen, endeavoured to capture the monster. It being found that the lazy brute lays perfectly still at the bottom of the ocean, and, being fed by sea-animals, a bait was useless, a strong wire rope with a grapnel attached was lowered to a depth of 2,000 fathoms. After drifting a while they grappled the monster and brought him up 1,000 fathoms, when unfortunately the swivel gave way. Two or three attempts were made with a like result, and it was resolved to postpone all operations to a more favourable time.

To the Editor of the "Atlantic Telegraph."

SIR,

Why should I be placed in a position compared to which that of the Prince of Wales is enviable. I cannot pursue my daily avocations

without being insulted by Captain Moriarty taking a sight at me. If I retire for a moment behind a cloud, the gentleman waits to catch me before I am half out. If this persecution is continued, I shall keep out of sight till the *Great Eastern* arrives in the Thames.

 THE SUN.

(NOTE.—The Editor has been obliged to suppress much of the language of his distinguished correspondent. The original letter can be seen in his office.)

We are sorry to announce the untimely death of Sir Melior Cable on board the *Great Eastern* at 1 P.M on Wednesday, August 2. The unfortunate gentleman was the eldest son of Sir Bonus Cable. He started for America on a peaceful mission on the 15th of July, accompanied by a large retinue of friends. Whether, as is supposed by some, his health had been secretly tampered with during the temporary absence of his chief attendants, or whether there was some natural defect in his constitution, he first showed signs of decay on Monday, July 24th, but under the skilful treatment of the family physicians, Drs. Canning and Clifford, he quickly revived. A more serious attack of the same disease occurred, from which he also recovered, and great hopes were entertained that he would attain the object of his voyage and pass the rest of his days in a most beneficent activity. These hopes were crushed by a third attack early on Wednesday, August 2, and, in spite of the skill and unwearied attention of his doctors, he suddenly expired at one o'clock. A strange fatality has attended the family. Sir Bonus, the first baronet, left England in 1858 for America. When half-way across the Atlantic he sent his better-half back to Ireland, and proceeded alone to America. Both reached their respective shores in safety, but expired shortly after landing. Sir Melior Cable is succeeded in his vast estates by Sir Optimus Cable, now an infant in arms. According to the reports of Drs. Canning and Clifford, and his head nurse, Mrs. Cyrus Field, there is every reason to believe that the seeds of decay so fatal to his father and grandfather have been eradicated, and that there is every prospect of his attaining a very old age. It is said that he will proceed next year to America on the same mission undertaken by his ancestors, and we heartily wish him a speedy and successful voyage.

BIRTHS.

August 2nd, on board the *Great Eastern*, Sir Optimus Cable, his unfortunate father dying at the same moment. On the 6th of July, Mr. Varley, of a formula, still-born.

Money Market and Stock Exchange.

Nothing doing. Prices purely nominal.

A prospectus has been issued of the Atlantic Dredging Company, Limited. According to the reports of the scientific men sent to explore the bed of the ocean and analyse its contents, there is an unlimited supply of ooze, which will yield a profit of at least £3,000,000 per cent.

The Humble Petition of a Buoy.—*August* 5, 3865.

To the New Zealand Authorities.

Two thousand years ago I was born in an obscure island called Great Britain, and taken early to sea. When more than half-way across the Atlantic, for no fault of mine, but merely to serve some selfish purpose, I was cast overboard by my unnatural guardians and tied to a raft, which was attached to the ground. I had no provisions, but, being fortunately possessed of an iron constitution, I suffered my privation without detriment to my health, a brisk gale having released me from my painful position, and I was free to seek a home wherever chance directed. I have seen many changes since that moment, and have visited every quarter of the globe without ever setting foot on shore. Several unscrupulous commanders have endeavoured to kidnap me. I once witnessed a fearful encounter between a French and an American skipper for the possession of my body, but I escaped during the fight. After wandering two thousand years, I was cast naked on your shores. I am very old and feeble; my ribs are broken, and the rosy hue of my skin has turned to a rusty red, besides being covered with millions of filthy sea-vermin who are continually devouring me. I, therefore, hope that you will take into consideration my wretched condition, and, in virtue of my parentage and useful services, will give me a peaceful retreat for the remainder of my days.—And your petitioner, &c., &c.

One Farthing Reward.

Lost some soundings taken by the *Sphinx* on July 26, and of no use to anyone but the owner. Whoever will bring them to Mr. Halpin shall receive the above reward.

Advertisement.

Captain Anderson will sell by auction in the chief saloon of the *Great Eastern* on Saturday, August 12th, at one o'clock, the following articles, the property of various gentlemen leaving their present quarters:—

Lot 1. The *Great Eastern.* For cards to view, apply to Mr. Gooch on board.

2. The goodwill of the Atlantic Telegraph Company.

(This invisible property is in Mr. Field's possession.)

3. A small brass pot, belonging to Professor Thomson.

4. A sextant. (Above 3,000,000 observations have been taken with this interesting instrument by Captain Moriarty.)

5. Some miles of telegraphic cable, taken from a depth of 2,000 fathoms. (Messrs. Canning and Clifford recommend this lot to enterprising speculators. It is calculated that by cutting it into slices of ¼ inch in thickness, sufficient would be realised to pay off the entire debt of Great Britain. No one to bid for less than one yard.)

6. La vie de Jules César. (Recommended by Mons. Despecher for soporific purposes.)

7. Several abstruse calculations, formulæ, &c. (Mr. Varley will explain the use of the same to the fortunate purchaser.)

8. A colour-box, some drawing materials, and some letters of introduction to various American celebrities (literary). (Mr. O'Neil will guarantee the perfect condition of these articles, as he has never used them.)

9. A large quantity of volatile spirits of hope, part over-proof.

10. Two buoys, with rafts, &c. To be seen in or about lat. 51.30 N. and long. 39 W. For cards to view, apply to Messrs. Canning and Clifford. (This lot must be removed by the purchaser.)

11. A complete electric apparatus. Messrs. de Sauty and Saunders.

12. A free pass from Boston or Halifax to Liverpool by any of the Cunard boats, the proprietor, Mr. W. Russell, having no use for the same.

FINIS.

Published by DAY on board the *Great Eastern.*

The Atlantic Telegraph.

Thursday, August 17th, 1865.

The Editor to his Readers.

DEAR FRIENDS,

In a day or two we shall separate, and I cannot part with you without thanking you for the kindness and courtesy with which you have received my poor attempts to amuse you. I hope we may meet again, but in any case I shall ever retain a grateful recollection of the pleasure I have derived from your company. With every kind wish, believe me, yours very faithfully,

HENRY O'NEIL.

Great Eastern, August 17th, 1865.

IN REQUIEM. Augt. 11, 1865. Horace, Epod xi. 3.

Mourn not, my Canning, for th' untimely end
Which for an hour has ta'en away thy friend;
Though lost to sight to memory ever dear,
Ere long he'll rise submissive from his bier.
And then responsive to electric rush,
Shall force the genial current's warming touch.
Still passive, labouring with his ardent soul,
Shall waft a sigh from Indus to the Pole,
Shall make two continents their tribute yield
Of cent. per cent. to Pender and to Field.
And lying mute down in the darkling sea
In every message still shall speak of thee.
Shall tell how, struggling with the wind and wave,
For nine long days indomitably brave

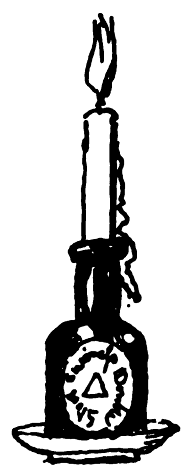
Thou waged'st battle 'gainst his sullen might;
Beaten, again returning to the fight.
Till, conquered by such fortitude and force,
Upward he came and owned his stern remorse.

W. H. R.

Literary Intelligence.

Books are getting so scarce that it is probable a few copies of Martin Tupper's "Proverbial Philosophy" might soon find readers.

We have been much gratified by a private view of the ingenious and elegant mode of lighting up the ladies' saloon recently adopted on board the *Great Eastern*, which is, we understand, the result of long continued researches on the part of Mr. Gooch, Mr. Field, and the head-steward. It consists of two parts. The first is a disk of china or alabaster, slightly concave, which is bordered by a beautiful design of a cable rampant vert on a white ground passant, with Britannia couchant in the middle, having recently given birth to a lion and an anchor. On this chaste pedestal is erected a pillar of a dark green colour, highly polished, of rich metallic lustre, supposed to be Mr. Varley's recently discovered metal "Betty Martinium," much recommended as a medium for spirits. It is circular, and is of the same diameter for four-fifths of its total length, but gradually is rounded off in a graceful curve to a homuncular plinth of true mathematical form, crowned by a simple volute of the same material, in which is inserted the carbonized hydrogen lately discovered by Professor Fatti, of Bologna, by the aid of De Sauty's observations on the lunar equations of adiospere. Annexed we give a sketch of this exquisite apparatus, with the igniferous and luciferous arrangements.



W. H. R.

A novel and economical mode of illuminating London and other cities by electricity has been patented by Professor Thomson. It condenses the currents generated by the use of matches, cigars, cigar lights, lucifers, &c., in the streets by means of a simple but beautiful adaptation of Rhumcock's coil and Papin's digester, and will soon, no doubt, supersede the ordinary gaspipe and collector.

W. H. R.

GREAT RACE BETWEEN MR. FIELD AND MONSIEUR DESPECHER.

(Distance, between London and Paris.)

Latest betting, 2 to 1 on Field. Despecher's backers confident.

MONEY MARKET.

There has been a steady rise in all kinds of Stock, especially in Great Ship shares and Atlantic Telegraph, owing to the mysterious winks of a French gentleman who is said to be in daily communication with the Emperor Napoleon.

QUOTATIONS (literal and otherwise) FROM SHAKESPEARE.

Capt. Moriarty. "Farewell, the sextant and the telescope,
And altitudes from sun and moon and stars.
Poor Moriarty's occupation's gone." *Othello.*

Phantom of cable vanishes.

S. Canning. "So—being gone, I am a man again." *Macbeth.*

C. Varley. "My little airy spirit—see—see—see—
Sits in a foggy cloud and waits for me." *Macbeth.*

C. V. de Sauty. "Hence, wiry Phantom! through thy core
No longer flash the units of Intelligence.
Thy nerves lack continuity." *Macbeth.*

Prof. Thomson. "Who steals my purse steals trash.
But he who filches from me my brass Pot,
Robs me of what enricheth not himself,
And makes me poor indeed." *Othello.*

(*To small piece of iron wire in cable.*)

Clifford. "Hence, heap of wrath! Foul indigested lump!
As crooked in thy manners as thy shape."
Henry VI., 2nd Part.

C. W. Field. "Age cannot wither—custom cannot stale
My infinite prospectusses."
Anthony and Cleopatra.

J. Temple. "A Haw-ser! A Hawser!
My kingdom for a Hawser." *Richard III.*

THE CABLE WORM (*Teredo Cablistrius*).

This singular animal was entirely unknown to the ancients, being called into existence by the manufacture of submarine cables, and showing in all respects the strongest proofs of its parentage. It is greasy and dark in colour, and, from some experiments made by Mr. Varley, it was found if cut into pieces each part was perfect in its electric current, but if a pin was stuck into the whole animal, maliciously or otherwise, the current was broken.

MUSICAL AND DRAMATIC.

Pig and Whistle Theatre.—A miscellaneous entertainment, given at this theatre on Monday evening, drew a large and fashionable audience. It would be difficult to speak in detail of each musical *morceau* provided, nor was the selection less varied than original, for, in most judicious juxtaposition, gems of tragic composition sobered the lively strains of the comic opera. Where all acquitted themselves so worthily, it would be invidious to award the palm oil to any individual performer, but we may be permitted to single out the "Life of a Cadger" for special mention. This tragic masterpiece was grandly rendered by Mr. Parrott, though, at the risk of being deemed hypercritical, we must confess to a strong opinion that it was taken a quarter of a tone too low. This defect, however, was amply atoned for by the magnificent vigour and precision of the appogiatura with which the grand rise at the finale was given from double X below to G in alt. It was indeed a triumph, and richly deserved the burst of enthusiastic applause it elicited from a most critical audience. Not less charming in its way was the celebrated chansonette by Sauerkraut, "Nil Desperandum," which was well declaimed by Mr. Whatman. The substitution of the "a" for the "u" in the last syllable produced a burst of applause from the truly British audience assembled.

Space will not permit us to more than mention Mr. Grogin's Rondo on "Slap-bang, here We are Again," which was excellent, whilst Mr. Perrott's dancing was highly chaste and elegant.

Amongst the distinguished company present on the occasion we noticed Lord Gooch and staff, General Field, Lord de Clifford, Viscount de Sauty, the Earl of London, Bishop Varley, Dr. Ward, Professor Phthomisson, Hon. Willoughby de Smythe, Earl Dudley, Sir Saunderson Saunders, and other swells.

Baron Despecher, Sir W. H. Russell, the Dean of Erin, and O'Neil of O'Neil were unavoidably prevented by serious whist from being present.

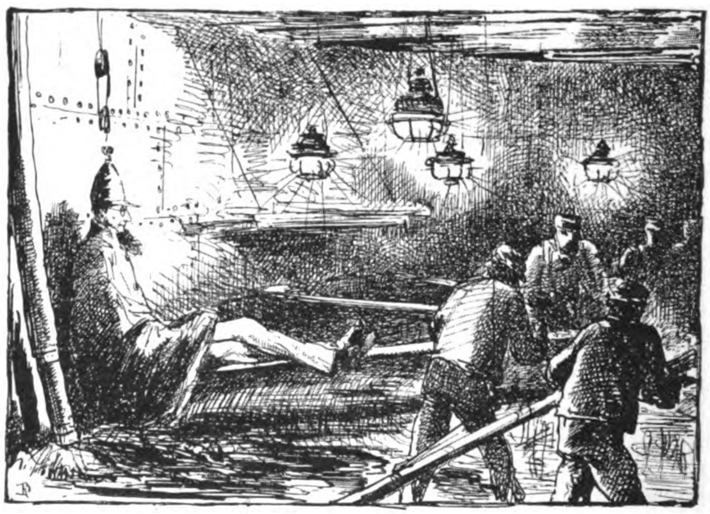
R. D.

Published by DAY on board the *Great Eastern*.

The Atlantic Telegraph.

"Now meteors fright the fixed stars of heaven,
The pale-faced moon looks bloody on the earth,
And lean-looked prophets whisper fearful change,
Rich men look sad and ruffians dance and leap".

Richard 2nd Act 2. scene 4

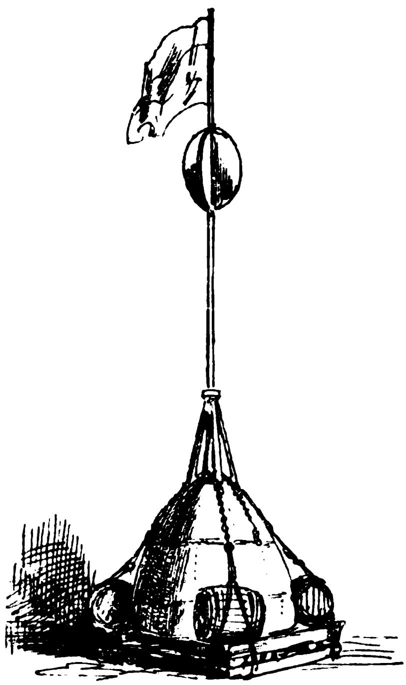


THE · NIGHT · WATCH

No useless sentry within the Tank
Not in slumber or sleep we found him
But he sat like a warrior, stiff on his plank
With his Inverness cloak around him

AIR—"The *Buoy* I left behind me."

Sung by Mr. Canning to the tune, "The girl I left behind me.'



1.

Twas not that I was void of heart,
As some kind critics have defined me,
That I was forced by fate to part
And leave my darling Buoy behind me.

2.

When dozing in my easy-chair
Whilst softest chains of slumber bind me,
Still shall my fancy wander where
I left my dearest Buoy behind me.

A A

3.

And when I'm doomed again to rove,
  In sight of thee should Fortune find me,
I'll greet thee with a father's love,
  Poor wretched Buoy I left behind me.

FINIS.

Published and Printed by Day on board the *Great Eastern*.


STEAMSHIP "GREAT EASTERN" JULY · 1866
A
FIELD
GLASS
BEING A
CABLEISTIC and EASTERN EXTRAVAGANZA
By N. A. WOODS and J. C. PARKINSON
showing the inexplicable and vitrified adventures of a GURNET (h)A MILTON oyster, a BARBEL, and other queer fish. being an UnVARLEYed tale of a Tank, after the manner of THOMSON's SEASONable aid to DANIEL's profits on ELLIOT and BARCLAY's ENTIRE.
BY · PERMISSION · OF AMPHITRITE AND 'ER SON JAMES!
CAN · INGlishmen do more ???????????
GLASS – (a young man from the country) by Mr DUDLEY
NEPTUNE (an old man of the sea) .... COLONEL DE BATHE
GOOCH – (not Daniel Lambert; but A GREAT EASTERN) ...... Mr G·W·ELLIOT
FIELD — (of the cloth of Gold ..) .... CAPTAIN BOLTON
CLIFFORD ("Master" of the "Hunchback") – Supposed to be in love with Susan. LORD HASTINGS
A SEA MONSTER (a A B SEA·one) . Mr H·F· BARCLAY
1st · MERMAID (Poor though Virtuous). Mr POORE
2nd MERMAID (a vaunting female) Mr VAUGHAN
SEVERAL TRITONS, (Right-uns and Tight-uns though Tritzuns) unavoidably absent.
MANAGER · CAPTAIN BOLTON.
LEADER · OF · THE · ORCHESTRA ..... Dr WARD.
The Captain's Gig and the (Gun) Carriages may be ordered at any hour precisely.
R. Dudley Del.

APPENDIX B.

A FIELD-GLASS.

SCENE I. *Curtain rises, discovering* Neptune's *Morning-room;* Mermaids *and* Sea Monsters *discovered in attendance.*

Song and Chorus. (Tune—"Paddle your own Canoe.")

We've travelled about a bit in our time,
And of fishes we've seen a few,
But found it better in every slime
To paddle our own canoe.
Our wants are small, we care not at all
If our debts are paid when due;
We drive away strife, in the ocean of life,
While we paddle our own canoe.

(*Chorus.*) Then love a codfish as yourself,
As these seas you go travelling through,
Aud never dive down, with a tear or a frown,
But paddle your own canoe.

We have no wives to bother our lives,
No lovers to prove untrue,
But the whole day long with a laugh and a song
We paddle our own canoe.
We rise with the tide, and sport in our pride,
And nothing we have to do,
But balance our scales, and waggle our tails,
And paddle our own canoe.

(*Chorus.*) Then love, &c., &c.

Neptune (*outside*). Where are they ?
(*Enter R.*) These presumptuous souls ?
I've searched for them mid sands, in caves, and holes.
Where's Barclay, produce me Smith,
Or Gooch, or Glass, their kin or kith.
Revenge I'll have, on Hamilton it may be,
Nor Pender, nor Edwards with their yachts shall stay me.

Double rap heard at door L. Enter Mermaid *with a slip of glass, and presenting it to* Neptune, *returns and leads in* Glass.

(*Enter* Glass *L.*)

Glass. Oh! Neptune, what's the noos ?
What says our cable ? How's the ooze ?
And, by the way, I've called to-day—
We're going to try another lay.
Neptune (*angry.*) Lay where you will, 'tis not again through me;
You've blocked my channels, and cut up my sea.
Glass. *Sea!* *Saw*, you mean, a modern instance for you!
To *see* if you will—I hope I do not bore you.

(Glass *shows* Nep. *a bit of cable.*)

Neptune. That's very fine, you don't see-saw with me.
You snapped last year! I hadn't had my fee!
Cables have always been my bitter curse;
You make them badly, and you've laid them worse;
My parks are ruined, and you've spoilt my walks,
Hemp, wire, and rubbish all my freedom baulks.
Talk of marine stores, talk of littered stables,
They're nothing like the mess that you call cables.
If you'd but leave them still, my rage I'd smother;
Its trying to "pick up" that makes the bother.
You have often grappled, dredged, and sounded,
And all our joys below you've quite confounded.
Only last year one of your dreadful grapples
Attacked my palàce roof, and spoilt my chattles;
Floating about, you left a sea of *Oxon*,
Not soapy Sam's, but those thrown by your *cox'on.*
In short, I haven't a bower, or e'en a grot,
Which isn't choked with buoy-ropes, chain, or shot.
If you want mud, I'll let you have enough;
I never make a fuss about such stuff,
Though you did last year, and I wish you joy
In finding fun with such a dirty toy!

I rather think it cost you something though;
I needn't magnify, though you did so.
You'd better far by half have me been paying
Than try to steal a march in cable-laying.

Glass. Come, come, you damp old swell, all this is rot;
You've had your innings, and must go to pot.
Why talk this fustian when no press-man's by?
(*Aside.*) We don't encourage them, 'twixt you and I!
(*Loudly.*) Shuter! how about those last cables
Which Neptune here compares to littered stables?
(*Aside.*) Oh! Shuter's gone, Barclay's *Beer*haven bound,
Our great (hem) ex-Pender's nowhere to be found.
So *now I'll* beard him on his standing ground!
Now mark me, Neptune, well! I'll make an offer,
As sure as eggs is eggs I'll ribbons proffer
To all your court—I'll make a ribbon cable!

Neptune. What then, indeed, supposing you are able?

Glass (*mockingly*). What then, indeed? poor fool, ha! ha! he! he!
Why, every mermaid then would side with me.

(*Sees* Mermaids *peeping round corners behind* Nep.)

Glass. I love them all, dear little girls,
With eyes like diamonds, and with teeth like pearls!

Mermaids *rush in and touch his face and eyes curiously, and furiously embrace him, dance round to music, and leave him exhausted in centre of the stage.*)

Song by 1st Mermaid.

Tune—("In a Cottage by the Sea.")

1st Mermaid. Stay in the sea, dear Glass, do stay with me;
Ashurst,* be blowed, stop here and have a spree;
Your wild sea oats were sown while in the *Hawk*,
What made you land at Ryde?

Glass. To take a walk.

1st Mermaid. You've guessed the truth, we're driven to despair,
For lack of ribbons for our golden hair.
It is hard lines, you'll learn from any belle,
To deck our chignons with an oyster shell;
We've lots of corals, jewels too, and pearls,
But sea-weed does not do to bind one's curls.
With the help of your cables we did for a time,
But we've used the last yarn of your very last line.

* The Glass-house.

Glass. Yes, my dear. Here's a shore-end, a beautiful wire;
'Tis from Henley-on-Thames, you can't better desire.
(*Aside.*) And if ever I lay a smaller rope,
I'll come prepared with razor, strop, and soap,
And shave their hair; for this I plainly see
They're so hairbrained they won't let cables be.
Neptune. Oh! this won't do. I'll quickly turn the tables,
Dwellers in Glass-houses can't throw cables.
You scaly minx, you flirt, you water shrew,
Whatever comes to Glass, I'll pay off you.
I'll nail the cable, and the ribbons handle,
Nor leave you silk enough to make a sandal.
(*Loud.*) You think your hair wants braiding! Let me braid it.
1*st Mermaid.* You upbraid me, sir, in the way you said it.
Dear, darling Glass, I fear you'll prove a *tumbler*,
Elliot and you have made a fearful blunder;
Why not have settled it with us above?
Nothing old Neptune's tyranny can move;
You've brought things now, sir, to a pretty pass,
You want a second name to rhyme with Glass.

(*All this time* Neptune *rages—business.*)

Neptune. With gentle strains, let me my chiefs recall,
If row there is to be, I'll ope the ball!

(*Blows trumpet, and rings bell.*)

(*Enter* Tritons *pell-mell; business.*)

1st *and* 2nd Mermaids *come to the front and sing* (Air "La Cachuca.")

1*st Mermaid.* Oh, my! here is a lark now,
How Neptune is swearing;
If Glass runs away now,
My hair I'll be tearing!
Of all lovely mortals
That ever I see,
I think that the palm I'd
Give freely to he!

2*nd Mermaid.* Oh! sister, dear sister, you're in luck indeed,
He's the loveliest gemmon that ever I seed;
His figure so perfect, so neat, and so trim,
In fact, dear, Adonis were nothing to him!

Chorus and dance. Tritons, *&c., look on, keeping time with their hands.*

Neptune *whispers to* 1st Triton, *and points out* 1st Mermaid.

1*st Triton*. What ho! my master,
Prompt to remedy disaster!
"I am here!" (*imitates Fechter*).
Neptune. A stranger here—'tis Glass!
1*st Triton*. "With care!"—I'll break him on the famous wheel.
"This side up" (*pats stomach*), I'll make him feel,
And, like a rat without a tail,
He'll squeal, he'll squeal, he'll squeal! (*Macbeth' business*)
Glass. Break, break, break, break on thyself, old sea.
Don't think, old cove, you'll make "dead earth" of me.
I'm used to kinks; in fact, in them I deal.
"Breaks," too, are known to me, and from the wheel
E'en of Ixion's, nothing worse could come
Than those from which I suffered—see the *Drum!*
In fact, my briny gent, you're no free agent—
You've played a part, but missed a good engagement.
Neptune. Engagement, quotha! don't that picture draw?
You've no commission here—I'll try the law!

(*Sings*) Oh! I want you, stranger, to go off soon,
Oh! I want you, stranger, to go off soon,
Oh! I want you, stranger, to go off soon,
Or they'll set you laughing to another tune!

1*st Mermaid*. Stay; let me oil upon the waters throw.
I've got a document just come below—

(*Begins to read "Instructions between Ship and Shore."*) (*All stop ears and make signs of weariness.* Neptune *blows trumpet, silence restored.*)

Enter Clifford *among the* Mermaids *with paying-out apparatus.*

Stage darkened. Enter Gooch *and* Field *cautiously.*

Field *has his hands full of shares, and* Gooch *has his hands in his trousers pockets, and is smoking.*

Clifford sings. Air—"The Sewing Machine."

I'm sure I've lost my heart;
My darlings, have you seen
That nice young man with his hair in curl,
That works this 'ere machine?
It's used for paying out
Where cables have to be laid.
Oh! keep from seeing him down in the deep,
If you don't want your hearts betrayed.

(*Chorus.*) Oh! I shall lose my heart;
I wish I only had seen
The nice young man with his hair in curl,
That works this 'ere machine.
Sam Canning is his name,
He's pretty well known to you all,
His cables are always laid without blame,
And work still the best of them all;
I wish I could show him you now,
But the sea he never could stand,
So in consequence of this little defect
He's preferred to go overland.

Mermaids *cluster round* Clifford *and hustle him off with the machine. Exit R.*

Gooch. Hark!
Field. Hush!
Gooch. Where?
Field. How?
Gooch. I'll listen!
Field. I'll go for it.
Gooch. Don't leave me! (*holds him*).
Field. In the United States—
Gooch. They're still at par!
Field. Where's Barber?
Gooch. Putting on the screw!
Field. To Heart's content?
Gooch. Tell me, dear Cyrus, are not the banks around Newfoundland those on which the wild thyme blows?
Field. My wildest time was in the tank.
(See Dudley's draught) tho' not on any bank.

Turning from Gooch (*who retires and sits on* Neptune's *throne, and, listening attentively, gradually falls asleep.* (*Half aside*).

Oh! that I could shuffle off this mortal coil,
(*A la Hamlet*) I've furrowed the Atlantic many times,
And 'mid such toil have held convivial dinners. (*See Pamphlet.*)
For me the sparkling wine cup nightly flowed,
And often flowed in vain;
While others to the joys of music clung,
I plied the bottle, but 'twas then of ink.
Prospectuses I drew; percentage showed,
And e'en through worse times on 'change
Could lead grave, bearded men
To wander forth and muse
On the triumphant joys I promised them.

Oh! if we are only able to lay a cable,
Which shall prove stable, across the sea,
We'd desire no better, for we'd need no letter.
To send loving messages 'twixt you and me.
Gooch (*half asleep*). What's his little game?
Field (*considering*). Oh yes, of course, I thought as much; just so;
But then? but oh! but if? but oh? No! no!
If I could only—yes, of course—but then?
I can't consider, how or why, or when,
This must indeed be done, or Nep. shall rue it;
I've made my mind up, and I'm sure to do it.

(*Rouses himself from trance and turns to* Gooch, *who has fallen asleep.*)

Ah! who have we here?
A stranger, when I thought my friend was near!
Can he have overheard my calculations
Laid out to benefit my dear relations?
Between the home of freedom and this land—I mean the ocean—
Which I could never cross without emotion,
Oft as I've tried it, and must try again
Till Britain and my country are no more twain.
(*Turns fiercely to* Gooch). Who are you, sir?
Come, tell me quickly, man!
Gooch. Gooch is my name, styled in some circles "Dan."
Pray call me that, "or any other man."

(*Field examines him carefully.*)

Why, it's George Elliot!! Boy, are you gone mad
To give a Tory's name to Felix Holt, the Rad?

(*They scuffle, when* Neptune *returns with the* Mermaids *and parts them.*)

Song. (Air—"Ballo in Maschero.")

Field. Let Dogs delight to bark and bite,
For 'tis their nature to.
Gooch. And Rads and Tories growl and fight,
Then why not me and you?
1st *Mermaid.* Oh! mortals, you should never let
Your angry passions rise,
Those dirty hands were never, never made
To black each other's eyes!

After song, Glass *and* Neptune *hold private conversation.* Field *approaches with shares.* Neptune *refuses all overtures at first, but succumbs on* Field *showing him a placard marked* 98 *per cent. and a specimen of the new cable.*

Exit Field *and* Neptune, *leaving* Glass *and* Gooch *on stage, with* Mermaids *and* Sea Monsters *around them.*

Glass. Dear friends, I'm not responsible for all this trash!
'Tis Woods and Parkinson have made this hash!
While we've been talking here we've done the trick!
The *Great Eastern's* laid the cable like a brick.
Anderson and Halpin retire with wealth,
And all ill-wishers slink away by stealth;
And the directors bid me say
They mean to give you all four times your pay,
That is, twelve meals instead of three per day!

(Field *and* Neptune *return suddenly. Business.* Nep. *drunk.*)

Neptune. I *always* back the *field*,
It's all his fault I did not sooner yield;
I, like the cables, have sold too, every share,
At such a price as made my brokers stare.
Where's Mrs. Nep.? Why don't she share my joy?
Your child is mine; where's my Atlantic *buoy?*

(*During the above the Cable is lowered and* Mermaids *swing upon it.*)

Neptune. Come out of that, is that how you disable
Our new Manilla twist, galvanic cable?
You're sitting on the messages;
Get up, that's Smith you're stopping,
Not the Director, but Willoughby, the topping.

Finale.

Air—"The Sensation."

Gooch. My dears, beware of sitting on or tampering with the cable.
Field. But give the messages a shove, and help them if you're able.
Neptune. Every time the current flies 'twill give you delectation.
Glass. And every separate shock will cause a curious sensation.

(*Chorus.*) For it's here, and there, and everywhere
We find the symbols flying,
The more they puzzle us to read
The more we keep on trying!
With a dot and a dash, and a dash
And a dot, by Bolton's numeration,
Trying to read it is useless indeed,
But it makes a new sensation!

(*Messages on slips of paper drop from the top on the stage, and are picked up by the* Mermaids.)

1st Triton. Here's Mr. Jones to Mrs. Jones, "My dear, how is poor Bobby?"

1st Mermaid. Here's Mrs. J. to Mr. J., "The child is looking nobby."

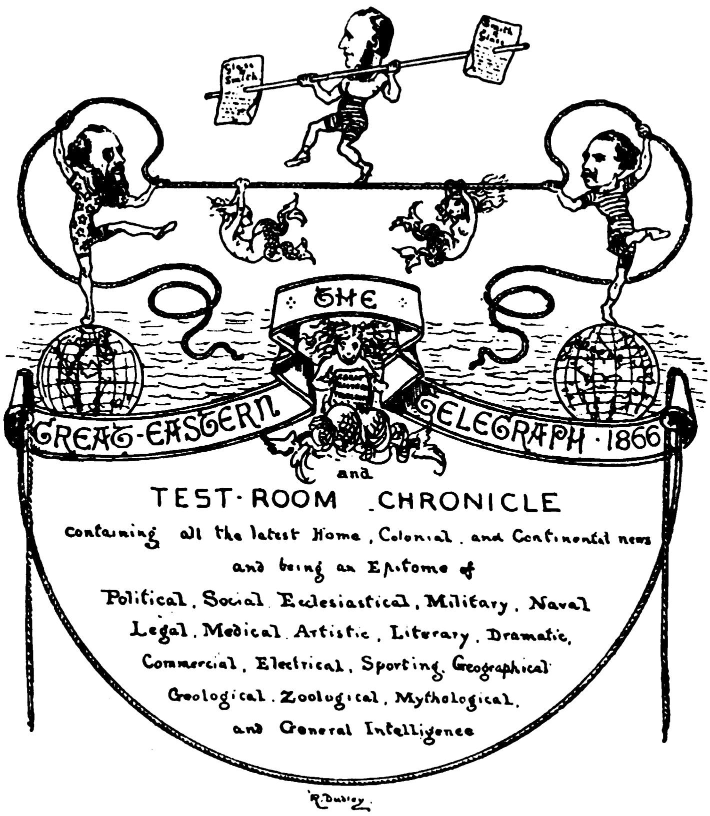
Glass. Here's Uncle Sam to Mistress Vic., "I think we now may laugh, eh?"

Field. Here's Mistress Vic. to Uncle Sam, "Success to Telegraphy!"

(*Chorus and Dance.*)

R.—Clifford. 1st Triton—*L.*
Field. Gooch.
1st Mermaid. 2nd Mermaid.
Glass. Neptune.

Curtain.


THE
GREAT-EASTERN TELEGRAPH · 1866
and
TEST·ROOM CHRONICLE
containing all the latest Home, Colonial, and Continental news
and being an Epitome of
Political, Social, Ecclesiastical, Military, Naval
Legal, Medical, Artistic, Literary, Dramatic,
Commercial, Electrical, Sporting, Geographical
Geological, Zoological, Mythological,
and General Intelligence
R. Dudley

APPENDIX C.

The Great Eastern Telegraph.

Saturday, July 21*st*, 1866. *Lat. N.* 51.18, *Long. W.* 36.1.

TELEGRAMS RECEIVED THROUGH THE CABLE DURING THIS WEEK.

HOME NEWS.

July 15*th*, 1866.

Saturday's News. No alteration in Bank rate. Consols, 87½.

Cork steamer *Osprey* in collision with H.M.S. *Amazon*, for Halifax, off Portland, July 6th. Both foundered; dozen drowned; rest reached Torquay in boats. *Amazon* put helm hard starboard.

July 16*th*.

Cholera broke out at Liverpool; several deaths.

Birmingham Banking Company stopped payment on Saturday. Liabilities over two millions; 800 shareholders.

Darmstadt, *July* 12, 2 A.M. Princess Louis of Hesse gave birth to a princess.

S.S. *Hibernian* left Greencastle for Quebec, Friday 6 A.M.

House of Lords, Friday. Enfield rifles to be converted into breech-loaders.

July 17*th*.

Money market firm. Bank rate, 10. French bonds risen ½ per cent.

Birmingham Bank to be wound up in Chancery; much local but no general suffering. London prices unaffected.

Ex-Chief Baron Pollock to be Baronet.

Lord Henry Lennox is now Secretary to the Admiralty.

Racoon leaves Valentia to-morrow for Queenstown.

July 19*th.*

English Funds risen $\frac{3}{8}$ per cent. Stock Exchange rate for short loans on English securities, 5 and 7 per cent. General rate for good paper, 9 and $9\frac{1}{2}$ per cent.

House of Commons, Monday night. New Ministers took their seats. Attorney-General said it was not intended to proceed with Bankruptcy Bill this Session. In reply to several members, General Peel said rifles altered to breech-loaders would be ready for our troops before end of financial year. Gladstone withdrew Reform Bill.

Verdict of murder against the warder of Brighton for the murder of his wife.

Prince of Wales and Duke of Edinburgh visited "Miautouoneoh," Saturday.

July 19*th* (*late*).

Money well supported at yesterday's improvement. Great Western and South-Eastern Railways Stock, $1\frac{1}{2}$ per cent. Money is easy on Stock Exchange. Short loans on Government Securities, 7 to 6 per cent.

Mrs. Gordon declines to prosecute ex-Governor Eyre.

Mr. Berkeley's ballot motion lost, 197 to 119. Commission to inquire into the condition of mercantile marine; causes of falling off in numbers and efficiency in last twenty years. Mr. Henley objected to Government action. Sir Stafford Northcote objected also, but pledged Government to institute full inquiry into the subject. Motion withdrawn. Parliament to be prorogued August 4th. Lord St. Leonards gave notice of motion that should severance between Church at home and colonies take place endowments of latter should revert to donors.

100 to 80 against Gladiateur for Goodwood Cup. 33 to 1 against Dragon for Derby, 1867.

July 21*st.*

Reform League announced intention to hold demonstration in Hyde Park notwithstanding prohibition of police.

Consols risen $\frac{1}{4}$ per cent.; steady demand for United States Bonds, which have risen $\frac{3}{8}$ per cent. Money plentiful on Stock Exchange; rate for short loans on Government Securities, 5 to 6 per cent.

House of Commons.—Mr. Creay withdrew his Elective Franchise Education Tests Bill. Election Returning Officers Bill for giving no votes referred to Select Committee. Debate on second reading of Mr. Gladstone's Church Rate Bill. Mr. D'Israeli offered no objection to it, but could not pledge the Government to oppose the third reading.

First dinner of the Cobden Club met Saturday at the Star and Garter, Mr. Gladstone in the chair, supported by Earl Russell.

First delivery of breech-loaders to War Office, 4th August.

An influential deputation from Glasgow to Chancellor of the Ex-

chequer, praying for a commission to inquire into working of Bank Act.

National Rifle Association's annual camp gathering on Wimbledon Common going off very merrily. A member of the London Scottish won the Queen's Prize. Common illuminated every night. Theatrical concerts and hospitable festivities in honour of Belgian volunteers.

Grand Volunteer Review in Hyde Park to-morrow (Saturday).

London, *Saturday Morning.* Lord Stanley declared last night in Commons England's policy pacific, observant, free from all engagements.

The War in Germany.

July 14*th.*

General Cialdini is marching upon Rovigo with an army of more than 100,000 men and 200 guns. The Austrians have evacuated the whole territory between the Mincio and the Adige.

July 15*th.*

Paris, *July* 11*th* (*evening*).—Italy has already declared to France not to accept separate armistice. Impressions here very warlike, chances of peace having declined. French fleet on its way to Venice, and French Commissioners ordered to occupy Venetia. Notice sent to headquarters of Prussians to announce armed mediation of the Emperor.

July 15*th* (*late*).

Prussians have declined armistice.

July 17*th.*

Prussians had successful engagement before Olmutz yesterday; captured six guns. Further fighting expected to-day. Austrians withdrawing from Moldavia towards Vienna.

July 17*th* (*late*)

Cialdini occupies Padua and Venice, both on the line of railway connecting Vienna and the Quadrilateral, Venice. Padua is only 23 miles from Venice. The only Austrian troops now having railway connection with Venice are those in Venice itself.

Conflict between Prussians and Federals on 13th. Prussians completely victorious. Federals evacuated Frankfort, Prussians marching there. Among conditions of peace, Prussia and Italy include the re-establishment of Hungary. Count de Chambord's palace at Vienna is offered for sale.

July 19*th.*

Prussians repeating victories and gaining adhesions from small States. The main army, within fifty miles of Vienna, have cut the railway to

Vienna. Austrian army between Prussians and Vienna under Archduke, 160,000 men. Money and archives removed from Vienna to Comorn. Armament of French fleet stopped.

London, *Thursday Morning.*—The Italians occupy Borgo Forte. Fleet left Ancona. *Moniteur* denies Emperor contemplates armed mediation.

July 19*th* (*late*).

Frankfort is occupied by the Prussians, who are advancing on Vienna· Negotiations for a three days' truce between Prussians and Austrians have failed. All Austrian troops still in Vienna have retired to fortresses.

Italy.—Volunteers defeated by Austrians at Condino, 16th inst. Prince Napoleon has gone from Paris on a special mission to headquarters of Victor Emmanuel.

July 20*th.*

Zara, 19*th July.*—Italian fleet, consisting of ironclad vessels and several steamers, opened attack on the Island of Lissa, on the coast of Dalmatia. Result not known.

Moniteur announced Prussia accepted basis arrangement proposed by Napoleon. Agrees abstain from hostilities for five days to await Austrians' reply.

July 21*st.*

Prussians crossed river; marched near Holitzon, Hungary.

Austrians accepted proposal. Prussia abstain from hostilities for five days, during which Austria will have to notify acceptance of preliminaries peace.

American News.

July 15*th.*

China arrived. Money abundant; gold, $153\frac{1}{8}$: exchange on London, 167. Dreadful fire at Portland; half city burnt; 2,000 families homeless; damage ten million dollars.

July 16*th.*

Yellow fever raging in Vera Cruz.

July 19*th.*

Maryland has decided upon extending negro testimony from the courts at Smyrna. Fight between citizens and negroes sundered. A fight between soldiers and negroes at Atlanta. Sweeney urges Fenians to continue their preparations. Cholera gone from New York.

July 21st.

Java arrived, New York, 11th. Creoles revolted against Spanish Government at Puerto Principi, 27th. Four Chilian ships disembarked 2,000 men to assist insurgents.

General Foreign News.

July 16th.

Drammau, Norway, fire, 300 houses burnt, 6,000 persons homeless. July 13th.

July 19th.

Great preparations at Cronstadt for grand reception of Captain Fox, bearing address from American Congress congratulating Czar on his escape from assassination.

Atlantic Telegraph Cable.

Saturday, July 21st, noon (ship's time).

Distance from Valentia.	Distance from Newfoundland.	Cable paid out.	Percentage of slack on whole distance.
952·3 knots.	716·7 knots.	1074·33 knots.	12·8

The Queen's Message.

Received on board the *Great Eastern*, July 27th, 1866.
Commenced receiving, 11.28 A.M.
Finished „ 11.49 „

"The Queen, Osborne, to the President of the United States, Washington.—The Queen congratulates the President on the successful completion of an undertaking which she hopes may serve as an additional bond of union between the United States and England."

The President's Reply.

Received at Heart's Content Station, July 31st, 1866.
Received from New York, 3.42 P.M.
Commenced sending, ... 3.50 „
Finished „ ... 4.1 „
Received in London, ... 4.11 „

Message received of its having been delivered to the Queen at Osborne at 5 P.M.

"The Executive Mansion, Washington, 11.30 A.M., July 30.—To Her Majesty the Queen of the United Kingdom of Great Britain and Ireland.—The President of the United States acknowledges with profound gratification the receipt of Her Majesty's dispatch, and cordially reciprocates the hope that the cable that now unites the Eastern and the Western hemispheres may serve to strengthen and perpetuate peace and amity between the Government of England and the Republic of the United States.

ANDREW JOHNSON."

I certify that the above messages were sent through the Atlantic Cable.

WILLOUGHBY SMITH,
Chief Electrician of the Telegraph Construction and Maintenance Company.

The Great Eastern Telegraph.

Saturday, September 8th, 1886.

THE FOLLOWING NEWS HAS BEEN RECEIVED THROUGH THE 1865 ATLANTIC CABLE SINCE ITS RECOVERY ON THE 2ND INST. TO THE PRESENT DATE.

Sunday, September 2nd.
Lat. 51.2.26 *N.*
Long. 41.53 *W.*

Cholera abating in London.

Cable works splendidly. Seventeen messages have been received during the hour.

Treaty of peace signed between Austria and Prussia. Warlike news between France and Prussia. Prussian Chamber of Deputies, Tuesday. —Bills for treaty of commerce with Italy, and for treaty with England, were adopted unanimously. It is stated that Prince Royal of Prussia intends to fix his residence in city of Hanover.

Fenian agitation increasing in America. Three regiments shortly leave for Canada, and two gunboats for lakes.

Monday, September 3rd.
Lat. 51.34 *N.*
Long. 39.35 *W.*

Cavalry, infantry, and artillery are being sent hastily to Canada to prevent threatened outbreak.

Bank rate now 6 per cent. Reduction of 4 per cent. within 15 days.

Telegraph offices now reopened in Frankfort. Shut during war.

St. Petersburg, *August 30th.*—Great heat prevails; cholera spreading. Emperor left for Moscow, August 30th. Deputation of Russian peasants waited on Mr. Fox, American Ambassador, to offer congratu-

lations in name of whole Russian peasantry. Mr. Fox presented M. G. Wosden, spokesman, with an American flag. M. G. Wosden, thanking Mr. Fox, declared, if necessary, all Russia would unfurl its banners by side of those of the great American Republic.

Rio Janeiro, *August 8th.*—Brazilian Ministry resigned 30th July, consequence of difficulties financial measures. New Government proposes energetic prosecution of war to speedy termination. Paraguayans continue to send fire rafts and torpedoes; do much damage.

Revolutions in Catamarca and Cordoba; Governors of both driven away. Empress of Mexico in Paris; political mission, failure of which *Opinione Nationale* believes will be followed by her husband's abdication.

Tuesday, September 4th.
Lat. 51.2.26 *N.*
Long. 41.53 *W.*

London papers have leaders on great triumph of raising cable. *Times* says, "There is extreme satisfaction in finding any lost treasure, especially when it has cost labour, skill, knowledge, talent, perseverance, and all the valuable and priceless expenditure of mind. The Atlantic Telegraph is triumphant out of all its troubles."

On Monday Anglo-Americans were done at 14¼; closed at 13⅛. Atlantic Pref. done at 90; closed 84½. T. C. and M. Co., 14 ex-div. Bank of England rate reduced to 6 per cent. Money now easy.

Cholera has greatly abated.

Serious insurrection in Canada. Three regiments infantry and 126 hussars leave England for Canada directly.

Foreign News.—Peace treaty between Austria and Italy progresses favourably. Mission Empress Mexico not successful.

London, Tuesday (noon).

Atlantics, 3⅞ to 4⅛; Anglos, 13¾ ¼. Maintenance dis. par.

Weather unfavourable, floods north.

Reported in London that *Monitor*, which made so much sensation, was towed across the Atlantic. Also stated privately that when her two 15-ton guns were fired at Portsmouth one turned over and other broke away.

Statement of Pakington, First Lord of the Admiralty, of paucity of ships causes much fuss in papers as to inefficiency of navy; also much discussion on reorganization of army. Troops going to Canada will have breech-loaders. Successful experiments at Shoeburyness with chilled iron shot and shell.

Rumours that King of Greece will marry Princess Louise, Queen's fourth daughter.

Emperor Napoleon has been very unwell, but better. Drouyn de Lhuys resigned French Ministry of Foreign Affairs. Emperor temporarily given up claim for extension frontier.

Russia dissatisfied with recent turn in Continental affairs, and believed will make some frontier extension towards Turkey. Warm demonstration St. Petersburg in favour of American naval visit.

Wednesday, September 5th.
Lat. 50.11.20 *N.*
Long. 44.59 *W.*

Valentia, *5th September.*—Severe thunderstorm here last night with heavy rain.

Picking up of old cable excites even greater interest than laying new one and is general topic of conversation.

Continued wet weather causes fears for harvest in many parts.

Great Western Railway Report adopted. Cause of Gooch's absence explained amid cheers.

Chatham and Dover meeting very stormy. Investigation Committee appointed. Indignation at improper disposal of £124,000 Debentures.

New Cannon Street Station opened Saturday. All trains go in, but cannot get out. Two hours' ride Charing Cross to City. Great block; much public disgust and swearing.

Trial of ironclad *Bellerophon.* Main speed 13 knots. Goes well under canvas only.

Great Reform meeting, Birmingham; Bright spoke. Beales, President of Reform League, deprived of revising-barristership. Working men's subscription for him.

Great bribery disclosures at Lancaster, Totnes, Yarmouth, and Reigate. Election Commission. Quarter of a million spent in those places in last twenty years. They will all be disfranchised.

Many leaders in London papers on great results likely to follow quick communication with America. *Pall Mall* again urges cultivation of close and friendly relations. *Times* says, "Feeling in America being strange and distant—country only now dissolving—a better understanding must naturally follow."

A direct communication from Canada (addressed to Mr. Field on board) states that "there has not been any outbreak, nor has there been any anticipated."

Foreign News:—

Prussia quietly taking possession of annexed States. Bismarck's

policy of unity of Germany very popular. On exchange of prisoners, Prussia gave up 514 Austrian officers and 35,000 rank and file, 13,000 Austrians being left in hospital. Austria had actually only to give seven Prussian officers and 450 rank and file; 120 wounded left.

Question French evacuation of Rome is now principal point of interest. Resignation of Drouyn de Lhuys no doubt connected with matter. Impression is Bismark has not kept faith with Napoleon in extension of French frontier, and it is believed annexation game will still be played between France and Russia.

Dreadful famine Orissa, Bengal; 15,000 died in six weeks.

London, *Wednesday*, 1 *p.m.*

Atlantics, 4¼ ⅜; Anglos, 15¼; Maintenance, 1¼ dis. to 1¼ prem.

Earl Craven dead.

In Candia arrangements with insurgents expected.

Italian army reduced by 120,000 men.

America.—Davis will shortly be released on bail. Convention at Philadelphia to support President's policy met with success. President received with great enthusiasm at New York. Cholera disappeared New York. Another Fenian raid on Canada preparing for September.

Price gold, New York, Monday, 145¾.

Thursday, September 6th.
Lat. 49.47 *N.*
Long. 48.1.20 *W.*

London, *Thursday*, 1 *p.m.*

Bank rate just reduced to 5 per cent. All securities very firm. Atlantic, 4½ to ¾; Anglos, 16¼; T. C. and M. Co., 1½ prem.; Great Western, 56⅞ to 60; United States Fives, 73⅛ to 73. Wheat improved. Operations of Atlantic Telegraph does not yet check transmission of gold between England and America.

Marquis of Exeter dangerously ill. Bright to attend Dublin banquet, October. Beales, of Reform League, to put up as M.P. for Lambeth.

Attempts to get up North Atlantic Telegraphic line still going on. Introduction of various kinds expected, but public already bled too much. Telegraph from Azores with American capital spoken of in American letters.

A lifeboat, ship rigged, 26 ft. long, called the *Red, White and Blue*, now shown in London, from New York in 27 days, with two men and a dog. One profane writer asserts boat was brought to Channel on board sailing vessel. No further evidence.

Cholera at Naples and Genoa. Austrians leaving Venetia. Better feeling between Austria and Italy.

Nothing yet known as to settlement Roman question. One cause of Drouyn de Lhuys' resignation stated to be his inducing Emperor to open question of frontier with Prussia and Russia, and they declining. French people annoyed at France being snubbed.

London, 3 *o'clock p.m.*—Atlantics, 4½ ¾; Anglos, 16¼ ½; T. C. and M. Co., 1¼ ¾ prem.

Lord Northbrook, late Sir Francis Baring, seriously ill. The battery of artillery ordered for Canada will embark Liverpool to-morrow. Money at call, 4 per cent.

Friday, 7*th September*.
Lat. 49.8 *N.*
Long. 51 *W.*

London, *Friday*, 9 *a.m.*

Bank minimum expected to remain at 5 for a little time. Gold, New York, September 5, 146¼; Five-Twenties, 2.

Report intended marriage of Princess Louise to King of Greece officially contradicted.

Roebuck's speech at Sheffield predicts union of Conservatives and moderate Liberals, and formation of strong Ministry that will maintain power of England throughout the world, and preserve the English people from control ignorance and vice.

Weather in England continues disastrous for harvest. Cattle plague dying out; sheep disease increasing.

Court-martial on Jervis, India, concluded 29th. Finding not yet promulgated.

Health Emperor Napoleon unsatisfactory.

London, *Friday, Noon.*

Atlantics, 4⅝ ¾; Anglos, 16½ ¾; T. C. and M. Co., 1¼ ¾. Confederate Bonds have risen from 4½ to 7½ during last few days.

New York, 30th.—President enthusiastically received. Entertained at banquet. Expressed determination to restore Union. Several Republican Senators have accused President of officially sanctioning assassinations and massacres at New Orleans, declaring his policy would cause another civil war.

London, *Friday afternoon.*

Closing prices. Atlantics, 5¼; Anglos, 16½ 17; T. C. and M. Co., 2 and 3 prem.

Roebuck in Sheffield. Speech; abused Gladstone and late Ministry, and promised support Derby Cabinet.

Three ships with new season's tea left China, May 30th, arrived Downs yesterday.

Five people killed last night Carnarvon Shore Railway.

Chatham Dockyard. Boiler burst, killing two men, injuring others.

Eastern question discussed with increasing interest by Paris papers. Suggestions made for alliance of France, Austria, England, and Italy for settlement, excluding Russia and Prussia.

Wife and daughter of Francis Polzsky, Hungarian exile, who recently obtained permission from Emperor Austria to visit his sick daughter, are dead.

Saturday, 8th September.
Heart's Content.

London, 8 *a.m. Saturday*

£288,000 gold withdrawn from Bank England to-day to pay for Five-Twenty bonds.

Weather England still bad. Harvest's prospects really getting worse.

Rice in improved demand at Calcutta and Bombay, September 4th. Import markets exceedingly low.

Monetary Convention, France, Belgium, and Italy, to assimilate the coinage to that of France.

Speech Mr. Gladstone at Salisbury. Thinks recent events on Continent favourable to peace and prosperity. Said Reform Bill would not be long in abeyance, and he advised cordial acceptance of Reform Bill from present Government if it were an effective and honest measure.

Lord Northbrook, late Sir Francis Baring, dead.

Duke of Edinburgh will shortly be commissioned to *Galatea*, with Commander Hugh Campbell as 1st Lieutenant.

I hereby certify that the above telegrams were sent through the 1865 Atlantic Cable since its recovery on the 2nd September, 1866.

WILLOUGHBY SMITH,
Chief Electrician of the Telegraph Construction and Maintenance Company.

GREAT · ATLANTIC · HAUL

SEPTEMBER 17th 1866

CONTENTINA

OR

THE ROPE !! THE GRAPNEL !!!! AND THE YANKEE-DOODLE !!!!!!!

being a great eastern mystery typifying the instructive story of Cyrus in search of his love

---

BY J·C·DEANE & C·V·POORE

R DUDLEY

TABLEAU I.—A Banqueting Hall in the Palace Hotel.

Evening closes in. Festivities interrupted! Supernatural appearance!! Flight and pursuit!!!

Cyrus . . . . . . *The Original Doodle* . . . . Mr. Dudley.
Sir Morgan Rattler . *An Influential Capitalist* . . . . Mr. Deane.
(with a song)
Sir Sharon Beanpody . . *A Retired Admiral* . . . . . Mr. Chubb.
The Baron Cent. per Cent. *An Influential Guinea-pig* . . . . Mr. Smyth.
Reporter *to the "Kentucky Blunderbuss" and Special Correspondent to the "Field"* Mr. Wynne.

American Minister, Lords of the Admiralty, Dukes, Marquises, Earls, &c., have just retired.

TABLEAU II.—A Blasted Heath on Cable Island.

The Witches' Sabbat. "Pot versus Plot." The Skedaddlers and the Month of June. "Tis my delight on a shiny night in the season of the year."

1*st Witch*, "Glassina," Mr. Deane; 2*nd Witch*, "Elliotta," Mr. Dudley; 3*rd Witch*, "Henleyana," Mr. Poore.

Προφεσσορ Θομπον, ABC, DEF, GHIJ, OK *The Wizard of the North* Capt. Prowse.
Cyrus . . . . *Still Doodle* . . . . . Mr. Dudley.
Companions . . . . Messrs. Chubb, Smyth, & Willey.
Triton . . . . Mr. Wynne.

TABLEAU III. — The Coral Caves of the Atlantic.

The Toilet. "How Happy could I be with either." Light Fantastics. The Combat! the Slaughter!! and the Great Magician!!!

Neptune *An old dealer in Marine Stores, and large holder in Cable Stock* Mr. Deane.
Cyrus . *His 3rd edition, illustrated by Dudley (not Henry M.) all objectionable passages omitted* Mr. Dudley.
Contentina . *Nep's Daughter, plummy and crumby, but not dumby* . Mr. Poore.
Betsy . *A mere-maid—most respectable references given and required* Mr. Vaughan.
Willoughby Smith . . . . *A merciless Critic* . . . . Mr. Smyth.
Sam Canning . . . . *A fortunate Fisherman* . . . . Mr. Chubb.
Dead Earth . . Mr. Willey. Foul Flake . . Mr. Wynne.
Kink . . . . . Mr. B. Smith.
Προφεσσορ Θομσον, ABC, DEF, GHIJ, OK . *A real Potwolloper* . Capt. Prowse.

Conductor and leader of Orchestra . . . . Dr. Ward.
Manager and Prompter . . . . Capt. Hamilton

Performance to commence at 9.30 p.m.

APPENDIX D.

CONTENTINA:

A COMIC OPERETTA IN THREE TABLEAUX.

TABLEAU I.

A Banquet Hall. Cyrus *discovered entertaining his guests* (Sir Morgan Rattler, Sir Sharon Beanpody, *and the* Baron Cent. per Cent.). *The curtain rises to jingling of glasses, laughter, and cries of* "*A song. A song.*"

Sir Morgan sings. Air—"Let the Toast Pass."

Here's to the cable of dear fifty-eight,
Here's to the one sixty-five, sir,
That we left in the sea in a critical state,
For which we intend to go dive, sir.

(*Chorus.*) Let the toast pass,
Long life to our Glass;
His cables are good, be they hemp, wire, or grass.

Here's to the copper so bright and so thin,
Here's to the tinker that filed it,
Here's to the gutta and percha put in,
And here's to the biler that biled it.
Let the toast pass, &c., &c., &c.

Here's to the man who subscribes fifty shares,
Who has helped us with heart and with cash, sir
Here's to the wiry electrical snares
That catch all the dots and the dash, sir.
Let the toast pass, &c., &c., &c.

Cyrus (*rising*). 'Tis just one year, one month, one week, one day, one hour,
Since last of balmy sleep I've felt the power.
I've been up writing every weary night,
And would twice more to fix the cable right.
Atlantic Swells! you're all right welcome here,
Let us do better than we did last year.
Sir Sharon (*interrupting*). I'll trouble you, Sir Morgan, for the Port.
Cyrus (*continuing*). And make a cable of another sort,
With wire of galvan manufactured soon.
The Baron. I'd like to see it, this bright month of June.
Cyrus. Well, then, I'll give ye all a rattling toast:
"The British Lion, who subscribes the most!"
I'll give you Captain Anderson, who has worked with heart and will
To lead us on to victory—to him your glasses fill.
I'll give you Mr. Brassey, and I give you Mr. Gooch,
Who have nobly taken shares—ay, and have paid for such!
But money is not all, my friends,
Before us there are nobler ends.
Sir Sharon. End, indeed! I only wish 'twere here.
The Baron. I suppose the end you mane we lost last year?
Cyrus (*angry*). Take notice now all, while guests at my table,
I'll not hear a word spoke against that dear cable,
'Tis a zone that will bind my Columbia to you.
Sir Morgan (*inebriate*). Zonà mou sas agapou.
Cyrus. A truce to this; if laughing be your aim
My plot will make you do it all the same.
My mode of working now is simply this—
I'll marry Neptune's daughter, pretty Miss;
Contentina's her name; her suitor is Cyrus,
Kalkilated the best of all her admirers.
If Neppy consents, 'twill be awfully nice
A damsel and rope to respectively splice.
Oh! she's a stunner! My heart's Contentina's.
Though the *Odour Colon-ial* is not Jean Farina's.
I crave your assistance, all you round this table,
To marry Neptune's daughter and submerge the Atlantic Cable.
The Baron. Oh! Cyrus, my jewel, may I be blown tight
If it wouldn't be well just to tip us a sight
Of the lady you've talked of so sweetly to-night?
By jabers! she's here, in a dress full of light!

All start from table in amazement. Contentina *appears, like* Marguerite *in "Faust." She is discovered cleaning a codfish.*

Contentina. *Music, blue and red fire.*

Air—"My lodging is on the cold ground."

Oh, my lodging is with the cods' sounds,
  On the flake where they're put out to dry,
The aroma is strange that pervades and surrounds,
  So pungent, so strong, and so high.
I'd care not one straw if my Cyrus were near
  To comfort this damsel forlorn.
I salt all the cods with the brine of my tear,
  As for my true lover I mourn.

(*Air changes to* "Oh come to me when daylight sets."

Guests in Chorus. You've come to us when daylight sets,
  Sweet Contentina!
We're the jolliest boys you ever met,
  Sweet Contentina!
Content—content—tentina,
  Heart's Contentina!

Contentina interrupts. There's a codfish among you, dear Cyrus, my pet,
  Remember Contentina!

She retires, beckoning. All the Guests *follow, as if entranced.*

TABLEAU II.

The Witches' Haunt *on* Cable Island. Three Witches *discovered with cauldron in the middle of stage.*]

1*st Witch.* Round about the cauldron go,
In the poisoned things we'll throw.
Deadish earth from under vaults,
Breeding the worst of electric faults.

2*nd Witch.* Sweltering zinc and coppered rot
Boil thou first i' the charmèd pot.

3*rd Witch.* Cool it with Financial blood,
Then the charm is firm and good.

All. Double! double! toil and strife,
Put in gimlet and sharp knife;

1*st Witch.* By the pricking of my limbs
Something wicked this way swims!

2*nd Witch* (*sings*) Προφεσσορ-εσσορ-εσσὸρ Θομσον σὴ σὴ σὴ σὴ,
Γγῖδες ὀν ἰς βράσσε σλῖδε ἀνδ νᾶιτς φὸρ μὴ.

Προφεσσορ-εσσορ-εσσὸρ Θομσον σὴ σὴ σὴ σὴ
Φόλδερολ φόλδερολ τόλδερολ τόλ τόλ δὴ!

Προφεσσὸρ Θομσον *appears, gliding in on his slide. Music.*

Θομσον. Ὅυ νôυ ὑε σῆκρετ βλàκ ελέκτρικ νàγς
ὝUατ ἰστ ὑε δῶ?

1st Witch. We're spoiling the chance of words or tests,
With black ingredients, destructive pests!

Θομσον. Ἀναὺντ! Bὲγον! Σκεδάδελ! μίσσελ! ὑκ ίτ!
Γίυ πλὲς τὸ μῆ, μέ βôις ἀνδ I ὑιλλ κῦκ ίτ!

(*He kicks the* Witches *off and upsets their cauldron, replacing it with his brass pot.*) *Exit.*

[*Enter companions of* Cyrus.]

Song. *Air*—"Bob and Joan."

1st Companion. I'll bring hemp and wire.
2nd Comp. I'll bring gutta percha.
3rd Comp. I'll bring lightning fire.
4th Comp. And I'll bring something else, sir.

1st Comp. Bid the drums to go,
2nd Comp. Down to Greenwich take it,
3rd Comp. The T. C. M. and Co.
4th Comp. Right cleverly will make it!

1st Comp. Hi for Gooch's ship,
2nd Comp. Hi for Elliot's coal, sir;
3rd Comp. Shares will never dip
4th Comp. While we work heart and soul, sir!

1st Comp. Barclay's Bank is good,
2nd Comp. The great cod bank is better;
3rd Comp. The Penny Post has stood,
4th Comp. But telegrams will fret her!

Enter Cyrus.

Cyrus. Ho! Well done! I commend your pains,
And every one shall share i' the gains.

Song. *Air*—"The young May Moon."

Cyrus. The month of June is beaming, boys,
The cable's chance is gleaming, boys,
How sweet to list to the wiry twist
While Chatterton's compound is steaming, boys.

1st Comp. Then send the current through, my dear.
Come, Willoughby, don't look gloomy, dear,
For you're the best to try and to test,
With you no faults will do, my dear.

Cyrus. Now the big ship rides at the Nore, my dear,
And Canning is well to the fore, my dear,
With Anderson's lot, and C. W.'s plot,
We'll do what was ne'er done before, my dear!

2nd Comp. Then give a loud cheer for Dick Glass, my love,
For he has an eye for each lass, my love;
And as for the man who sneers at our plan,
We'll hoot him and call him an ass, my love.

(*Chorus.*)

Cyrus. Ri fol ol di toodle dums,
Wack fol ol di spoodle gums,
Crinkum Crank
And Stinkum Stank,
Old Cocky the Yankee Doodle comes!

They repeat together in chorus. Business, and scene closes.

Tableau III.

The House of Contentina *in the coral caves of the Atlantic.* Contentina *discovered sitting before a glass, while her favourite maid* Betsy, *is dressing her hair.*

Contentina. This morn as on my snoozy bed I lay,
I dreamed a dream. (Put less pomatum, pray.)
I saw my Cyrus, my selected suitor,
A-walking with Mr. Secretary Shuter;
I saw the ship rent right in twain,
And I sank on the bosom of my swain.
Loud creaked the rivets in the screaming gale,
And I woke, with pins and needles in my tail.

Betsy. And I, madam, had a dream the other night,
Which woke me up in horful fright.
I dreamed as how I was a-dressin' of your 'air,
And puttin' on pomatum layer by layer.
I see my young man's swarthy face
Of your's in yonder mirror take the place.
I screamed aloud and started up in bed——

Contentina. You stupid minx ! that hairpin's in my head !
interrupting.
But dreams, I tell you, have no fear to me,
For Cyrus, well I know, is near to me.
So put up the brushes and combs, my dear,
And make all tidy and clean appear;
Stop talking of dreams and such stupid romance,
Let's enliven the time by a song and a dance.

[*Music from "Dinorah," slow movement. Then the shadow dance.*]

Contentina sings. Now, Betsy, my love, we'll have a jolly, jolly, jolly dance
Before dearest Cyrus he falls by my glance,
Betsy. And I will dance light on my fantastic toe,
And I wish I were twirled by my dear lovin' Joe.

(*Chorus.*)

Contentina. Sing Hi Cockalorum, with a jump, jump, jump, jump !
Betsy. Sing Pons Asinorum, with a thump, thump, thump, thump
Contentina. Sing Hi Kachuka-chuka-chuka, jig, jig, jig, jig !
Betsy. Sing Folderol di diddle diddle, fig, fig, fig, fig !

[*They repeat chorus together and dance.*

Cyrus heard without. What, ho ! my little maids, my water witches,
Unhook this grapnel from my Sunday breeches !

He enters crawling on his hands and feet, with a grapnel fastened to his trousers.

And while you do it, loves, with fingers taper,
Would you oblige me with the evening's paper ?
Contentina, my love, oh come to my arms !
Unhook me, my dearest, dispel all alarms.
Brush off from of my clothes that horrible ooze;
I know now you'll do it, you could not refuse.
Contentina. Indeed I will, though you're a nasty brute
To approach your love in so filthy a suit.
If my father should come there'll be such a row, sir,
He'll have no respect for the man or his trouser.
But here he comes, in his whaly chariot,
So well described by Captain Marryat.
Well, well, I'll do it now, and while I try,
Betsy, with this here wipe do shade my eye.
Betsy (aside). Tis all my eye, her modesty's a sham.
Cyrus. Oh ! Ah !

Contentina. 'Tis done, rise, nephew of Uncle Sam!
Cyrus. I'm much obliged, my dears, and am nothing loth
To take the liberty to kiss you both.
Contentina. 'Twas I unhooked you, and I must upbraid:
You court the mistress, and you kiss the maid.
But, lo! my father, Neptune, comes, retire,
And do your best, my love, to soothe his ire.

Enter Neptune, *reading a copy of "Artemus Ward."*

Cyrus. Do you know me, my lord?
Neptune. Excellent well. You're a salt fishmonger.
Cyrus. What read you, my lord?
Neptune. Artemus—Ward's, Ward's, Ward's.
Cyrus. What is the matter, my lord?
Neptune. Between whom?
Cyrus. I mean the matter that you read, my lord.
Neptune. I read on Forts, sir. Slander, sir; for the satirical navvie says here that "Cyrus Field's fort is to lay a submachine tellegraf under the bounding billers of the oshun, and then hev it bust."
Cyrus. Bust! No, my liege, indeed Artemus lies
As sure as over sea there float the skies.
Bust! No. What message could be sent
From Congress to England's Parliament?
Or from——
Neptune. But stop awhile and cease your gabble,
(*interrupting.*) Such talk as this may suit your common rabble.
Look in this face, and ponder as you gazes,
If 'twere not better just to weigh your phrases.
Don't let your tongue run wild within your jaws,
You're in my kingdom now, beneath my paws;
And if your cable comes within my sway
I'll break, destroy, and bust without delay!
Cyrus. Oh, don't, great king; indeed you didn't oughter
To contemplate or think of such a slaughter.
Neptune. Keep your sheep's eyes from off my lovely daughter,
The heiress sole of all this bright green water
Shall have the sway of everything that floats——
Cyrus. In fact, a kind of a marine Miss Coutts.
Neptune. She'll have for dowry the Newfoundland Banks,
And draw large checks on all your cable pranks;
That is, she will, if she obey my word,
Which I've no doubt she'll do, sir.

Contentina. Like a bird.
I like my Cyrus, and approve my love,
Your rage is impotent my mind to move.
Cyrus. Come to my arms, embrace me, dearest, do!
(*aside.*) Your dad begins to look a little blue.
Neptune. Ha, ha! He, he! Ho, ho! my trident bring.
(*A trident is brought in by a Triton.*)

Did anyone e'er hear so cool a thing?
To take my daughter and ne'er ask my leave.
Oh! How this poor old heart doth grieve!
Ho! Tritons! Blow your cheeks with eastern gale!
I'll cause these cable-sinkers all to quail.
Cyrus. But patience, Neptune, stop a minute, pray.
Let's fight it out in a time-honour'd way.
What say you to a combat, not fought in a hurry,
As they are at the Britannia and the Surrey?
Neptune. Agreed, agreed, indeed the very thing,
But ere we fight, a battle-song we'll sing.

Quartette. *Air*—"The One Horse Chay."

Cyrus. Come, fight with single stick,
For Cyrus knows a trick,
To lick you double quick,
With his one, two, three!

Neptune. Your men they must be tight-uns
To combat with my Tritons,
Whom nothing never frightens
In the depths of the sea.

Contentina. Oh, Cyrus, take this locket,
It was mine, so do not mock it,
And in exchange give up your pocket-
Wipe to me.

Betsy. And here's a little bottle
That your nose with red could mottle,
But will serve to wet your throttle
Ere you swipe at he.

All. Then come on one and all,
Slim or fat, or short or tall,
We'll open quick the ball
If fight there's to be.

Then come on every one,
Come with pistol, sword, and gun,
Stand fast and do not run
From the fight below the sea.

Neptune. Enough of this; come, Cyrus, form a ring,
By "*Bell*" considered to be quite the thing.
Come to the scratch, inspired with fervent hopes,
Come form a ring.

Cyrus. But, hang it! where's the ropes?

Neptune. Ropes! indeed. All right, as I'm alive,
(considering.) In store we've got your rope of sixty-five,

Cyrus. So then my roll-call's here, my men are nigh, sir.
Call yours at once.

Neptune. At once it is. Aye, aye, sir!
Come on, Dead Earth, with cold and clammy claws.
[*Enter Dead Earth, L.*

Cyrus. My Willoughby will fight him, with Electric Laws.
[*Enter W. Smith, R.*

Neptune. Come on, appear, you crookt-backed elfish Kink.
[*Enter Kink, L.*

Cyrus. Whom Clifford will spiflicate, I rayther think.
[*Enter Clifford, R.*

Neptune. And now I'm at ye in another form,
Here's a Norwester. Enter, Mr. Storm! [*Enter Storm, L.*

Cyrus. Approach, my sailor, with your jovial crew,
Clan Halpin, near relative of Roderick Dhu!
[*Enter Halpin, R.*

Neptune. Appear, Foul Flake, whose aspect is unmanning.
[*Enter Foul Flake, L.*

Cyrus. Last, but not least, come on, my Samuel Canning!
[*Enter Canning, R.*

They fight. Music to fighting. Dead Earth, Foul Flake, Kink, *and the* Storms *fight respectively with* Smith, Canning, Clifford, *and* Halpin, *and all the combatants are killed, and when the others are dead* Neptune *and* Cyrus *come to the front and fight.*

Neptune. Cyrus, of all men else I have avoided thee,
But Neptune, ruling god of azure sea,
Disdains to turn his scaly back on thee.

Cyrus. As English Shakspeare says, Lay on, my duffer,
You'll soon find out that you have had enuffer,
For if I can I'll prod you in the buffer.

(*He does so.* Neptune *is mortally wounded.*)

Neptune. Your buffer thrust doth quite o'ercrow my spirit,
Why did you push your sword so fiercely in it?
Lift me (*groans*). I'll speak as long as I am able,
My daughter splice, and also splice the cable. (*He dies.*)

Contentina. And so you shall, and quickly too, my battle Field.
But stay, they shall not die, their fate's not sealed.
What, O! K Θομσον, be for once physician,
And give them shocks all round, my electrician.
(*Enter* Θομσον, *L.*)

Cyrus. My love, my dear, you surely must be mocking,
He's not, I'm sure, the power to be so shocking.
But see. By Jove! I'm wrong.

Contentina. So I was thinking.
They're up and dancing in an eyelid's twinkling.

Θομσον *gives galvanic shocks to all those who are killed and brings them to life.*

Θομσον. Ω σὴ λῦκ θέρ λῦκ Μοριάρτι λῦκ
Δ'υε σῆ θὲ κὰβλε ὀν θὲ γράπνελ ὑκ
'Ω ὑκυμσνὶυι Κάννινγ ὑατ δ'υε σᾶι
Θε κάβλε σίξτιφῖνε ίς νοῦ Ω Κ.
I δῶντ καῖρ νοῦ λὲτ Μάυρι ρᾶγε ἀνδ ράνγυλ
Δ'υε σὴ θὲ σῖδες ὀφ θὲ κάτεναρι τριάνγυλ.

Finale, Air—"95."

Neptune. The grappling rope at length has come,
Winding slowly round the drum,
And on its end, as I'm alive,
Hangs the rope of '65.
For Anderson, who guides the ship,
Let's shout and cheer with a hip, hip, hip;
Moriarty, too, who straight did dive
At the dear old rope of '65.

Cyrus. Experience has done the trick,
And solved the question double quick.
What pleasure Canning must derive
From a sight of the rope of '65.
Then for him give three ringing cheers,
He has proved the best of engineers,
And with his might did work and strive
To recover the rope of '65.

Contentina. And hurrah for our consort ships so true
And Prowse and Batt who helped us too,
And all who worked like bees in a hive
To gain the rope of '65.
Then hurrah for the tanks that held the coils,
And the grapnel the truant that caught in its toils,
And the ship whose fortunes will revive
With the glorious rope of '65.

Chorus. *They all dance.* *Curtain.*

THE END.

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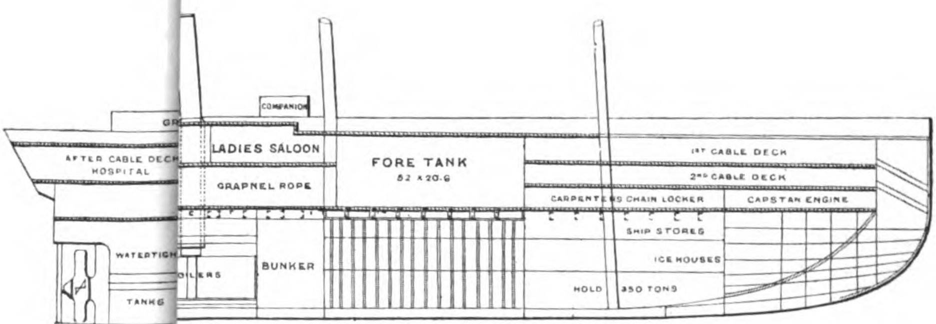

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