OCEAN TELEGRAPHY.

BY GEORGE B. PRESCOTT.

NUMBER I.

If the unexpected discoveries and gigantic works which have been realized during the past half century had not familiarized us with the marvelous, we should consider the accomplishment of ocean telegraphy to be the eighth wonder of the world: a wonder, on account of the almost supernatural results which it furnishes, the numerous difficulties which it has encountered, the physical results which it has produced: and even a wonder on account of the enormous amount of money which has been expended in its development. In discussing the extent of this marvelous system of international communications, it seems proper to consider to whom is due the credit of taking the first steps toward its accomplishment. Up to 1847, no substance suitable for the insulation of a submarine wire was known. During that year, Mr. John J. Craven obtained and experimented with some gutta percha, and discovered its insulating qualities and its adaptability to subaqueous communication. The Trenton, N. J., *State Gazette*, for May 10, 1848, contains the following paragraph: "Gutta percha is now used for insulating telegraphic wires. Mr. Craven has tried it for the old New York and Philadelphia line in the Passaic river, and has been so successful that the company intend to try to cross from Jersey City to New York by laying several wires, thus insulated, under the water." The New York *Tribune* of June 17, 1848, contains the following paragraph: "The wires of the New York and Philadelphia Telegraph have been extended across the Hudson from Jersey City, and are now in successful communication with that place. They are encased in a double covering of gutta percha, and laid on the bottom of the river in the track of the ferry boats."

In 1846, Mr. James Reynolds, of New York, invented a machine for covering wire with india rubber, and during the year 1847 covered a large amount of wire with this substance; but in consequence of the difficulty of drying it (vulcanization of rubber being then unknown), it proved a failure. Early in the spring of 1848, Mr. Craven brought a piece of wire covered with gutta percha to Mr. Reynolds, and asked if he could cover wire with gutta percha with his machine. Mr. Reynolds undertook to do so, and immediately proceeded to manufacture gutta percha covered wire. He covered the cable which was laid across the Hudson river between New York and Jersey City, *which was the first gutta percha cable ever made, and the first submarine wire ever constructed and successfully operated for the transmission of intelligence over a distance of half a mile.*

One of Mr. Reynolds' workmen, named Champlin, shortly after this cable was laid, went to England and communicated the process to the Gutta Percha Company, who at once commenced the manufacture of gutta percha covered wire.

On the 16th of December, 1859, Mr. Charles Vincent Walker, an experienced telegraph engineer, testified before the joint committee, appointed by the British Government to inquire into the construction of submarine telegraph cables, as follows: "I was the first to use gutta percha in England. I advised Mr. Foster, of Streatham, to apply it in our very early difficulties in telegraphing. We purchased and used the first wire covered with gutta percha, on November 11, 1848."

The first submarine cable ever laid in the open sea was laid between Dover and Calais, in 1850. It was a single strand of gutta percha, unprotected by any outside coating, and worked only one day. The next cable was also laid between Dover and Calais, in 1851. This cable contained four conducting wires, was 27 miles in length, and weighed 6 tuns per mile. This cable is still working, after having been down 23 years. The next long cable was laid in 1853, between Dover and Ostend, a distance of 80 miles, and contained six conducting wires, and weighed 5½ tuns per mile. It is still in working order. It 1853 a cable of one conducting wire was laid between England and Holland, 120 miles, weighing 1½ tuns per mile. This cable worked for 12 years. From 1853 to 1858, 37 cables were laid down, having a total length of 3,700 miles: of which 16 are still working, 13 worked for periods varying from a week to five years, and the remaining 8 were total failures.

On the 6th of August, 1858, the first Atlantic cable was laid between Ireland and Newfoundland. The weight of this cable was 1 tun per mile, and its cost was as follows: Price of deep sea wire per mile, $200; price of spun yarn and iron wire per mile, $265; price of outside tar per mile, $20. Total per mile, $485. Price, as above, for 2,500 miles. $1,212,500; price of 25 miles shore end at $1,450 per mile, $36,250. Total cost, $1,249,235. This cable worked from August 10 to September 1, during which time 129 messages were sent from Valentia to Newfoundland, and 271 from Newfoundland to Valentia. The failure of the cable was mainly due to carelessness in the manufacture and subsequent handling. When the cable was in process of manufacture, it was coiled in four large vats, and left exposed day after day to the heat of a summer sun. As might have been foreseen, the gutta percha was melted, and the conductor which it was desired to insulate was so twisted by the coils that it was left quite bare in numberless places, thus weakening and eventually, when the cable was submerged, destroying the insulation.* The injury was partially discovered before the cable was taken out of the factory, and a length of about thirty miles was cut out and condemned. This, however, did not wholly remedy the difficulty, for the defective insulation became frequently and painfully apparent while the cable was being submerged. Still further evidence of its condition was offered when it came to be cut up for charms and trinkets.

The next long cable which was laid was from Suez to India, a distance of 3,500 miles in 1859. This cable was laid in five sections, which worked from six to nine months each but was never in working order from end to end.

The total length of all the cables which have been laid is about 70,000 miles, of which over 50,000 miles are now in successful operation. The 20,000 miles of cables which have thus far failed represent 58 in number. Up to 1865, none of them had been tested under water after manufacture, and every one of them was covered with a sheathing of light iron wire, weighing in the average only about 1,500 pounds per mile. These two peculiarities are sufficient to account for every failure which has occurred. No electrical test will show the presence of flaws in the insulating cover of a wire, unless water or some other conductor enters the flaw and establishes an electrical connection between the outside and inside of the cable; and all cables laid in shallow water should have an armor weighing not less than five tuns per mile.

The core of long submarine cables generally consists of several wires of pure copper covered with alternate layers of gutta percha and Chatterton's compound, the latter consisting of gutta percha, resin, and Stockholm tar. Over this is placed a layer of tarred yarn, and the whole is finally included in a sheathing of iron wire laid on spirally, to give the cable sufficient strength to withstand the strain of paying out, or that to which it may be subjected by the inequalities of the ocean bed. Not infrequently the iron wire of the sheathing is also protected from corrosion by tarred hemp. Figs. 1 and 2 show the construction of the Malta and Alexandria cable. The different layers are so far peeled off as to show the construction. The strand of seven copper wires is shown at the top; then follow three layers of gutta percha and one of tarred yarn, the whole enveloped in the eighteen wires constituting the sheathing. The diameter out in the sea is 0·85 of an inch. Near the shore the sheathing is made stronger, to meet the danger of accident from the dragging of anchors.

Fig. 1.

Including the original 1858 cable, five cables have been laid down between Ireland and Newfoundland, of which only three are now in working order. These three were laid in 1866, 1873, and 1874. The cable of 1865 of a similar type as the above has not been working for over two years.

Fig. 2.

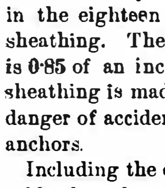
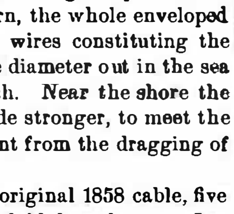


Fig. 3.



The following are the details of construction of the last four Ireland and Newfoundland cables. Fig. 3 shows the section, and Fig. 4 the external appearance and construction, of the 1865 cable in the full size, 1⅛ inch in diameter. Fig. 5 shows the shore end in section. The construction of the 1865 cable is the same as that of all the subsequent ones, with one or two non-essential differences.

Fig. 4.

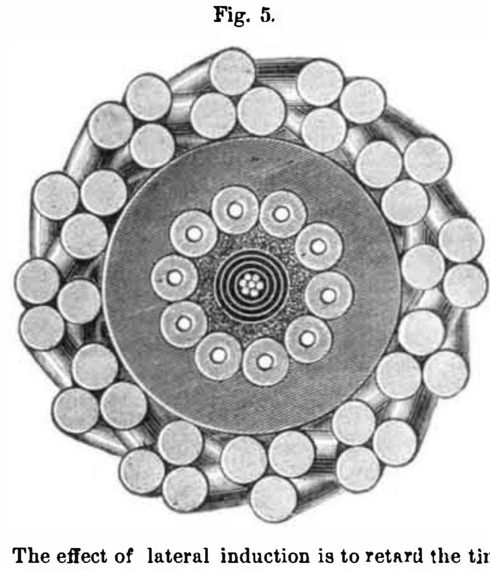
The conductor of this cable consists of a copper strand of seven wires, six laid round one, and weighing 300 pounds per nautical mile, imbedded, for solidity, in Chatterton's compound. Gage of single wire, 0·048 of an inch; gage of strand, 0·144.

The insulation of each cable consists of four layers of gutta percha, laid on alternately with four thin layers of Chatterton's compound. The diameter of core (conductor and insulation) is 0·464 of an inch.

Its external protection consists of ten steel wires, 0·095 of an inch in diameter, each wire surrounded separately with five strands of tarred manilla hemp, and the whole laid spirally round the core, which latter is padded with tarred jute yarn. The weight in air is 35 cwt. 3 qrs. per nautical mile; weight in water, 14 cwt. per nautical mile. Any of the cables would bear eleven knots of itself in water without breaking.

When a telegraph wire at a distant station is disconnected from the ground and placed in connection with one of the poles of a battery, the other pole of which is to earth, a charge flows into the wire at the instant in which the connection is made and, if the insulation of the line is perfect, almost instantly ceases. The needle of the galvanometer makes a sudden deflection, and then returns to its position of rest. If the battery is cut off and the line, at the same moment, put to earth, the needle deflects momentarily in the opposite way, and the charge given to the wire returns and goes to earth. In land lines, this return charge is very slight except upon very long lines, but in submarine cables it is very marked. This return charge shows that a telegraph wire may be charged like a Leyden jar. The wire is the inner coating, the air or gutta percha the dielectric, and the earth or sea the outer coating. The statical charge of which a line of telegraph is then capable shows that the electric force tends to propagate itself not only longitudinally but laterally.

Fig. 5.



The effect of lateral induction is to retard the time of delivery of a signal and to prolong it, so that, although it is a momentary signal at starting, it becomes a prolonged signal at its destination. The mere slowing of the signal would not matter much, provided it was delivered at its destination as sent; but it is not. Each signal at the receiving station takes a longer time to leave the line than it did to enter it. Hence, in a cable, if the sender transmitted at the same rate and with the same apparatus that he does in land lines, the signals would run into each other at the receiving station, and be indistinguishable. Time must be given to allow each signal to ooze out of the cable before another is sent. Retardation increases with the square of the length of the line. The maximum speed of signaling through 2,000 miles of the Atlantic telegraph of 1858 was two and a half words a minute. The copper core had a conducting power somewhat higher than a No. 4 iron wire If the ratio of the thickness of the core to that of the insulating coating be kept the same, the number of words that can be sent varies as the amount of material employed, or as the square of the diameter of the cable. Thus, if a cable be of the same make and of equal length as another, but twice as thick, four times as many words may be sent by it.

The conductor of the Atlantic cable of 1858 consisted of a strand of seven copper wires of No. 22½ gage, weighing 93 pounds per mile, while those of 1865, 1866, 1873, and 1874 have each 300 pounds per mile. The highest rate of speed obtained through the 1858 cable was 2½ words per minute, while through the 1865, 1866, 1873, and 1874 cables they have obtained a speed of 17 words per minute in regular working, and of 24 words per minute upon an experimental test.

THE CONSTITUTION OF THE SUN.

BY PROFESSOR C. A. YOUNG.

Number III—Conclusion

THE ENVELOPE OR CHROMOSPHERE.

The edge of the sun's visible disk is much less brilliant than the central portions, and this fact was long ago recognized by Arago and others, as evidence of an atmosphere of some depth, covering his surface and cutting off a portion of the light.

This lower portion of the solar atmosphere, which is rich in the vapors whose condensation produces the photosphere, and in which most of the dark lines of the spectrum originate, is comparatively shallow, not more, probably, than from 500 to 2,000 miles in thickness.

But it is surmounted to the much greater elevation of some 8,000 or 10,000 miles by the hydrogen and other non-condensible gases which form the rose-colored envelope to which Mr. Lockyer has given the name of chromosphere. This is a sheet of scarlet flame which clothes the whole surface of the sun, and here and there rises in cloud-like forms that ascend to enormous hights above the general level.

The upper surface of the chromosphere is exceedingly uneven, such as fully to justify the expression "a sheet of flame;" for the whole appearance suggests the idea that it is formed of jets of heated gas rushing up from the central fire through countless orifices and rents between the clouds which constitute the photosphere. And yet "flame" is hardly the right word, for in the chromosphere, so far as we can learn, there is no true combustion; the heat does not come from chemical combinations. These solar flames are mere masses of intensely heated gas, absolutely too hot to burn—at a temperature above what chemists call the "dissociation point," where all play of chemical affinity ceases.

Occasionally the up-rising jet attains a very great velocity, and spreads out in the upper regions of the coronal atmosphere into precisely such forms as those familiarly assumed in our own air by smoke and vapors. For many years they were the subject of much discussion, but in 1868 the spectroscope for ever set the question at rest by showing that they are nothing but heated clouds of gas, largely hydrogen. Their spectrum exhibits conspicuously the bright lines of that element, and besides them another very prominent one, which, from the circumstance that its place in the spectrum is very near the two lines of sodium, D_1 and D_2, is commonly referred to as the D_3 line. Many circumstances make it nearly certain that this line is due to some other