SUBTERRANEAN TELEGRAPHS.

CHAPTER XLI.

Subterranean Lines in America, Prussia, Russia, Denmark, and France—Lines in Great Britain—Underground Lines in Hindostan—Mode of Testing Subterranean Telegraphs—Repairing the Insulated Wires.

SUBTERRANEAN LINES IN AMERICA, PRUSSIA, RUSSIA, DENMARK, AND FRANCE.

In America we have had comparatively little experience in subterranean telegraphy. That which we have had has been confined to short distances, not exceeding one or two miles, and then in connection with air lines. We cannot, therefore, give any information from the practical experience of American telegraphy. The experimental line authorized by the Congress of the United States was attempted to be laid in lead pipes. The line was laid in the earth nine miles from Baltimore, and it proved a failure. The wires were No. 16 copper, covered with cotton and shellac, drawn through the lead pipes. When the underground process was abandoned, the wires were pulled out and placed on poles, and the line was thus completed in the month of May, 1844, under the direction of Prof. Morse.

In Europe there have been constructed many subterranean lines, some of which have proved eminently successful, and others total and costly failures.

Prussia was among the foremost to lay down subterranean telegraph wires. They were insulated with gutta-percha and covered with a leaden pipe, fitting close thereto. These wires were buried in the earth about twenty inches or two feet deep. After they had been laid a few years, much difficulty was experienced in working them, and repairs became necessary continually. The interruptions following this necessity for continual examination of the buried wires became annoying and very expensive. The government had all the telegraphs placed upon poles, abandoning the subterranean lines.

While at Berlin, in 1854, through the kindness of the administration of the telegraphs, I was present at the examination of the subterranean wires then being substituted by the pole lines. These wires had been laid under the gutters along the curbstones of the sidewalks. The leaden covering or pipe had been in several places eaten away by the acids of the earth, originating, no doubt, from the slops conducted from the houses into the streets. The gutta-percha insulation had been destroyed, and on bending it would fall to pieces, leaving the copper conducting wire exposed. It was the opinion of those in authority that the gutta-percha had been improperly manufactured, and that the leaden covering had not been placed around it with sufficient care to give the necessary protection.

About the same time Russia established a subterranean line of two wires from St. Petersburg to Moscow, along the railway. Like the Prussian lines, they failed from time to time, and the government was compelled to abandon the underground wires and erect another on poles. The effect on the subterranean wires was found to be the same as was discovered in Prussia. Besides, the retardation of the electric current was sensibly felt between St. Petersburg and Moscow, a distance of some four hundred miles.

In the city of St. Petersburg and for the telegraph to Cronstadt, some twenty miles long, the wires are laid in the earth, with extraordinary care and protection from the salines of the earth. During my visits to Russia in 1854–'57, I never heard of any complaint against the working of the lines laid through the cities.

In Denmark the first lines were laid in the same manner precisely as the Prussian lines, and like results were experienced there. In 1854, the line across the island of Zealand, from Copenhagen to Corsor, was placed upon poles. It was during my visit to Copenhagen, in the summer of 1854, that I observed the retardation of the voltaic current on underground lines, which had been made known by Prof. Faraday. There were, therefore, two obstacles in the way of successfully working the subterranean lines, namely, the non-insulation of the wires and the retardation of the electric current when being transmitted from station to station, the philosophy of which is considered elsewhere in this book.

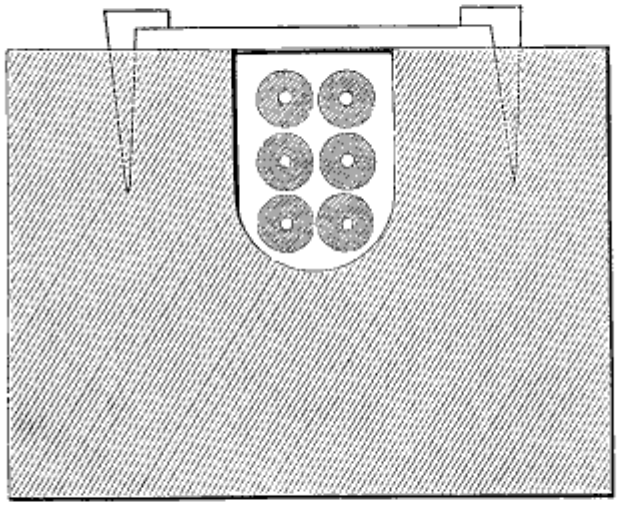
In Paris, the subterranean lines insulated with gutta-percha and lead were at an early day abandoned. By authorization of the Emperor, I was permitted, in 1854, to examine the details of the telegraphs in France, and I was informed that the subterranean lines had been unsuccessful. Subsequently, and

in 1857, I witnessed the laying of some subterranean wires along the Champs Elysees. Trenches were dug about four feet deep and about three feet wide. At the bottom a small trench about twelve inches wide and ten inches deep was dug, for the wires to be placed. There were about thirty wires drawn taut, some two inches apart, along and in this smaller trench, sustained by boards temporarily, and until the trench was filled with asphalt and very dry gravel, as adopted in Hindostan, and hereinafter explained. This gave a solid mass of composition around the wires. I have been informed that the wires proved to be perfectly insulated. They were covered with cotton and shellac. The process was expensive, and it yet remains an experiment.

SUBTERRANEAN LINES IN GREAT BRITAIN.

In Great Britain a very large number of lines have been laid underground, the greatest extent of which has been by the Magnetic Telegraph Company. These subterranean lines extend over England, Scotland and Ireland, and they work with an efficiency and durability fully commensurate with the expectations of the company

Fig. 1.



Upon the lines of this company magneto-electricity, described elsewhere in this work, is employed. Some telegraphers are of the opinion that this species of electricity is more serviceable on underground lines than that which is generated by the ordinary chemical voltaic batteries.

In a communication from the now Sir Charles T. Bright,

the engineer of the above-named company, and under whose direction a very large range of subterranean lines have been constructed, I have been informed that the chief part of the underground lines laid by him have been in troughs of kreosoted Baltic timber, with a lid of galvanized roof iron, overlapping the groove by half an inch on each side of the gauge No. 14 in thickness.

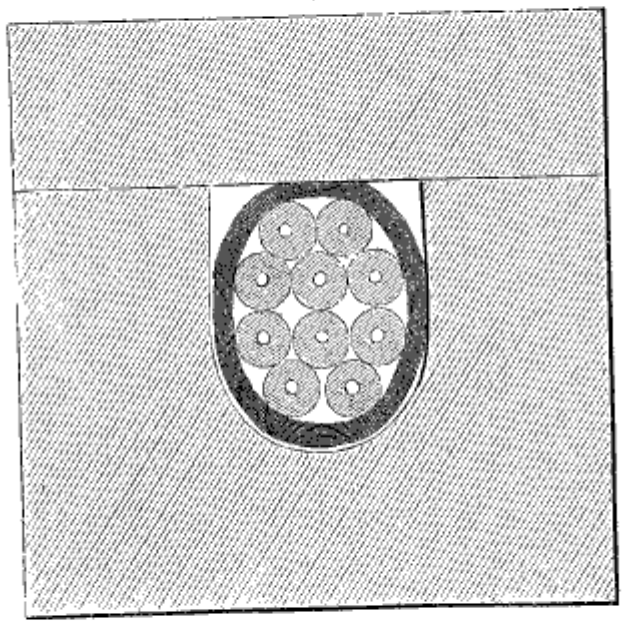
It is drawn with six wires, but in some places ten are laid.

The line from Manchester to London, the first laid, has a wooden lid instead of the iron lid afterward introduced. The district is easy of access by railway the entire distance, and the roads well attended to by the road surveyors (county, not *telegraph* officers), who inform the company of any work, &c., to be done on the line of the wires.

The wires on this line, ten in number, are covered with a serving of tarred jute as an additional protection, especially while laying, the expense being nearly covered by the saving in labor and carriage, in having the wires all together in a rope, and wound on the same drum.

A full size section is given at fig. 2. The two plans are

Fig. 2.



under the ordinary high road; but through the paved streets of towns, where the roads are often opened for laying gas and

water pipes, drains, &c., and where, from the nature of the ground, the full depth of the trench cannot be made, the wires are laid in cast-iron pipes.

The proportion of street work is generally about three miles out of every hundred, but on some lines considerably more. Between London and Manchester there are twenty-one and a half miles laid in iron pipes out of two hundred.

Street wires used to be drawn through solid gas piping of about three inches diameter, the pipes being laid first, and the insulated wires drawn through afterward. In doing this the insulating material was frequently injured; sometimes the wires were broken inside the gutta-percha, or other insulating material, by the force necessary to pull them through, and occasionally they were drawn so tight that, on the slight settlement of the ground, usual after the line has been laid a short time, some of the wires broke inside the insulating material, occasioning great difficulty and expense in detecting the fault.

The great proportion of the faults, however, were only abrasions of the insulating material; and though at the time the wires passed with all appearance of perfection through the ordeal of testing, and the streets were closed, and the pavement reinstated, before long the defects became so manifest as to interfere with the working of the apparatus, and the streets had to be re-opened, and the wires tested through, length by length, for the fault.

The wires required jointing at every other drawing point, and these points frequently proved defective, particularly in the old varnished-cotton method of insulation and others, prior to the use of gutta-percha.

"In 1852," says Mr. Bright, "having considerable lengths of street work to lay, I gave a good deal of attention to the subject, and determined on having the pipes cast longitudinally in two pieces, so that the wires could be *laid in* the under lengths, and the upper lengths then attached, instead of drawing, or threading them through solid pipes. I was the better able to carry this out through the introduction of gutta-percha, rendering the exclusion of moisture for the interior of the pipes of less moment. I tried various forms, rectangular, half-rectangular, with an arched lid, semi-cylindrical, with a flat sole, &c., but the form I found most generally useful and convenient, was that having the upper and under half exactly similar, making together a round pipe. I have the pipes cast in six-foot lengths, and about two inches internal diameter, the substance being three eighths of an inch; the sides fitting together without any flange, but fixed by small bolt and nut fastenings

through semi-circular lugs projecting about one and a half inches from the side; one pair of lugs being about nine inches from the faucet, and another pair two feet from the spigot end.

A pipe of these dimensions is cheaper than the old three-inch solid pipe, and more generally useful, the halves being convenient for fixing to walls, viaducts, &c., over wires needing good protection in such places; and, from its circular form and smallness, it is very difficult to break, as a pick-axe, or other tool, cannot easily strike it full.

The process of laying in the wires is rendered much more expeditious and economical by the use of half pipes. The under halves of the pipes are laid down in the trench, and then a large drum, on which the insulated wires are wrapped, is rolled along over the trench, and the wire is paid off easily and rapidly into its place—the upper parts of the pipes put on afterward, and secured in their places by means of screws through small flanges, left outside for the purpose.

So well has this mode succeeded, that in Liverpool the whole lengths of the streets, from Tithebarn railway station to the office in Exchange-street east, were laid down in a single night (eleven hours), and in Manchester, the line of streets from the railway station in Salford to Ducie-street, by the Manchester Exchange, in twenty-two hours. This was the whole time occupied in opening the trenches, laying down the telegraph wires, and re-laying the pavement.

Mr. Reid has invented an ingenious modification of the half pipe, of the rectangular form, which he has patented, and which we have used. Mr. Henley also has improved on the circular half pipe where it is intended only for subterranean work, which he has also patented; but both of them have top and under lengths differently shaped, and I find my original plan preferable for general purposes. All the telegraph companies have adopted the two-piece pipe in place of the solid round pipe, except the old company. The depth of trench is two feet, but all obstacles, as drains, &c., are passed *under*.

I have had no experience in laying underground wires with single-covered gutta-percha, having, in common with all telegraphic engineers in this country considered the occasional small flaws and air bubbles which occur in single wire, and which are covered and made good by the second coating, a bar to its use, except about stations, &c., where it is not in close contact with the earth, and may be readily examined.

I do not think wire, covered with hemp only, could ever be laid so as to preserve good insulation, equally with that coated properly with gutta-percha.

The wires through the streets of towns used, prior to the introduction of gutta-percha, to be coated with a double serving of cotton, varnished, tarred, and enclosed in a leaden tube, which was passed through cast-iron three-inch piping. The wires were continually getting defective after being laid some little time, and we have only been able to have underground wires of any length in a good state of insulation since the adoption of gutta-percha, and that only within the last five years. Before that, the art of coating wires had not reached its present high state of practice; and in one of its first trials, in the most important lengths of street wires in London, it proved in a few months to be an utter failure.

The cost of laying varies very much according to the hardness of the roads, the price of labor, the season at which the work is done, &c.; for six wires, according to the plan shown in fig. 1, a line along the old mail road varies from £180 to £200. The price of gutta-percha has changed so much as to make estimates very little to be depended on for a long time. For ten wires, according to the plan with wooden lid shown by fig. 2, and covered with hemp, the cost may be set down at about £230 per mile—this is on hard Macadamized roads.

I should never lay less than four wires under ground; the proportionate expense of cutting the trench, and for troughing, &c., being about the same for one as for ten, unless the scarcity of timber be much reduced, the expediency of which I doubt.

Wires laid without some protection cannot be depended on very long, unless in a very favorable country. We have had to relay a line from Manchester to Liverpool, which was originally laid without protection, though sunk to a good depth. A line of two wires laid from Dumfries to Stranraer, in Wigtonshire, by a now defunct company, has never been worked, and never will be.

The depth of the trench is two feet. In towns, and where gas and water pipes, &c., are laid, more according to the level of the mains and service pipes, which we keep under in all cases.

Where the road is rocky we blast out about a foot deep, and lay the wires on iron pipes, packing up the trench with the shale and earth. We have had a great deal of rock crossing Shap Fell; on the road from Liverpool to Carlisle we had a considerable length of solid rock; on the London line about Stoney Stratford, on that from Dumfries to Glasgow, near Abington, and through the Deloin Pass, and a good deal in Ireland.

Our wires are in every case, as yet, laid along the old mail

roads, which have been so carefully made and kept in repair throughout the kingdom for years past; we do not therefore ever pass through *marshes*, as the road would always pass over anything of the sort with a bridge or viaduct. We have no telegraphs in England "across country" without regard to roads. For the same reason, we have no upheaving of the roads from frost; they are all too old and firmly set for any such disturbance. The only danger at all of the sort that I apprehend is the *settling* of the roads in some places in the colliery districts, from seams of coal mines passing under the roads.

Our mail roads always cross by bridges, and our wires are laid over them, frequently close over the parapet, about six inches deep (as the crown of the bridge is generally shallow, to avoid much raise of the level of the road), enclosed in wrought iron solid pipes, about an inch in diameter, by three sixteenths in substance, which are threaded over the wires for the short distance required."

The old Electric Telegraph Company has employed for its subterranean lines, to a considerable extent, glazed earthen pipes of the best stoneware, three inches in diameter. They cost about £60 per mile, and in the opinion of some telegraphers are preferable to the iron pipes. They afford all the mechanical protection required, and are totally indestructible by corroding agents of any kind. Glazed earthenware pipes are also employed on the Hindostan lines, such as figs. 3, 4 and 5. Like these patterns have been prepared troughs of ordinary brick clay. The rectangular or tubular shape, open at the side, is to be preferred where hydraulic cements are procurable. The closed tubes, or pipes requiring the wire to be drawn through, are not to be used when the other forms can be procured, in the opinion of telegraphers generally. A very simple, cheap and effective protection is afforded by common tiles of the shape shown in figs. 6, 7, and 8. They are grooved along the

Fig. 3.

Fig. 4.

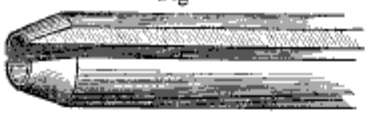


Fig. 5.

Fig. 6.

Fig. 7.

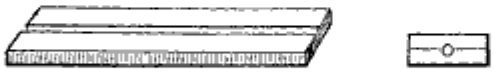
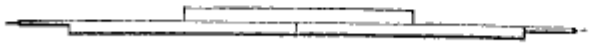


Fig 8.



centre, and applied break-joint fashion. Fig. 6 represents the wire enclosed in the trough. Figs. 7 and 8 show how the pieces are put together. The pieces are laid as represented, and fastened with cement or mortar. The gutta-percha insulated wire should be covered with spun yarn or tape saturated with tar.

Besides the use of earthenware pipe, slate protectors have been suggested.

Wooden troughs, made of good and durable timbers, pickled in sulphate of copper or chloride of zinc solution, have been considerably used.

SUBTERRANEAN TELEGRAPHS IN HINDOSTAN.

An underground line of twelve miles has been laid in Hindostan from Calcutta to Bishtapore, in a peculiar manner, and with perfect success. Dr. O'Shaughnessy describes the connecting of this line thus:

"For these twelve miles the line is made of round rod iron, three eighths inch diameter, made up from separate lengths of 13 feet 6 inches each, welded together end to end. This was first done at the iron bridge works at Alipore, so as to form lengths of 200 feet. These, in bundles of ten rods, were carried on men's shoulders along the road, laid end to end, and welded up by a party of native blacksmiths, with a portable forge in charge of a European sergeant. A mile daily was thus done with ease.

The rod being supported on bamboo stakes, three feet above the ground, was next coated with two layers of Madras cloth, saturated with melted pitch, softened with a due admixture of tar, so as to form a flexible coating when cool. These coatings were applied in spiral bands, each 2½ inches wide, wound round like a surgeon's bandage, and overlapping each other in opposite directions, so as to give four layers of a pliable insulating envelope, quite impervious to water and saline matters, and not liable to decay or to attacks of white ants or vermin of any kind.

This coating was applied by a native *tindal* (boatswain) with twenty *lascars* (sailors), at the rate of 2,000 feet daily.

To protect the rod still further, chiefly from mechanical injury, it was finally laid in a row of thin roofing tiles, of semi-cylindrical form (the *koprile*, of Bengal). These were half filled with a melted mixture of three parts dry sand and one part rosin by weight, and when laid, the whole was filled up with the same melted mixture. When cold, the mass is as hard as brick or sandstone, and perfectly impermeable to water when well prepared.

The sand used for this purpose must be sifted to free it from particles of straw, leaves and sticks; next thoroughly washed, to remove clay and saline matter; thirdly, dried perfectly over a furnace of iron plates, heated by a strong fire. When quite dry and cool it is stored in barrels for use.

The rosin and sand, weighed in separate bags of 10 pounds rosin and 30 pounds sand, are sent on the road and melted in iron bowls (*kuroys*), on temporary fireplaces by the roadside. the mixture is thoroughly incorporated during the melting of the rosin, and poured on the tiles from iron ladles with long handles."

MODE OF TESTING SUBTERRANEAN TELEGRAPHS.

Having now explained the different modes of laying a wire underground and insulating it for telegraphic service, I will add a few explanations in regard to the mending of the gutta-percha insulated wires, and the testing of the line to discover faults in the conductors. Fig. 9 represents a test-box, made of iron plates, resembling when screwed together a mile post. The small door is fastened with a lock. The line wires, at given distances, for example, every mile, more or less, are brought into these test-boxes, where they can be examined and the place of difficulty ascertained, whether to the right or to the left. Fig. 10 represents the wire, insulated with gutta-percha, separated ready to be tested. The flat pieces above are brass, and fastened below to the copper wire, covered by the gutta-percha. Fig. 11 represents the two wires fastened together by the double screw at the top of the figure. The projecting nipples seen in fig. 10, fit in the holes seen in the respective pieces, which, together with the double screw in fig. 11, unite the wires tightly. In order to prevent the brass pieces from oxydating, or from causing an earth circuit, a gutta-percha cap is fitted on as seen in fig. 12. All the wires brought into the test-box are thus

Fig. 9.

Fig. 10.

Fig. 11.

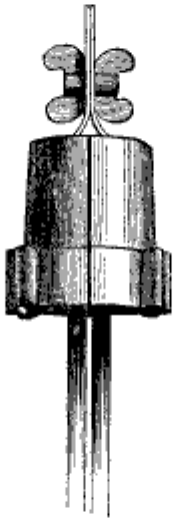
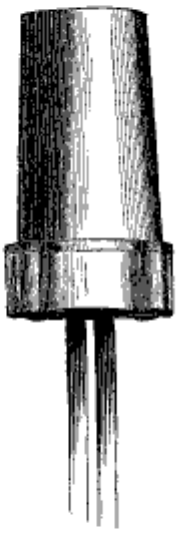


Fig. 12.



arranged. It will be seen from these explanations that it is an easy matter to discover in what direction the fault may be on any wire desired. With instruments nicely adjusted, as to resistance, nearly the precise spot or place at fault can be discovered at one of these test stations, and then by measurement from a marked place, the fault can be discovered and remedied in a few hours.

REPAIRING SUBTERRANEAN TELEGRAPH WIRES.

When the wire is found to be injured as to insulation, it is immediately repaired. This process is executed in the following manner. Figs. 13, 14, and 15, will enable the reader

Fig. 13.

Fig. 14.

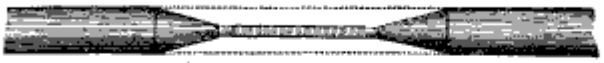


Fig. 15.

to understand the mode of splicing a subterranean wire. Fig. 13 is the two ends spliced, having first been cleaned with a file or a piece of sand paper. The ends of the wire it will be

seen, have been filed so as to lap over each other, and yet form but the thickness of the wire. After the ends are thus placed together, a very small copper wire is then wound around the place of splice, as seen by fig. 14. When thus prepared, with a spirit lamp the solder can be spread upon the joint uniting the small with the larger wire. If the solder is not carefully spread on the splice the wires may separate as seen by fig. 15. which ought never to be the case. After the wires are well united, the gutta percha is put on and completes the insulation by uniting it as represented by the dotted lines in fig. 14. This process is as follows:

Have in readiness a few strips about three eighths inch broad of very thin gutta-percha sheet, also a little warm gutta-percha about one eighth inch thick, one or two hot tools, and a spirit lamp.

Remove the gutta-percha covering from along the wire no further than may be necessary for making the joint in the wire. Having joined the wire, warm gently with the spirit lamp the bare wire and joint and the gutta-percha near to it; taper the gutta-percha over the bare wire until the ends meet; warm this and immediately apply one of the strips of thin sheet in a spiral direction over it. Press this covering well on until cool, then, with the spirit lamp, carefully warm the surface and proceed as before to put on a second strip of the thin sheet, observing to wrap it in a direction reverse from the first strip, always making the commencement and termination of these coverings to overwrap the previous ones. It is safer to perform this operation a third time.

Next take a piece of the warm one eighth inch sheet and cover over the coats of thin sheet, again overwrapping the original covering of gutta-percha, which should be heated so as to insure perfect adhesion. Press it well on as it cools, and when cold, or nearly so, finish off the joints with a warm tool, working well together the old and new material at each end.

Lastly, and in general, avoid moisture, grease or dirt, and be careful not to burn the gutta-percha, which would prevent proper adhesion.

I have been quite particular in these explanations in regard to the mending of wires insulated with gutta-percha. Some of the lines, however, in England use wires wrapped with cotton thread, and well coated with a mixture of tar, resin, and grease. This coating forms a perfect insulator, in the opinion of some telegraphers. But some ten years ago I employed this composition to saturate osnaburg coverings to submarine wires, and I did not find it to answer.