PARATONNERRE, OR LIGHTNING ARRESTER

CHAPTER XL.

Lightning on the Telegraph—Highton's Paratonnerre—Reid's American Paratonnerre—Various Apparatuses on American lines—Attachment of Paratonnerres at River Crossings—Incidents of Lightning striking the Line—Steinheil's, Fardley's, Meisner's, Nottebohn's, Breguet's, the French, and Walker's Paratonnerres.

LIGHTNING INTERRUPTING THE TELEGRAPH.

Early after the establishment of the electric telegraph, its operation was found to be materially interfered with by atmospheric electricity. So great and so frequent were the interruptions that it commanded at once the study of the ingenious telegrapher to devise an efficient remedy for the serious evil. In Europe contrivances were invented and successfully applied. The rapid spread of the American lines presented opportunities for witnessing the effect of atmospheric electricity in different latitudes and longitudes. Lines traversing several hundred miles, north and south, were subjected to repeated and almost constant interruptions. The adjustment of the apparatus had to be changed from moment to moment. In the transmission of a word, it was quite common to change the adjustment for each letter. The hand had to be on the adjusting screw nearly all the time. In some seasons such impediments are experienced at the present day, and it is not supposed to be possible to overcome the difficulties in question. The sudden charge of the wires with electricity, commonly termed lightning, frequently proves to be of serious consequence not only in the working of telegraph lines, but also in its destruction. It has been very destructive to the apparatus, sometimes totally destroying it, and at other times it has temporarily rendered ineffective the electro-magnet.

In America, the lightning has been more fatal with the telegraph lines than has been experienced in Europe. In

England it has been occasionally very destructive, and many of the wire coils or bobbins have been torn to pieces by it.

Among other circumstances, Mr. Highton, a distinguished telegraph electrician, has related the following:

The lightning struck the line, and traversed it through one of the stations, and in its passage it did considerable damage, and especially to the telegraph instrument at the station, fusing some of the metal work therein. It thence proceeded by the telegraph wires to the ground at the next station, Thrapston, a distance of more than eight miles. At this station also considerable damage was done to the telegraph instrument; several of the wires, and some of the metal-work, were fused.

Fig. 1.

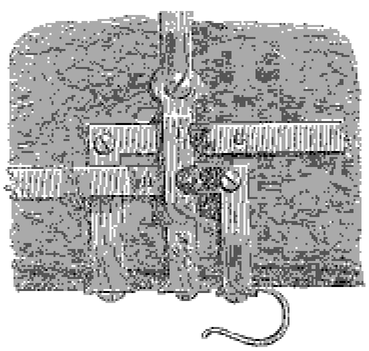


Fig. 2.

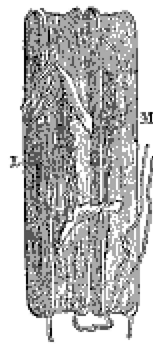


Fig. 3.

Fig. 1 is a top view of part of the telegraph apparatus at the Oundle station of the London and Northwestern Railway. The strips of brass G and H were in metallic communication with the wires on the line. The strip K was in communication with the ground at Oundle. The strips G and H were separated from K by an interval of about one-tenth of an inch. A flash of lightning was intercepted by the wires on the line, and conveyed to this point; but, although the strips G and H had metallic communication with the earth at Thrapston and Peterborough, yet the resistance offered to the discharge along these directions was such as to cause a large portion of the electric fluid to shoot through the interval between G K and H K, and to fuse the metals, and produce the effects shown at G, H, I, and K. The upper bridge-strip I, K, and the portion of H under it, have both been melted, and are now firmly united together by the molten metal. The strip G had its surface fused, and the strip I was melted also. The wood is scorched from L to M. There is also a melted spot at N, on which another portion of the apparatus rested.

Fig. 2 is a front view of one of the coils of the telegraph instrument at the Thrapston station of the London and North-western Railway.

This coil was burnt and fused on the 1st of August, 1846, by the same flash of lightning which damaged the apparatus shown in fig. 1, although it was more than eight miles distant therefrom! The lightning was conveyed along the wires of the telegraph. The small wires in this coil were fused together, and the silk and cotton burnt off, as shown at L and M.

Fig. 3 is a back view of the other coil in the telegraph instrument at the Thrapston station. Damages similar to that in fig. 2, will be observed at N and O. The fine wires were all melted together, and the silk and cotton burnt off.

HIGHTON'S PARATONNERRE.

Such occurrences as the above have been frequent in both Europe and America, and to avoid them or to prevent the damaging of the telegraph apparatus, divers contrivances have been from time to time applied. In the year 1846, Mr. Highton successfully employed the following arrangement:

A portion of the wire circuit, say for six or eight inches, is enveloped in bibulous paper or silk, and a mass of metallic filings in connection with the earth is made to surround such covering. This arrangement is placed on each side of a telegraph instrument at a station. When a flash of lightning happens to be intercepted by the wires of the telegraph, the myriads of infinitesimally fine points of metal in the filings surrounding the wire at a station, and having connection with the earth, at once draw off nearly the whole charge of lightning, and carry it safely to the earth. This arrangement at once prevents any damage to the telegraph instrument. Not a coil under Mr. Highton's charge has been fused where this plan has been adopted. The cheapest method is as follows: Line a small deal box, say six or twelve inches long, with a tin plate, and put this plate in connection with the earth; fill this box with iron filings, and then surround the wire (before it enters a telegraph instrument) with bibulous or blotting paper, as it runs through the centre of the box. All high-tension electricity collected by the wires will at once dart through the air in the bibulous paper to the myriads of points in the iron filings, and thence direct to the earth, and thus the telegraph instrument will be rendered incapable of being damaged even during the most fearful thunder-storms that may occur.

REID'S PARATONNERRE.

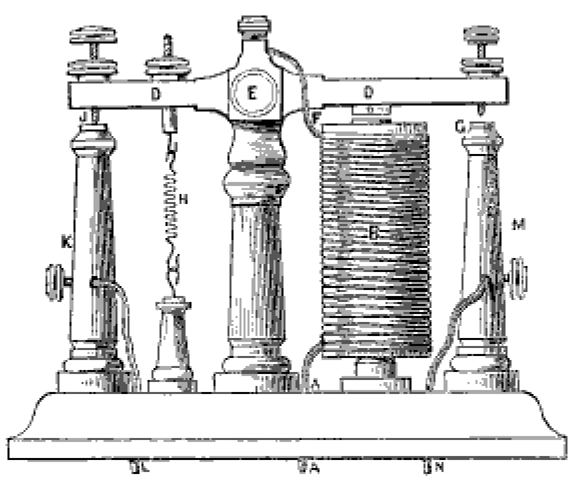
Early in the year 1846, Mr. James D. Reid, an expert telegrapher at Philadelphia, devised a contrivance for arresting the lightning. This gentleman had opportunities of witnessing the effect of the most severe thunder-storms upon the wires. Many times, when the heavens without seemed to be free from storm, his apparatus gave signs of heavy lightning, miles distant. These charges sometimes were sudden and destructive. The frequency of such accidents caused Mr. Reid to perfect the following arrangement, which was applied with the most complete success. The Franklin Institute of Philadelphia awarded to Mr. Reid a silver medal in consideration of the distinguished service thus rendered in the advancement of the telegraphic science. Mr. Reid describes the apparatus as successfully employed on the telegraph lines by him, as follows, viz.:

Description.—K and M are pillars of brass, secured upon a wooden platform, six inches apart.

The wire marked L leads to the telegraph machinery of an office.

The wire marked N leads to the earth, and is used as a lightning-rod, and of large size.

Fig. 4.



D D is a beam of brass, swung over the brass pillars named, in or near the centre, by two pivot screws, of one of which, E represents the head.

J and G are adjustable screws on the extremities of the moveable beam, and so adjusted that only one point of one screw can touch one of the brass pillars at a time. Thus, when J is down, there is no metallic contact at G, and *vice versa.*

H is an adjustable spring, which not only has to overcome the equipoise of the brass beam, producing metallic contact at J, but resists the ordinary magnetism of a battery current, passing through the magnet marked B, when that magnet is placed in the circuit of a telegraph line.

C C are the faces of the magnet and armature, the latter being affixed to the moveable beam D.

In placing this apparatus into use, the air wire, as it is usually called, or wire coming in from the line, is connected to the wire of the magnet B, marked A, which is coarse, that is, number sixteen, silk or cotton covered wire.

The circuit is continued by connecting the other terminating wire of the coil of the magnet to the moveable beam D, which being brought in contact with the brass pillar K, at the point of the adjusting screw J, leads to the wire marked L, which connects immediately with the machinery of the office.

During all ordinary circumstances, the apparatus thus described remains quiescent, the spring H being so adjusted that the current of the line has no effect in moving the beam, by the production of magnetism at C.

When, however, a flash or charge of atmospheric electricity enters the office, it having to pass through the magnet coils B, before reaching the office machinery, magnetism sufficient is instantaneously produced to overcome the power of the spring H, separate the connection at J, and establish, for an instant, connection at G, where the atmospheric electricity is at once discharged.

No sooner has this been effected than the spring H immediately restores the connection of the line.

This apparatus has been proved on many occasions, and once, during the existence of a severe storm, before a committee of the Franklin Institute at the telegraph office in Philadelphia.

The objection urged against it, that the exceeding rapidity of the progress of the fluid would prevent the apparatus from changing its direction, as contemplated by it, and which appeared to have a reasonable basis, has no reality in the experiment. Communication has been maintained among most violent storms thereby, when adjacent magnets were destroyed.

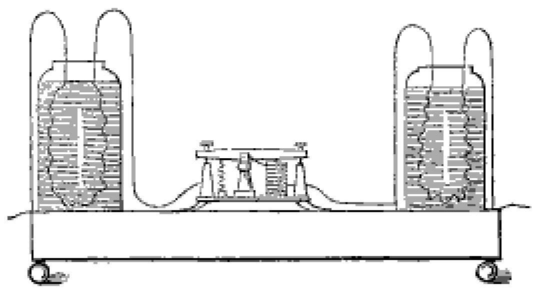
The following is the manner in which it was arranged at the exhibition in the Chinese Museum, in 1846. The vases were intended as an additional means of discharging the wild electricity of the atmosphere. To explain:

The vases were filled with water, acidulated slightly with sulphuric acid.

The wires from the line on the one side, and from the machinery of the office on the other, as well as those leading from each side of the apparatus which was placed between the jars, were of good large size.

On the contrary, the wire made to traverse the water in the spiral form, shown in the sketch, was of the finest description.

Fig. 5.



This small wire, if immersed, would at once be melted by the passage of an electric flash. Immersed, however, it was hoped that the fluid would use the acidulated water as part of the circuit, decomposing it in part, and being itself partially decomposed, and tamed by explosion at the surface.

This, I have no doubt, it did to some extent, but deeming the apparatus sufficient without them, I never subjected them to careful trial.

If lightning could be made to discharge itself on the surface of a body of water, it would be an easy mode of drawing off this grand enemy of magnets, and of the regular operation of the lines.

VARIOUS AMERICAN PARATONNERRES.

Various other contrivances have been resorted to by the telegraphers of America to effect the protection of the apparatus, and many of them have operated with success. One of these was the employment of a very small copper wire, about three feet long, placed in the line circuit before the electro-magnet. Within an eighth of an inch of the large line wire, an earth wire was placed. When thus arranged, the lightning would burn the small wire and leap to the earth wire, and thus pass off. Sometimes the earth wire was surrounded spirally with the small insulated copper wire. I never knew of any of the apparatus to be burnt when thus protected. There was, however, a disadvantage in the insertion of the small wire in the line; it served as a resistance or hinderance to the flow of the voltaic current.

Some lines, both in Europe and America, have used a protector made of two brass plates, with saw-teeth edges, screwed to a wooden base, so that the teeth would nearly touch. One of the plates is in the line circuit, and the other is connected with the earth. Between the brass plates and the coils or bobbins is placed a very small copper wire, less in size than the wire around the coils. The lightning enters the office, passes through the brass plate, and burns the small wire. The plus charge passes off to the earth wire, the saw-teeth serving as attractive points for the lightning to leave the brass plate and pass off to the earth. This arrangement has served quite successfully.

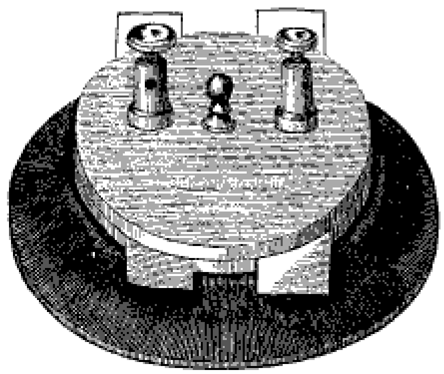
Another form of paratonnerre has been used on some of the lines, called the "brush protector." It is made in the following manner: A piece of leather, about four inches long and two inches wide, is pierced with small wires, making a brush. The leather is then fastened to a brass plate, so that the wires under the leather will touch the brass. Another plate with the wire brush attached is placed so that the teeth of small wires will almost touch those of the other. One of the brass plates is in the line circuit, and the other is connected with the earth. When the lightning strikes the line, it passes from the wire teeth of the one brush to the other, and thence to the earth.

The preceding form of paratonnerre has not been in very general use, and in fact all others have been superseded in America by the following arrangement. This ingenious contrivance was gotten up by Mr. Charles T. Smith, an experienced and distinguished telegrapher of America. Mr. Smith having been engaged in manipulating the telegraph in different parts of America, he, at an early day, found it necessary to devise an arrangement to parry off the continual presence of atmospheric electricity, and to that end he invented the paratonnerre represented by fig. 6.

Fig. 6 represents the circular form adopted by Mr. Thomas Hall of Boston. Many lines use the same appliance in an elongated form. The arrangements consist of two brass plates separated by a thin piece of silk or paper. The upper plate is in the line circuit; the wires are attached to one of the brass binding posts; the earth wire is attached to the under plate.

Between the plates are placed two narrow strips of paper. When the lightning strikes the line, it enters the upper brass plate and passes to the under one, and in its passage through the paper it burns many small holes. The plates are about

Fig. 6



two and a half inches diameter and one sixteenth of an inch thick; they are fastened to a small board, as seen in the figure, and the board is attached to the wall or to the table in the station. This form of paratonnerre is in universal use on the American lines, and it has proved to be the most perfect in the attainment of the desideratum.

ATTACHMENT OF PARATONNERRES AT RIVER CROSSINGS.

A similar arrangement as the above has been placed on each side of river crossings, to preserve the cables from destruction by lightning. I have had several cables destroyed by lightning. On one occasion, the line wire was struck by lightning about a mile distant from the cable. Several of the poles were torn to pieces. The current passed on to the cable, and then from the conducting wire to the water, cutting a longitudinal incision through the gutta-percha some ten feet long, as clear as if done with a razor. At another time, I found the gutta-percha very much swelled, rough and porous; and at another time, the gutta-percha was pierced with countless numbers of openings like pin-holes.

On an examination of a cable that had been worked during the whole summer, but had finally failed, I found the coating of gutta-percha destroyed as to its capacity for insulation. The inner coating was parched dry and easily broke; the second and third coverings were also brittle, and on bending the cable the gutta-percha would break. A few feet of the cable was thus injured, and the remainder was found to be perfect.

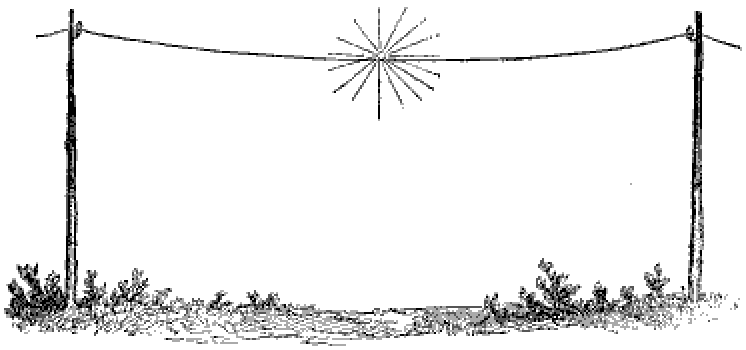
In the above cases the lightning produced different results, though all were fatal to the working of the line. Too much pains cannot be taken by the telegrapher to protect the river crossings, whether over masts or through submarine cables. The destruction of the conductor in either case occasions serious losses to the lines and a very great inconvenience to the public. It cannot be denied but what many cases of injury to the apparatus in the offices and to many crossings are justly chargeable to neglect, but many have been the result of incompetency of the telegrapher in charge of that special department. On the other hand, it is to be admitted that many have been the cases where the ingenuity of man has failed to devise the proper protection in the premises. That mysterious agent manifests itself sometimes in such power that no contrivance known in the arts can stay its wild and fearful flight between the heavens and the earth.

INCIDENTS OF LIGHTNING STRIKING THE LINE.

In 1850, I witnessed a very remarkable incident that took place at St. Louis. The telegraph wire crossed over the Mississippi river from a mast some 185 feet high, placed on Bloody Island. On the city side, a shot tower some 180 feet high from the water was used. Dark and heavy clouds mantled the whole heavens, and the storm seemed to be near the telegraph line; the wind was powerful, and my attention was directed to the line, fearing the mast would yield to the storm. In an instant the wire between the mast and the shot tower was struck, and simultaneously elongated drops of blue flame fell to the water. The scene was sublime; the deed was done. Providence, through his mysterious ways, in less time than the twinkling of the eye, dealt a lamentable blow upon the telegraph. A station was speedily established on the opposite side of the river; a ferry was used, and a messenger carried the dispatches from the city to the opposite station.

In the same year, while at a small village, about twelve o'clock at night, I happened to be looking out of the window, watching an approaching storm. Darkness was complete. A ball of fire fell from the heavens and struck the wire. Around the edges of the rotund flame there appeared a blue ring; in an instant the ball divided and spread to the right and to the left. Next morning the apparatus at the station was badly injured; the relay magnet was burnt, and the cores of the spools or bobbins were much fused. About three feet of the ribbon paper was burnt. The fire stopped at the rollers of the apparatus; no other injury was done. The station was about one fourth of a mile from the place where the ball fell upon

Fig. 7.

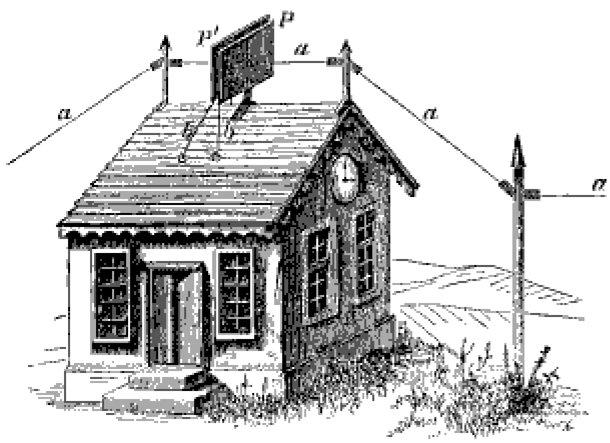


the wire. Whether or not the ball lightning did the injury in the station I am unable to say, but I presume it did. The end of the earth wire was a little burnt; the wires in the station were properly adjusted for the night.

STEINHEIL'S PARATONNERRE.

In 1846 Dr. Steinheil constructed the following arrangement for the Austro-Germanic telegraph lines.

Fig. 8.



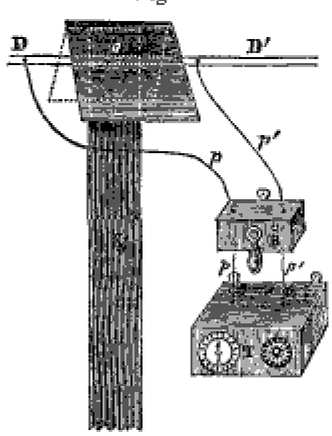
The wire *a a* passes over the station house in which the telegraph instruments are placed, as seen in the figure. On top of the house is fastened an arrangement consisting of two copper plates P′ P, to each of which the wire is attached; the wire on the right being fastened to the middle of the right-hand plate, and the wire on the other side fastened to the left-hand plate. These copper plates are about six inches in diameter, and between them is laid a thin piece of silk cloth, so adjusted that there can be no metallic connection between them. They are held in a vertical position, as seen in the figure on the roof of the station-house, by means of insulated supports, and they are protected from the weather by means of a small roof covering not placed in the figure.

By this means the large metallic circuit is interrupted or made incomplete, the silk between the plates serving as a non-conductor. From the brass plate P, the line wire *b* is extended down to the telegraph apparatus, and after traversing the coils or bobbins, it returns at *b′*, and is fastened to the plate P′. When the line is charged, the voltaic current passes over the wire to the plate P; thence over *b* to the apparatus; thence over *b′* to plate P′; and thence over the line to the next station. Atmospheric electricity will not pursue the same course. It will not follow the wires *b b′* except in a very small quantity. It passes from one plate to the other, traversing the silk cloth, and then it follows the wire until it becomes dissipated through proximate conductors to the earth.

The atmospheric electricity that passes over the wires *b b′* and through the apparatus is but little, and can do no damage. I was informed at many of the telegraph stations in Germany that this form of paratonnerre has proved to be a perfect protection to the apparatus.

FARDLEY'S PARATONNERRE.

Fig. 9.



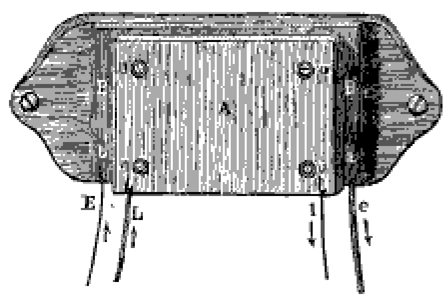
In the summer of 1847, Mr. Fardley constructed a paratonnerre on a stretch of fifty-six miles of line in the form represented by fig. 9.

A short distance from the station-house the line wire was divided into two parts, D D′, and on one side of the station was placed a post, upon the top of which the two divided ends of the line wire were brought within one fiftieth of an inch of each other. This place of separation was covered with a small roof. On each side of the post were two small copper wires p p', about twenty feet long, which connected the line wire with the apparatus T in the station-house. By this arrangement the lightning charge traversing the line overleaped the small separation at o, and passed beyond the station, and did not go over the longer route through the apparatus. During the most severe storms, no further injury was done at the stations than the burning of the small wires p p, p' p'. When a plus charge traverses p, it enters apparatus B, inside of the telegraph station, which, when thus charged, serves to detach the receiving apparatus T.

MEISNER'S PARATONNERRE.

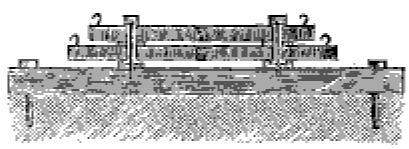
On the 5th of May, 1846, Mr. Meisner, of Germany, was noticing the telegraph wires, and he saw the electricity leap from the line to the earth wire in the station, burning the fine wire of the magnet coils. This circumstance led him to construct an arrangement in all the stations of the ducal Brunswick state telegraph, for the purpose of protecting the operators and the apparatuses. Figure 10 represents one of them.

Fig. 10.



The naked wire of the line is insulated on the poles by porcelain, shaped as bells, and it enters the ground near each station. It is insulated with gutta-percha, and drawn through tubes of lead or iron. This subterranean section, L, is conducted through the foundation of the house, and thence to the telegraph room, where it is fastened to

Fig. 11.

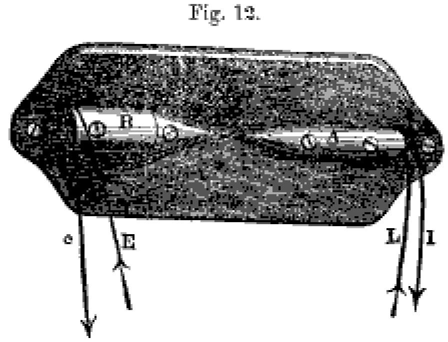


the copper plate A, which is eight inches long, four wide, and one eighth of an inch thick. From this copper plate A proceeds a fine insulated wire, l, to the telegraph apparatus through the voltaic battery, and thence through the wire E, traversing the copper plate B B, and then with the wire e to the earth, or onward toward the next station. Fig. 11 is a sectional view of both plates as screwed to the common base;

each is insulated from the other. The screws *n n n n*, passing through their respective holes, are insulated with silk, ivory or some other non-conductor; this arrangement is fastened to the apparatus table or to the wall, with screws, as represented at each end of the figures. The two insulated fine wires, *l* and E, are insulated from each other, and connect with the apparatus through the ordinary binding screws. The voltaic current traverses the whole route of the wires, but the lightning current enters plate A and leaps to plate B, and thence to the earth, or on to the next station, until dissipated in the air. The plates A and B were fastened near together, but did not touch. Voltaic electricity must have a metallic conductor, consummating a continuous and complete circuit. The smallest break in the conductor will arrest the flow of the current and its generation by the battery organization. Not so with atmospheric or static electricity; it traverses a conductor until it reaches the spot where it can pass off into the earth; it leaps from one conductor to another, from plate A to plate B. There are no known laws demonstrating the limit as to distance the atmospheric current will leap. A tri-cuspidated charge will be more energetic and will pass over a greater space to reach the earth than the ordinary heat lightning flash.

Mr. Meisner invented another contrivance for the arresting of atmospheric electricity. Fig. 12 represents the arrangement as placed on the line from the Brunswick station to Vechelde. The line wire I. entered the station and was fastened to the copper bar A, and from the bar by *l* to the apparatus, and then through E to copper bar B, and by *e* to the earth, or on to the line wire beyond the station. The bars A and B are fastened to a wooden base and separated at their points by a very small space. The voltaic current traverses the wires, but the lightning passes from the point of A to the point of B, and thence to the earth, or on to the station beyond.

Fig. 12.



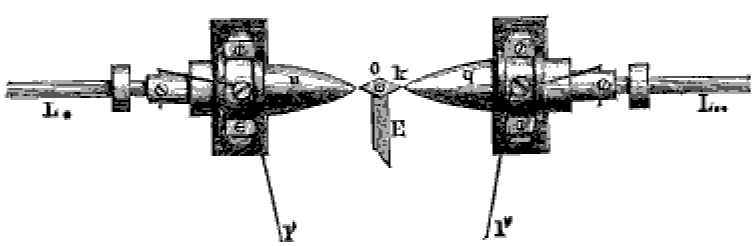
The reader will observe that the contrivances, figs. 6, 8, 10, and 12, are different one from the other, but at the same time the philosophy of each is the same. The American paratonnerre, fig. 6, passes the current immediately to the earth; Steinheil's carries it on to the next station, though it is certain to be dissipated from the wire within a few miles, and perhaps none of the plus charge will ever reach the next station in course. Mr. Meisner made the base of his contrivance a part of his circuit to the earth or of the line. The American improvement on Steinheil's plan, fig. 8, would lead the wire *a a b* to the apparatus, and thence to the earth, or on to the next station, but not by way of plate P′. From plate P′ the American plan is to conduct a wire immediately to the earth, and no other wire would be connected with plate P′. The same remarks may be applied to the arrangements invented by Mr. Meisner. In the use of fig. 10, arranged as above described, the American telegrapher attaches the line wire L to plate A, and by *l* through the apparatus, and then it is extended on to the next station. An earth wire is fastened to plate B; this completes the arrangement, as represented by fig. 6. In this combination the voltaic current traverses the line wire, through the magnet coils, and thence on to the next station or to the earth, as desired by the telegrapher. The lightning will not pass through the fine wire of the magnet, but will leap from plate A to plate B. If the line is extended through the office to the next station, a paratonnerre will have to be placed for the line on each side of the apparatus in the station.

NOTTEBOHN'S PARATONNERRE.

The director-general, Nottebohn, of the Prussian government lines, devised a novel combination for a paratonnerre. Fig. 13 represents the arrangement employed in the stations of the Prussian telegraphs.

Between the two pointed copper or brass cones, *u q*, is a

Fig. 13.

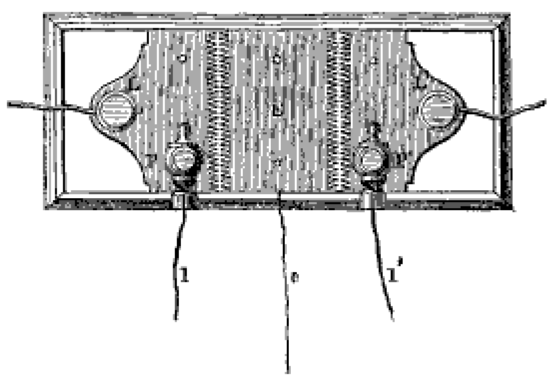


double pointed copper marked *o k*, with its points nearly touching the points of *u* and *q*. The copper piece *o k* is connected with the earth by means of the large copper rod or wire E. The pointed cones *u q* connect respectively with the line wires L. and L.. and with the wires *l′ l″*, which lead to the apparatus. The voltaic current from the distant station enters, for example, through the wire L. of cone *u*, thence by the wire *l′* to the apparatus, and thence through *l″* to the cone *q* and line wire L.. On the other hand, the current may come from line L.. and traverse the metallic circuit composed of *q l″*, the apparatus *l u* and L. The voltaic electricity follows the metallic circuit, but the lightning seeks its course to the earth through the diamond-shaped copper *o k*. This combination, in principle is the same as fig. 6, employed on the American lines. I am unable to say which of the two are the best for the purposes. On the American lines, the flat plates are found to be perfect in the protection of the telegraph apparatuses. Mr. Nottebohn informed me that the above device answered fully the objects in view, and that he had never known of its failing to successfully preserve the instruments of a station. The flash from cone to cone was observed on many occasions when, at the locality, there was not a cloud to be seen.

BREGUET'S PARATONNERRE.

On the French telegraph lines a different mechanism is used for the preservation of the apparatuses of the stations. At an early day in the history of French telegraphy, the distin-

Fig. 14.

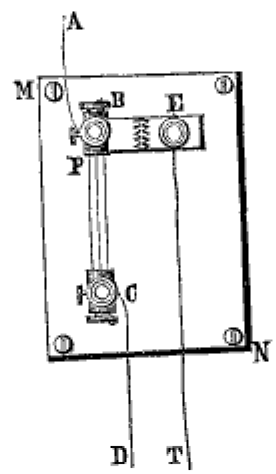


guished Breguet invented an arrangement represented by fig. 14. This paratonnerre is composed of copper or brass plates, L E and L′, with edges like saw teeth, as seen in the figure. The line wires are fastened at L L′. Between the plates L L is another plate E, with saw-teeth, fastened so that the teeth of the two former almost touch the teeth of plate E. From P P′ the wires *l l′* run and connect with the telegraph apparatus. The wires *l l′* are connected to the plates L L′ by means of the binding posts P P′. The middle plate E is connected with the earth by a large copper wire *e*. The voltaic current follows the metallic circuit L′ *l′*, the apparatus *l* and L, or *vice versa*. The atmospheric electricity escapes through the plate E and wire *e* to the earth.

THE FRENCH PARATONNERRES.

Fig. 15 represents a form used on the French railway lines. It is composed of a small wooden plate M N, upon which are placed binding screws, B and C, from two and a half to three inches apart. A very fine iron or platina wire, fixed at its two extremities in two copper posts, and placed in a glass tube, connects these two binding screws or posts.

Fig. 15.



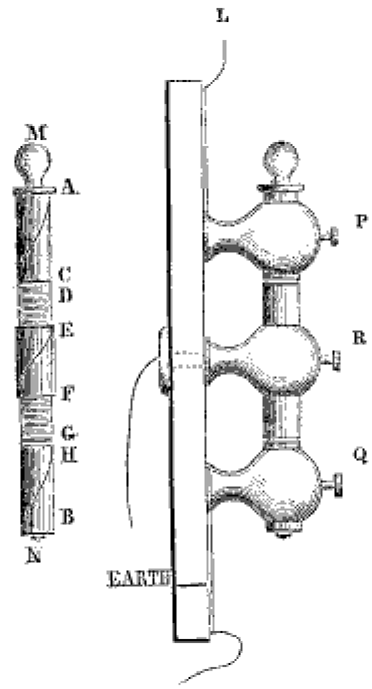
The upper part B communicates with the line A; the lower part C communicates with the wire of the station D. The current coming from the line must traverse the fine wire B C, so that if the electric discharge is strong enough, this wire will melt and interrupt the communication between the line and the apparatus.

In front of the upper binding screw B is a metallic piece, E, communicating with the earth. Copper points placed in front permit the electricity accumulated on the line wire to pass into the earth whenever the small wire is burnt.

It sometimes happens that the wire contained in the glass tube is volatilized by the effect of the discharge, and is precipitated against the tube so as to form a sort of conducting lining. The glass tube, however, is frequently dispensed with, as the sole object of its use is to protect the wire which it contains. When the wire is melted by the electric discharge, it must be replaced in order to re-establish electric communication. The French are of the opinion that these paratonnerres should be placed as much as possible outside the station-houses, in order that the line may be completely separated from the interior of the station house after the fusion of the small platina wire.

Fig. 16 represents a different form, and is considered more advantageous, particularly in making the line wire communicate with the earth when the fine wire has been broken. This paratonnerre consists of a rod M N, formed in three parts of copper, A C, D G and H B. The extreme parts A C and H B are separated by ivory disks, G H and C D, from the middle one, which bears a bulge part E F. A very fine silk covered wire is fixed on one side to the upper part M, which unscrews, and the other part is fastened to a little screw at the lower extremity N. This wire is coiled around the rod. The extreme portions of the rod, B H and A C, are in communication only by means of this covered wire. The middle part does not communicate with the two others except when the silk covering of the wire is removed. The rod traverses three globular supports, P, R, and Q. By means of screws the contact of these supports with the three portions A C, E F, and H B is secured.

Fig. 16.



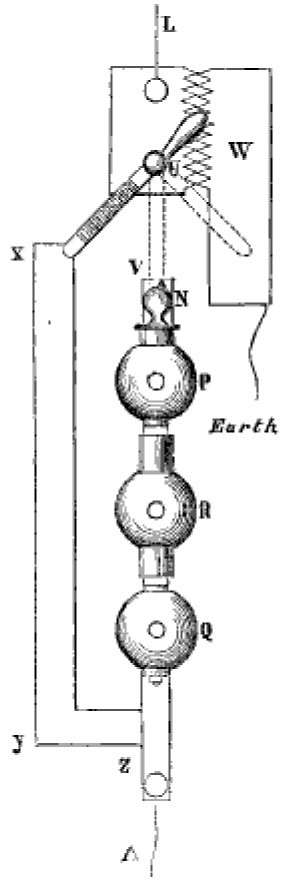
The first support, P, communicates with the wire of the line L; the second, R, with the earth; and the third, Q, with the wire of the apparatus.

When an atmospheric discharge melts the fine wire, or merely burns off its silk covering, a communication is established between the line and the earth. When this fusion has taken place, the rod is either replaced by another in readiness, or else another silk covered wire is coiled around it. The condition of these rods may always be known by noticing whether the current passes between the two extreme portions, and not between one of them and the middle.

A front view of this form of paratonnerre is represented in fig. 17. The line wire is attached to the button L. At U is a communicator which puts in communication this wire either with the strip N, or with the strip X Y Z, or finally with the copper plate W, which is in communication with the earth wire.

In the first case, the current of the line must traverse the wire of the paratonnerre; in the second, it goes directly to the apparatus; and, in the third, it goes to the earth.

Fig. 17.



Whenever the weather is stormy, this latter communication ought always to be established. The plates W and L are furnished with points, the use of which is the same as that of the paratonnerre hereinbefore described. When there is a prospect of a storm, the spring of the commutator U should be placed upon the strip X Y, but if the silk covered wire surrounding the rod M N is laid bare at certain points, the current, instead of traversing the wire of the apparatus, which offers a great resistance, goes directly to the earth by means of the support R. In order to prevent all communication between the plate X Y Z and the earth, the rod must be removed.

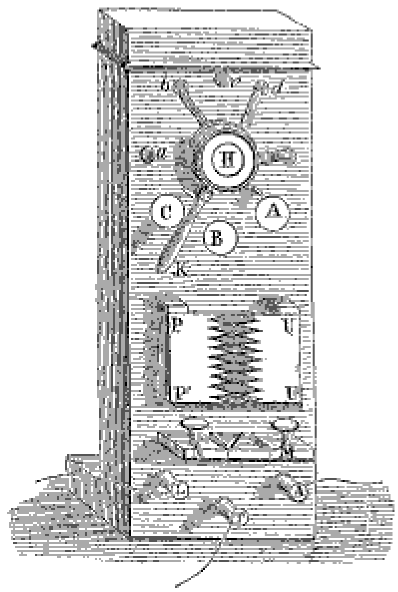
Attempts have been made in France to avoid this inconvenience, by giving to the paratonuerre the following form, which has been recently adopted on some of the lines (fig. 18).

This apparatus consists of a little vertical column, at the base of which are attached three little copper binding screws. At T, the wire of the earth is connected; at L, the line wire; and at A, the wire of the telegraph apparatus.

The binding screw L communicates with the axis H of a three-pronged commutator, which can be moved by means of the lever or arm K. The plate A represents "*with paratonnerre*," B represents "*earth*," and C represents "*without paratonnerre*."

The branches of the commutator may press upon little metallic plates, *a b c d*. The axis of the commutator communicates only with the middle branch; the two others are formed of a single piece, and are insulated by an ivory disk.

Fig. 18.



The fine silk covered wire is placed in the interior of the little metallic case Z. The extremities of the silk covered wire being laid bare, are fastened by screws in the two other little pieces M and N.

The following communications are established by means of wires or metallic straps fastened behind the plate. L with P P' and H; *a* with N; *b* with M; *d* with the lever A; *c* with U U'; and Z with T.

1st. When the rod K of the paratonnerre is over the letter C, representing "*without paratonnerre*," the middle branch of the commutator presses upon the plate *d*, as represented by the figure. The current coming from the line to the button L, traverses the copper plate furnished with points P P', and passes from the centre, H, of the commutator to the button *d*, whence it goes to the screw post A, and to the apparatus.

2d. If the rod K is placed above the letter A, representing "*with paratonnerre*," the three branches of the commutator will be upon the three plates, *a*, *b*, and *d*. The current, after having traversed the plates P P', arrives by means of the middle branch to the point *b* and to the copper piece M. It traverses the wire of the paratonnerre at Z, proceeds from N to the button *a*, follows the two extreme branches of the commutator, and passes from *a* to the screw below, lettered A. If an electric discharge melts the little wire, the line becomes in communication with the earth by means of the copper piece Z, in which the little wire is placed.

3d. In the third position of the rod K, the middle branch presses upon the plate *c*, which communicates with the earth by means of the rod U U′, the plate Z, and the binding screw T.

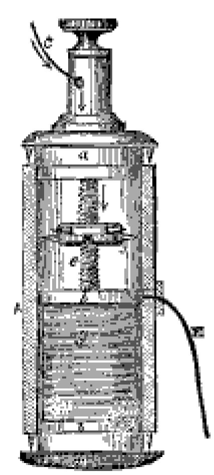
WALKER'S PARATONNERRE.

In writing upon the subject of atmospheric electricity in relation to its interference with the operation of the electric telegraph, Mr. Charles V. Walker, one of the most distinguished telegraph electricians in England, says:

"It is a well-known property of ordinary charges of electricity to expand, so to speak, and to occupy the outside surface of conducting bodies. If an ice-pail or metal vessel be insulated on glass legs, and a brass ball hanging to a silk thread, be employed to carry a charge of electricity from a common electrical machine to the *inside* of the vessel, it will part with *all* its charge the moment the two metals touch; and, on now applying a test instrument to the inside of the ice-pail, no electricity can be found there; the charge appears to have vanished. But, on presenting it to the *outside*, the charge is discovered there in its full quantity. I thence considered that, whatever arrangement I should insert in the course of the conducting wire, I might very advantageously place this arrangement *inside a stout metal* cylinder, in good communication with the earth; so that the charge, in that part of its course should be in all but contact with the earth connection, and further facilitated in its escape by having the latter on its *outside*.

Fig. 19 represents the lightning conductor very nearly in full size. A is a brass cylinder, one sixteenth of an inch thick (shown in section in the figure), in perfect metallic communication with the earth by the stout wire E, and insulated from the conducting wire by a disk of boxwood *a*, and a boxwood bobbin *b b*. The arrows show the direction of the charge from the line wire *c* to the telegraph, to which it is screwed by the end *d*. The ends of the bobbin closely fit the inner surface of the cylinder; but it is slightly grooved in its course to receive two or three layers of a silk covered copper wire *g*, finer than any elsewhere to be found in the instrument; the wire is in the circuit, commencing at the thick brass wire *c*, and terminating below at *d*, and is in very close proximity to the earth,

Fig. 19



—closer, in fact, than any other wire or piece of metal inside the instrument or the office. The wire *e* is further furnished with two nuts, *f*, fitted with points, made by gauge to approach almost within hairsbreadth of the cylinder. The boxwood terminations *a* and *d* are also capped with brass disks; from the upper disk, points approach the earth-cylinder; and from the lower end of the earth-cylinder, points are presented to the disk. The object of the coil *g*, of very fine wire, is, that, from its tenuity and from its juxtaposition to the earth-cylinder, it shall have a better chance of being burned, in an extreme case, than either the wire of the bell coil or that of the needle coil. The use of the points does not require any explanation.

The first set of these conductors were placed at Tunbridge Wells station; and not many weeks had elapsed before a lightning flash entered the station, and it behaved with the apparatus as I had been led to expect. It passed safely through the stout wire E, and immediately on arriving at the fine wire *g*, it darted off to the cylinder, and, by its explosion, singed the silk and exposed the wire where I have placed a black spot, near A. In this case the flash was moderate, and the wire was not burned.

It went a step further, and another of its features was called into requisition, on 8th August, 1849. During the night a violent thunder-storm occurred, the effects of which were especially manifested on the Ashford end of the Ramsgate branch. Three poles, unprotected by lightning-wires, were splintered at Chartham, about two miles beyond Chilham; and the lightning entered both Chilham and Ashford stations, and, by its snappings and explosions, very much alarmed all on duty. When all was over, it was found that at Chilham, where there were no lightning conductors, the wire of the bell-coil was burnt, and of both the electrometer coils, and other severe explosions occurred about the apparatus: one of the No. 16 size copper wires was burnt and broken. At Ashford there were lightning-conductors on the two instrument wires, but not on the bell-wire (a few days previously the bell-coil had been saved by the lightning-conductor being burned; the latter was brought away to be examined, and had not been replaced). It was now found that the Ashford electrometer coils, both of which had conductors, were saved; the fine wire, *g*, of the lightning conductor being burnt by the explosion in both cases, but the bell-coil, which was unprotected, was visited by the discharge and burned.

Lightning flashes occasionally disturb the polarity of the needles, and even demagnetize them. This is much more the case with the rhomboidal and the short needles than it is with the long ones; and the former have been found demagnetized even while furnished with these protectors; but in the storm above-mentioned, while the magnetism of the unprotected needles at the Canterbury station was disturbed, that of the protected needles at Ashford was undisturbed. I have sometimes been half induced to think whether the intense and momentary atmospheric charge may not act so violently and irresistibly on the *magnetism* in the needle, that it deflects it more rapidly than the *metal* can follow, and that the conflict thus caused by the *vis inertiæ* of the metal may overthrow the magnetic arrangement of the particles of steel. In like manner, it may be conceived that the loss of magnetism occurring in the ordinary use of the instrument may be mainly due to the incessant jars the needles receive as they strike against the stops by which their beats are limited."

It has often happened on the American telegraph lines that the lightning has entered the station, and burnt much of the wire surrounding the electro-magnets. I have frequently seen the iron cores partially fused, and the brass parts melted at their corners. Such accidents were of frequent occurrence in the earlier days of telegraphing. Then we did not have the beautiful contrivances practically and successfully applied at the present day. It was often the case, too, that the electro-magnet cores were permanently magnetized, which occasioned much difficulty in the reception of messages. On the English lines the needles suspended in the spools require to be permanently magnetized, and the atmospheric electricity has frequently demagnetized them. On the American lines the iron cores of the magnets require to be free from all permanent magnetism, and the lightning has on many an occasion permanently magnetized them. We are, however, making rapid strides in the comprehension of this strange and mysterious phenomenon.

The telegraph lines in southern latitudes are much interrupted by atmospheric electricity in ordinary quantities. Some of the lines have two wires, one above the other. When the wires are thus arranged, the atmospheric electricity will principally charge the upper wire. This I discovered at a river crossing some years ago; I had placed over the masts two wires, one above the other. The upper wire was nearly always more or less charged, and the under wire seldom charged. Where a line has two wires upon it, one above the other, it will be found best to make the under one the through or long circuit wire, and the upper one the short circuit or local wire. When thus operated, the plus electricity of one section of the country will not disturb the circuit in another. The local dispatches can be forced through with batteries of greater quantity current on the short circuits; and, besides, the local line circuits can be divided without interrupting the transmission of dispatches between places far distant from each other. In warm climates, electricity seems to exist in large quantities in the air, and it is this kind of electricity that retards the transmission on the wires. The flash of a storm is over in a moment, but the other seems to be sluggish and stationary, until conducted to the earth by the rain or the dews.

For the information of practical telegraphers not conversant with the subject-matter herein discussed, I will add a few instructions in regard to the restoration of the electro-magnet, when permanently magnetized by heavy charges of atmospheric electricity. Suppose, for example, the line extends from A to B, with the batteries on the line directed in their organization from the former to the latter station. The voltaic current traverses, first the right-hand spool, and then the left-hand spool of the electro-magnet. The above represents the normal positions of the batteries and the electro-magnets. In case the cores of the magnets become permanently charged with magnetism, it is important and indispensably necessary to expel it from the cores immediately, as the art of telegraphing solely depends upon the instantaneous magnetizing and demagnetizing of the electro-magnets by the opening and closing of circuits, and thus putting on or taking off the voltaic current of the batteries on the line. To restore the cores to their original condition, it is necessary to reverse the course of the electric current through the spools, so that it will pass first, through the left-hand coil, and then through the right-hand spool. To accomplish the end more rapidly, a current of quantity electricity may be passed through the spools for a few hours, traversing the magnets from left to right. If the iron cores are moveable from the coils, as many of the magnets are now manufactured, it will be better to heat them to a slight red, and then allow them to cool slowly. This process will expel the permanent magnetism, and restore the iron to its original susceptibility of magnetic action.

If the telegrapher will carefully study the details and illustrations in this chapter, he cannot fail to be fully equal to any emergency of his station, so far as pertains to the wild and restless lightning, let it come with whatever power it may from any zone that girdles the earth's surface.