STEINHEIL'S ELECTRIC TELEGRAPH

CHAPTER XII.

Experiments and Discovery of the Earth Circuit—The Electric Telegraph as Invented—The Electric Conducting Wires—Conductibility of the Earth Circuit—Apparatus for Generating the Voltaic Current—The Indicating Apparatus—Construction of the Apparatus—Application of the Apparatus to Telegraphing—The Alphabet and Numerals—The Discovery and Invention of Steinheil.

EXPERIMENTS AND DISCOVERY OF THE EARTH CIRCUIT.

In the years 1836–'37, Prof. C. A. Steinheil, of Munich, Germany, devised an electric telegraph; and in the latter year, he constructed a line of wire from the Academy at Munich to the observatory at Bogenhausen. He had constructed two other lines, making three circuits of wires, but the whole were arranged to be united into one common chain, to form an electric circuit. The first published notice made of this important invention will be found in the third volume of the Magazine of Popular Sciences, in a letter from Munich, under date of December 23, 1836. This telegraph was announced in the *Comptes Rendu*, in September, 1838.

In 1838, Prof. Steinheil made the important discovery of the practicability of using the earth as one half or the returning section of an electric circuit. The three lines, constructed as hereinafter described, had double wires, so as to form a complete metallic circuit from and to Munich. Subsequent to the erection of these experimental lines, the earth was discovered to be a conducting medium in the formation of an electric circuit, in conjunction with the wire stretched upon poles. This was the grandest discovery ever made in practical telegraphy. The discoveries of Volta, Œrsted, and Steinheil, are to be considered as pre-eminent, in the consummation of the electric telegraph. The first discovered the generating power, the second gave life and strength to that power, when it had become so feeble, that it seemed as though it was struggling in the arms of death; and the latter economized the commercial application of those elements for the uses of man. All telegraphs are formed upon these three discoveries. Let, then, the names of Volta, Œrsted, and Steinheil, be inscribed in golden capitals upon the bright escutcheon of telegraphic achievements, as the equals in renown, and subservers of man's weal, and the glory of the age.

Dr. Steinheil made an experiment in 1838, on the railroad. He insulated the chairs sustaining the rails with tarred felt; but this was a very imperfect insulation, and the circuit could not be extended beyond some five hundred feet. To test the matter more thoroughly, he had some new rails made, but the points of contact with other but inferior conductors were so numerous, that the experiment was for the time abandoned. This experiment produced an effect which convinced Steinheil that it was not necessary to bring a metallic conductor back to the voltaic source. The non-insulation of the rails gave off the electric current, and this fact was observed in the movement of the electrometer. Thus, when the current was transmitted over the rails, a speedy return was seen, even when the two lines of rails were not connected. Suppose the wires of the apparatus were connected to the rails on each side of the road, the rails insulated by resting upon the tarred felt, at a distance of 500 feet from the apparatus, the rails to be connected by a copper wire. The route of the current would be over the rails on one side of the road to the copper wire, and through it to the rails on the other side of the road, and thence back by the rails to the indicator. When the copper wire was disconnected, the circuit was supposed to have been broken; but it was not the case, as the current escaped from the rails, and returned with unmistakable indications at the apparatus.

Prof. Steinheil extended his discoveries still farther, and reduced them to mathematical precision as to cause and effect. He pursued this important question to its fullest extent, and gave to the world the results attained by his patient and laborious researches.

I will now proceed to explain to the reader the telegraphic apparatus invented by Prof. Steinheil, and in doing which, to a considerable extent, will use the language of the inventor. I have taken great pains to obtain the most reliable information concerning his labors in the invention of his telegraph, and his discoveries in the sciences pertaining thereto, and I hope the facts herewith presented will be found strictly correct.

THE ELECTRIC TELEGRAPH AS INVENTED.

This telegraph is composed of three principal parts:

1st. A metallic conductor between the stations;

2d. The apparatus for generating the voltaic current; and

3d. The indicator or receiving apparatus.

"In explanation of the organization of this telegraph," says Prof. Steinheil, "I will explain the above divisions; and first—

THE ELECTRIC CONDUCTING WIRES.

"The wire which connects two or more stations, forming a part of a voltaic circuit, is called the connecting wire, and may be extended to a very great length. This wire, however, must be considered relatively to the voltaic battery. With equal thickness of the same metal, the resistance offered to the passage of the electric current, will be proportional to the thickness of the wire. With equal lengths of the same metal, however, the resistance diminishes in an inverse proportion to the sectional surface. The conductibility of metals differs. According to Fechner's measurements, copper, for example, conducts six times better than iron, four times better than brass. The conductibility of lead is still more inferior, so that the only metal most suitable, and that can best subserve the purposes in this technical application, are copper and iron wires. Iron wire is six times less in cost than copper wire, nevertheless, it is necessary that the iron conductor should be six times greater than the gauge of the copper wire, in order to equalize the conducting powers of the respective metals. The expense of the two wires is the same. The iron, however, is the strongest and heaviest. The preference will be given to copper wire, as this metal is less liable to oxydation from exposure to the atmosphere. This latter difficulty may be surmounted by simple means, namely, by galvanizing it. It is believed that the mere transmission of the voltaic current through the wire, when the telegraph is in operation, will be sufficient to preserve the iron wire from rust, as has been observed to be the case with the iron wire used for the telegraph line in the city of Munich, for more than a year past, and which, too, has been exposed to all weathers.

"If the voltaic current is to traverse the entire metallic circuit of the wire, from station to station, without any diminution as to its intensity or force, the wire must in its whole course not be allowed to come into contact with any foreign conductors, but, on the contrary, should be perfectly insulated at every place of contact. If the wire be permitted to touch semi-conductors the electric power or current will return to the generating source by the most direct and shortest route. According to this philosophy the extreme station from the voltaic source will be deprived of the influence of the greater part of the electric current generated by the battery.

"Numerous trials to insulate wires, and to conduct them below the surface of the ground, have led me to the conviction that such attempts can never answer successfully at great distances, inasmuch as the most perfect insulators are at best but bad or inferior conductors. And since, in a wire of very great length, the surface in contact with the so-called insulator is uncommonly large, when compared with a section of the metallic conductor, there will necessarily arise a gradual diminution of the voltaic force, inasmuch as the wires *to* and *from* the station do communicate at intermediate points. This cross current may be very small; nevertheless it will occur. It would be wrong to suppose that this difficulty can be remedied by placing the to and from wires very far apart; the distance between them is, as we shall see in the sequel, almost a matter of indifference. As it is not probable that lines laid under the ground can ever be insulated sufficiently for telegraphic purposes, because the earth is always damp, and therefore a conductor, there is but one other course open to us, and that is to lead the wire through the air. Upon this plan, it is true the conducting wire must be supported at given places; it will be liable to be injured by evil-disposed persons; it will be liable to be interrupted by storms, and from ice which will form upon it from time to time. These are the difficulties to be expected, in stretching the wire through the air, and as there is no other method that can be made available, we must endeavor to make suitable arrangements to get the better of them, although they are of no ordinary consideration."

The conducting chain or medium of the telegraph constructed in Munich consisted of three parts:

1st. The line from the Royal Academy in Munich to the Royal Observatory at Bogenhausen;

2d. From the Royal Academy to the residence of Prof. Steinheil; and

3d. From the Royal Academy to the mechanical department attached to the cabinet of natural philosophy.

"As to the first," says Prof. Steinheil, "the wire was run from Munich to Bogenhausen and back, making a total length of wire 32,500 feet. The weight of the copper wire employed amounted to 260 pounds. Both of the wires, that is, to and from, are stretched across the steeples of the city at distances from three to ten feet apart. The greatest distance from one support to another was 1,200 feet; this distance is undoubtedly far too great for a single wire, inasmuch as during winter the ice will form upon the wire, and materially increase its weight, and augment its diameter, so that it becomes liable to be torn asunder and broken by the weight or by the storms. Over those places where there are now high buildings, the conducting wire is supported by tall poles, sunk into the ground five feet, and are from forty to fifty feet high. At the top of these poles, the wires are fastened to a cross bar. At the point where the metallic conductor rests, there is a piece of felt laid, and over which the wire is twisted around the wooden bar. The distances from pole to pole range between 600 and 800 feet; but these distances are far too great, for experience has shown that the wires become stretched, caused by high winds, and they have had to be re-stretched on the poles several times. These evils may be overcome by making the conductor of three strands of wire, twisting them so as to make a cord, which will be better than a single wire. It should be supported by poles about 300 feet apart, giving the wire a tension not exceeding one third of what it will bear, without giving way. This, however, can not be made on the experimental telegraph of this city for reasons that can not be explained here.

"The conducting wire thus mounted is by no means perfectly insulated. When, for example, the circuit is broken at Bogenhausen, the electric generator at Munich ought not to produce any current upon the remainder of the wire, not connected as a circuit. But even when the circuit was thus broken at Bogenhausen, an electrometer, as devised by Gauss, being connected with the wire, a current manifested itself by the action upon the electrometer. Measurement goes to show further, that the current goes on increasing as the point, at which the interruption of the stream is made, recedes from the inductor. The amount of this current is not always the same. Generally it is greater in damp weather. When there are heavy showers of rain, it may be fairly said to be five times as strong as when the weather is dry. At small distances of a few miles, the loss of electric power is of but little importance, as by the peculiar construction of the inductor, we can generate an electric force of any strength desired. When the distance amounts to, perhaps, some 280 miles, the continual loss of the electric current will, beyond doubt, be so great, that there can be no effect produced at the distance mentioned. In such cases, much greater precaution must be taken in regard to the insulation at the points of support.

"When thunderstorms occur, atmospheric electricity collects on the semi-insulated conductors, in the same way that it does upon lightning-rods. But this does not prevent the flow of the voltaic current.

"Reference may be made here to an incident, that may be well to remember, as a warning for the future. During a severe thunder-storm, on the 7th of July, 1838, a very strong electric spark darted at the same instant through the entire conducting wire, and on entering the apparatus in my room, a sound like the cracking of a whip was produced. At the same time the deep-sounding bell of the manipulator was made to sound. So violent was the presence of the lightning in the deviation of the needle, the revolving points of the magnetic bar were damaged. The same phenomenon was also observed at one of the other stations. As the deflecting power of frictional electricity is very inconsiderable, with respect to magnets, the above occurrence indicates the presence of a vast quantity of electricity. This phenomenon could only have arisen from the electricity of the earth having at that moment made its way to that collected in the wire. Whether this was brought about through the lightning conductors in the neighborhood, or the imperfect insulation of the points of support, cannot be well determined."

CONDUCTIBILITY OF THE EARTH CIRCUIT.

"Quite recently I have made the discovery, that the ground may be employed as one half of the conducting chain, forming the circuit with the line wire. As in the case of frictional electricity, water or the ground may, with the voltaic current, form a portion of the connecting wire. Owing to the low conducting power of these bodies, compared with metals, it is necessary that at the two places where the metal conductor is in connection with the semi-conductor, the former should present very large surfaces of contact. Taking water, for example, which conducts two million times worse than copper, a surface of water proportional to this must be brought in contact with the copper, to enable the voltaic current to meet with equal resistance, in equal distances of water and of metal; thus, if the section of a copper wire is 0.5 of a square line, it will require a copper plate of sixty-one square feet surface, in order to conduct the voltaic current through the grounds, as the wire in question would conduct it. But as the thickness of the metal is quite immaterial in this case, it will always be within our reach to get the requisite surfaces of contact at no great expense. Not only do we by this means save half the conducting wire, but we can even reduce the resistance of the ground below what that of the wire would be, as has been fully established by experiments made here with the experimental telegraph.

"The second portion of the conducting chain leads from the Royal Academy to my house and observatory in Lark-street. This conductor is of iron wire, and both the to and from wires are 6,000 feet long, and are stretched over steeples and other high buildings, as has already been described.

"The third portion of the chain or conducting wires runs through the interior of the buildings, connected with the Royal Academy, and thence to the mechanical workshop attached to the cabinet of natural philosophy. This is a fine copper wire, and 1,000 feet long. It is let in the joinings of the floor, and in part imbedded in the walls.

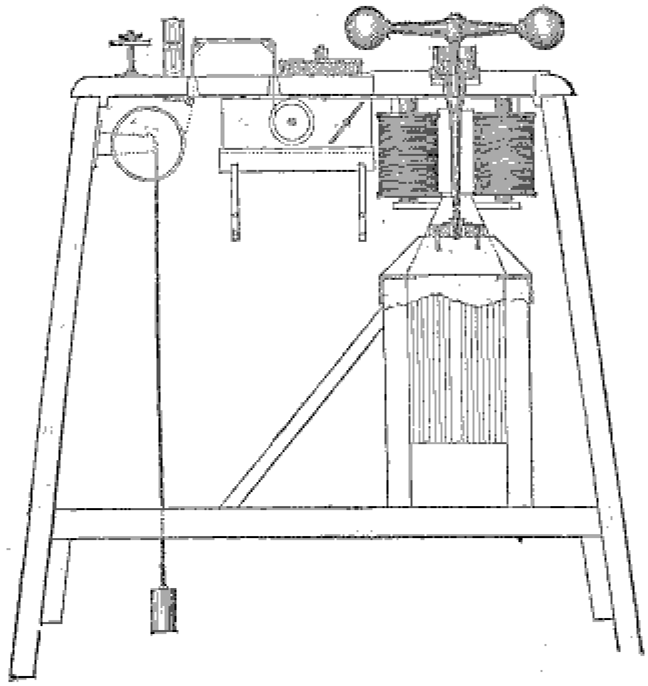
"The foregoing three different ranges or lines of wire, the first of copper, the second of iron, and the third of fine copper, in the aggregate near seven and a half miles of wire, run from and return to the same place, and to which, in whole or singly, may be attached the apparatus for generating the electric current, and for indicating the communication transmitted."

APPARATUS FOR GENERATING THE VOLTAIC CURRENT.

Hydro-electricity, or that current which is generated by the voltaic pile, is by no means fitted for traversing *very long* conducting wires, because the resistance in the voltaic pile, even when many hundred pairs of plates are employed, would be always inconsiderable, compared with the resistance offered by the wire itself.

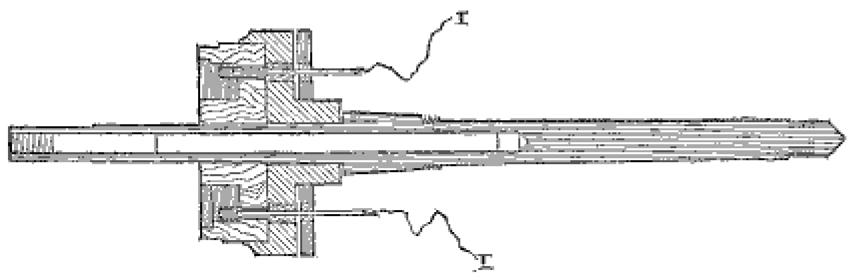
The principal disadvantage, however, attendant on the use of the pile or trough apparatus, is the fluctuation of the current, joined to the circumstance of its becoming very soon quite powerless, and requiring to be taken to pieces and put together again. The extremely ingenious arrangement of Morse is likewise subject to this inconvenience. All this, however, is got over, when one, to generate the current, has recourse to Faraday's important discovery of induction, that is to say, by moving magnets placed in the neighborhood or close to the conducting wires. The better way, however, is not to move the magnets, as Pixii does, in his electro-magnetic apparatus, but rather to give motion to the multipliers placed close to a fixed magnet. The arrangement that Clarke has given to the multiplier, is the one which, with some modifications, has been adopted. Assuming, on the part of the reader, a general knowledge of the principles of the apparatus, these explanations will be confined to its adaptation to the purposes of telegraphic communication.

Fig. 1.



The magnet is composed of seventeen horseshoe bars of hardened steel. With its iron armature, its weight is about sixty pounds, and it is capable of supporting about 300 pounds. Between the arms of the magnet there is fastened a piece of

Fig. 2.



metal, supporting in its centre a cup, provided with adjusting screws, and which serves as a support for the axis of the coils of the multiplier. The coils of the multiplier have, in all, 15,000 turns of wire; forty inches of this wire weighs fifteen and a half grains, and it is twice bespun with silk. Its two ends, which are insulated, are passed up through the interior of the vertical axis of the multiplier, and then terminate in two hook-shaped pieces, as may be seen by figs. 2 and 3. In order to insure perfect insulation, the vertical axis, fig. 2, was bored out hollow. In this hole, there are let in from above two semi-circular rods of copper, which are prevented from touching by a strip of taffeta fastened between them with glue; and these again are kept from touching the metallic axis by winding taffeta round them. In each of these little strips of metal there is, above and below, a female screw cut. In the lower holes, small metal pins are screwed in, to which the ends of the multiplier are securely soldered. While in the upper holes, as may be seen distinctly in figs. 3 and 4, there are iron hooks screwed in. These hooks, therefore, form the terminations of the multiplier wires of the coils of the inductor. They here turn down, fig. 5, into two semi-circular cups of quicksilver, that are separated by a wooden petition. From these cups of quicksilver there proceed connections, I I, figs. 2 and 6, toward the wires, and they, therefore, may be considered as forming part of the conducting wires or chain. The quicksilver, owing to its capillarity, stands at a higher level in these semi-circular cups than are the partitions, so that the terminal hooks of the wires of the multiplier pass over these partitions without touching them, when the multiplier is made to turn on its axis. One sees that the hooks are thus brought in to other cups of quicksilver, at every half turn of the multi-

Figs. 3 & 4.

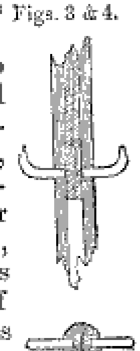


Fig 5.

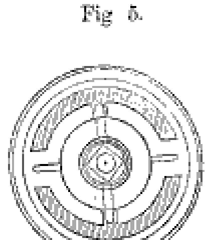


Fig. 6.

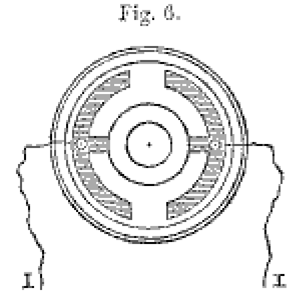
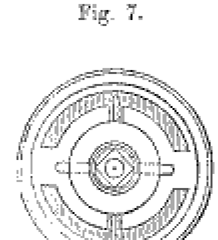


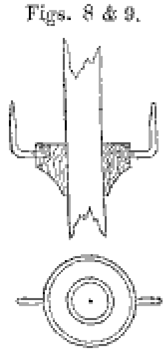
Fig. 7.



plier, in consequence of which, the voltaic current preserves its sign as long as the multiplier is turned in one direction, but it changes its sign on the motion being reversed. This commutation, which, it may be remarked, may be established without the use of mercury, by the contact of the strips of copper that act like springs, is found to answer completely. There are, besides, two other arrangements, which we must not allow to pass unnoticed.

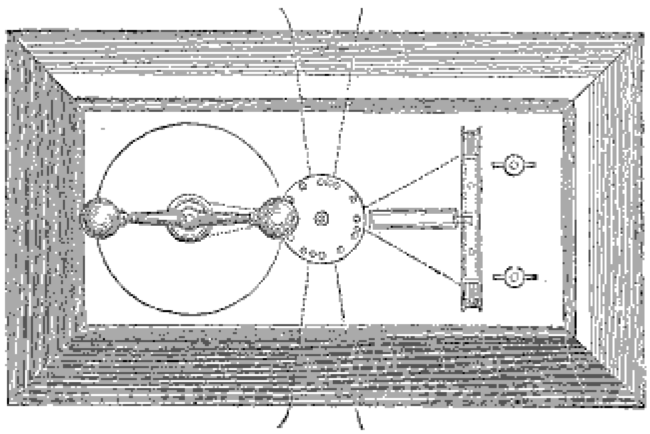
The voltaic current, as we shall see in the sequel, when treating of the indicator, should only be permitted to be in action during as short a period as possible, but during the interval should have the greatest intensity that can be commanded. The terminal hooks of the wires dip into the quicksilver, only at the place where it forms pools that advance toward each other at the centre, and where the current is at its greatest intensity, as seen by figs. 5, 6, and 7. Fig. 5 shows the position that the inductor has, when the terminal hooks first dip into the cups. In all other positions of the inductor, it should, however, form no part of the chain or wires, otherwise the signals made at the other stations will be repeated by its own multiplying wire; and this becomes of the more moment the greater the resistance in the conductor. In order, therefore, to cut off the inductor, when in any other position than shown in fig. 5, there is a wooden ring adapted to the axis of rotation of the inductor, as seen in figs. 8 and 9. This ring is encircled with a copper hoop, and into this latter two iron hooks are screwed. These hooks dip down into the semi-circular cups of quicksilver, as shown in fig. 7. At the moment, however, that they are passing across the wooden partition, the hooks of the inductor, which are at right angles to them, dip into the cups. When the hooks of the multiplier are in contact with the quicksilver, the connection with the hooks for diverting the current is broken. In every other position, the connection through the hooks of the multiplier is interrupted, while it is established through the others; whence it naturally follows that the current, on being transmitted from any other station, passes directly through the latter hooks, or, in other words, crosses directly from one quicksilver cup to the other, and is not forced to traverse the wire of the inductor for that purpose. In order to put the inductor in motion without trouble, there is a fly-bar terminating in two metal balls, fastened horizontally on to its vertical axis, as seen in figs. 1 and 10. To prevent the quicksilver from being scattered about, owing to the motion of the hooks as they dip into it, when the multiplier is turning rapidly, a glass cylinder is fitted on to this part

Figs. 8 & 9.



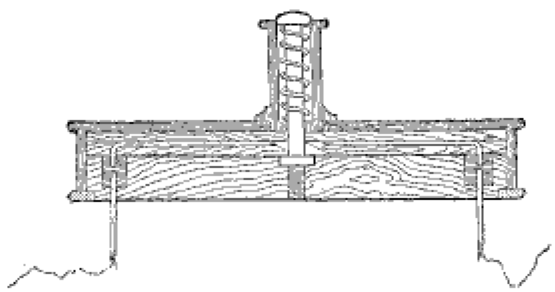
of the apparatus, fig. 11. At every half turn is seen the passage of the spark, as the hooks of the multiplier leave their cups of quicksilver.

Fig. 10.



If we choose to give up the phenomena of these sparks—a thing nowise necessary to the employment of the instrument as a telegraph—the inductor will admit of a far more simple construction. It will then merely be necessary to place the

Fig 11.



commutator directly above the anchor, and to let the axis of rotation pass farther up in the neck, in the direction of the fly-bar. It then becomes necessary to bore the axis out, but the ends of the multiplier are at once fastened by twisting on to two plates of copper, and these copper plates are let into a wooden ring, directly opposite to each other. The wooden ring is placed upon the vertical axis, and made fast to it by clamps. Externally this ring is, in addition to the above-mentioned plates, provided with an arc of copper let into it, which acts as a contact-breaker, and two ends of the chain that the current has to traverse, have the form of permanent springs, that keep pressing against the wooden rings directly opposite each other. By this means, with this arrangement also, the ends of the inductor are in metallic communication with the chain only during a small portion of each revolution, while during the rest of the time the connecting arc brings the ends of the chain into direct contact. This construction, in which quicksilver is entirely dispensed with, is, on account of its greater simplicity and durability, preferable to the arrangement first described. The apparatus of the stations at Bogenhausen and in Lark-street are thus constructed.

THE INDICATING APPARATUS.

Hereinbefore has been shown, that our aim is so to employ the current developed by the inductor, and led through the conducting chain, that when passed across magnetic bars that are delicately suspended, it may cause them to be deflected, as was discovered by Œrsted. These deflections, if we wish to give the signals in quick succession, must follow each other with the greatest rapidity, and should therefore be powerful. This points out to us the size we should give the magnetic bars we wish to deflect. They must not, however, be made too small, as in that case the mechanical force arising from their deflection, is not strong enough to be directly applied to striking upon bells, or any other similar purpose. The deflections are, as is well known, taking the force of the current to be the same, the stronger, the greater the number of turns in the multiplier, or, in other words, the oftener the wire is led along the magnetic bar. The size of the diameter of the separate turns, as we know, only exerts an influence, inasmuch as it adds to the entire length of the connecting wire. The indicator, therefore, is a multiplier, whose two ends connect with the conducting chain, and within which the bar to be deflected is placed. It must be borne in mind, that the thinner the wire of the multiplier is, the larger its coils are, and the more turns they make, the greater is the resistance to the current throughout the entire chain.

Figs. 12 and 13 represent the vertical and horizontal sections of an indicator containing two magnets, moveable on their vertical axis, and which, from their construction, are applicable both to striking bells, and also for writing characters in the form of dots or points. These figures will be more particularly explained hereinafter, reference to their application being sufficient for the present. Into the frames of the multiplier, which are made of soldered sheet brass, fig. 11, there are soldered two smaller cases for the reception of the magnets, and which allow of the reel motion of their axes. Above and below

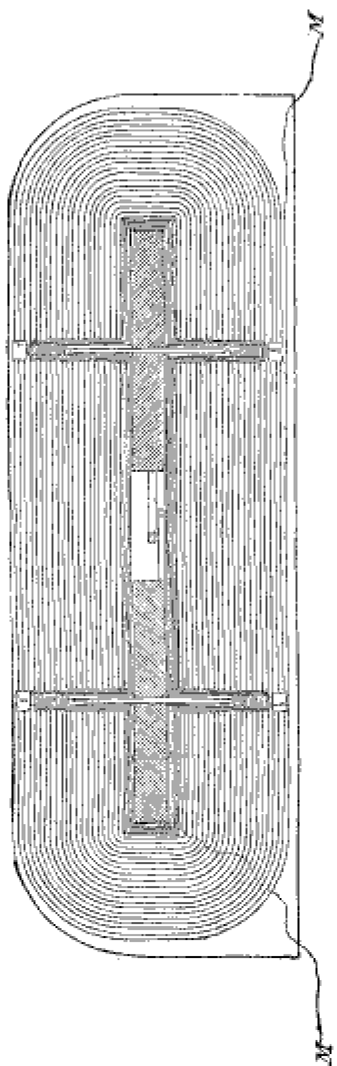
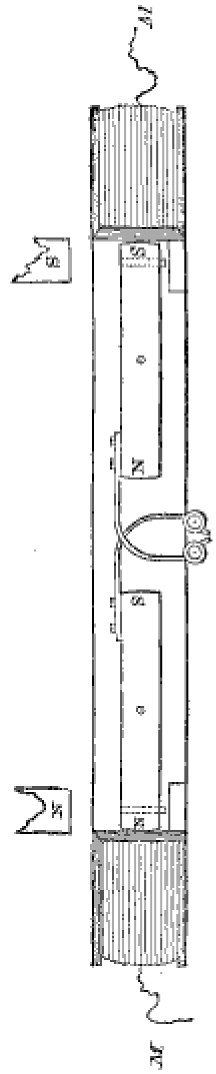


Fig. 12

Fig. 13.



they have threads cut in them, for the reception of four screws in holes, on the ends of which the pivots of the axes turn. By means of these screws, the position of the bars may be so regulated, that their motion is perfectly free and easy. In the frames of the multiplier there are 600 turns of the same insulated copper wire as was employed for the inductor. The commencement and the end of this wire are shown at M M, fig. 12. The magnetic bars are, as the figures show, so situated in the frame of the multiplier, that the north pole of the one is presented to the south pole of the other. To the ends which are thus presented to each other, but which, owing to the influence they mutually exert, cannot well be brought nearer, there are screwed on two slight brass arms, supporting little cups, figs. 13 and 14. These little cups, which are meant to

Fig. 14.

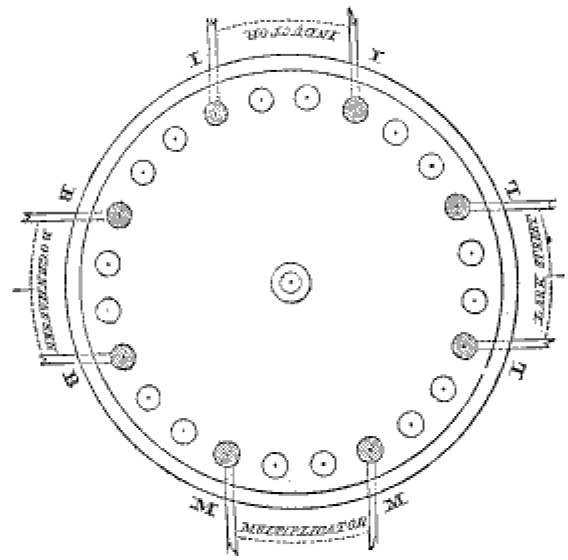
be filled with printing ink, or black oil color, are provided with extremely fine perforated becks, that are rounded off in front. When printing-ink is put into these cups, it insinuates itself through the bore of these becks, in consequence of the capillary attraction, and without running out, forms on the openings of the becks a projection of a semi-globular shape. The slightest contact suffices, therefore, for writing down a black point or dot. When the voltaic influence is transmitted through the multiplying wire of this indicator, both magnetic bars make an effort to turn in a similar direction upon their vertical axis. One of the cups of ink would, therefore, advance from within the frame of the multiplier, while the other would retire within it. To prevent this, two plates are fastened at the opposite ends of the free space that is allowed for the play of the bars, and against which the other ends of these bars press. Only the end of one bar can, therefore, start out from within the multiplier at a time, the other being retained in its place. In order to bring the magnetic bars back to their original position as soon as the deflection is completed, recourse is had to small moveable magnets, whose distance and position are to be varied, until they produce the desired effect. This position must be determined by experiment, inasmuch as it depends upon the intensity of the current called into execution.

If this apparatus be employed for producing two sounds easily distinguishable to the ear by striking on bells, it will be right to select clock-bells or bells of glass, both of which easily emit a sound, and whose notes differ about a sixth. This interval is by no means a matter of indifference. The sixth is more easily distinguished than any other interval; fifths and octaves would be frequently confounded by those not versed in such matters. The bells are to be supported on little pillars with feet, and their position with respect to the bars, and likewise their distance from them, is to be determined by experiment. The knobs let into the bar that strike on the bells must give the blow at the place which most easily emits a sound. These hammers, however, are not to be too close to the bells, as in that case a repetition of the signal can easily ensue. A few trials will soon get over this difficulty. If the indicator is to write down the signal, a flat surface of paper must be kept moving with a uniform velocity in front of the little beaks before mentioned. The best way of doing this is to employ very long strips of the so-called endless paper which is to be wound round a cylinder of wood, and then cut upon the lathe into bands of suitable widths. One of these strips of paper must be made to unwind itself from a cylinder, pass close in front of the cups, run along a certain distance in a horizontal position, so that the dots noted down may be read off, and lastly, wind itself up again on to a second cylinder. The second cylinder is put in motion by clock-work, the regularity of whose action is insured by a centrifugal fly-wheel. A longitudinal section of the entire arrangement is shown by fig. 1. Fig. 10 represents it as seen from above. At the corners of the frame over which the ribbon of paper is led, there are placed two moveable rollers, to diminish the friction. The frame moreover admits of being advanced toward the cups or withdrawn from them, so that the most proper position to give it can be ascertained by experiment. It is evident that the same magnetic bars cannot be at once employed for striking bells and for writing, the little power they exert being already exhausted by either of these operations. But to combine them both, all we have to do is to introduce a second indicator into the chain. By thus increasing the number of the indicators, the loudness of the sounds of the bells can be augmented at pleasure: this can, however, only be done at the expense of an increased resistance in the chain. In order that this may be increased by the indicator as little as possible, it would in future be better that its coils should be made of very thick copper wire, or of strips of copper plate.

CONSTRUCTION OF THE APPARATUS.

The longitudinal section of a pyramidal table, standing on the floor of the room, and containing the whole apparatus is represented by fig. 1. Fig. 10 shows the same as seen from above. The wires from Bogenhausen, those from the Lark-street, the ends of the indicator, and the wires from the quicksilver cups of the inductor, or, in other words, the two ends of the multiplier, all meet together at the centre of the table, as seen in fig. 10. They are here brought into connection with eight holes filled with quicksilver, made in a disk of wood as shown by fig. 15. The course that the

Fig. 15.



current we call forth will take depends upon the respective connections of these eight holes with each other. For example, suppose them to be connected together by four pieces of bent copper wire, as shown at fig. 15, the current would pass through the whole apparatus, and also, the entire chain. Establishing, however, the connection as shown by fig. 16 would cut off the Bogenhausen station, and would at once transmit the current direct from the inductor, through the multiplier of the indicator and through the Lark street station. Supposing this figure turned around 180 degrees, we should have the Lark street station cut off, and the current would pass through Bogenhausen. A third system of connections is shown by the copper wires represented in figs. 17 and 18. In this position of the sketch, the inductor and the multiplier would be in direct communication, while the two stations at Bogenhausen and in the Lark street would be cut off. But by turn-

Fig. 16.

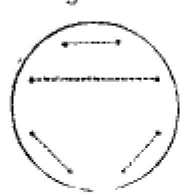


Fig. 17.

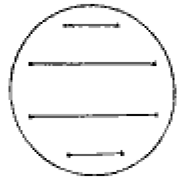
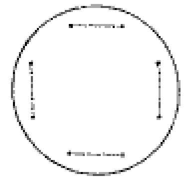
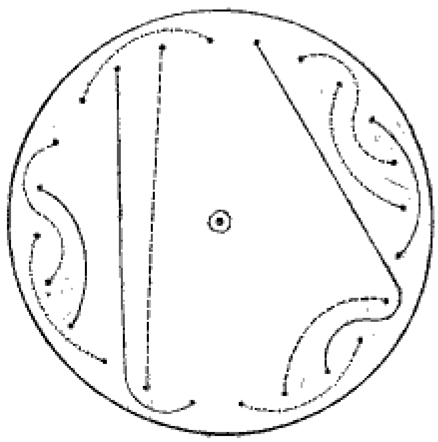


Fig. 18.



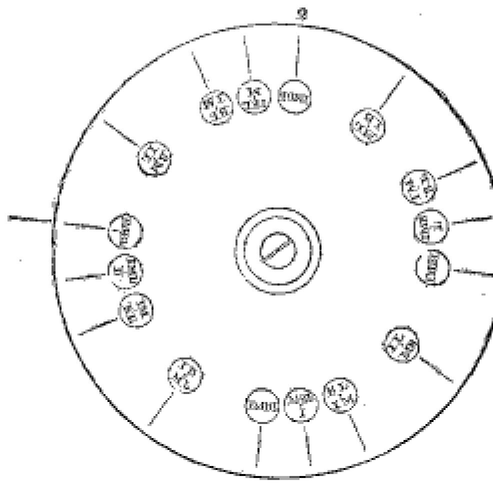
ing this figure 90°, we should connect these two stations, while we broke off the station in the Academy. Copper wires serving to establish these three systems of the connections and the combinations, are laid down upon the under surface of the wooden cover of the commutator, as seen at fig. 19,

Fig. 19.



There are twenty-four wires projecting downward from this lid. Only eight of them, however, ever come into use at once, so that there must be sixteen other holes made in the lower disk of wood, for the reception of the wires not in use, and having no quicksilver poured into them. It is thus in our power to direct the course of the current as we choose, and the systems concerned are indicated upon the upper surface of the cover of the commutator by engraved letters, as seen by fig. 20; this cover containing the different modifications of the systems of connection, as shown at fig. 19. Changing the position of this cover round the central pin springing from the table, enables us to vary the direction of the current in any manner we like. The use of the quicksilver cups in the commutator may of course be replaced by conically turned copper pins. This has indeed been done at the Lark-street and the Bogenhausen stations.

Fig. 20.

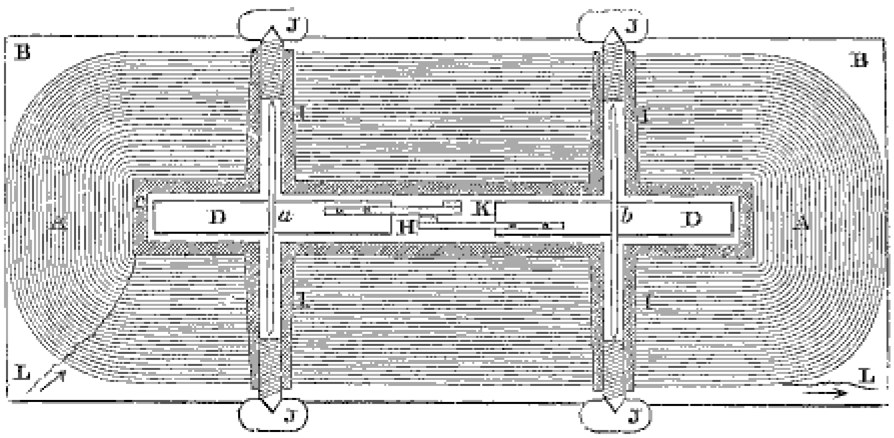


APPLICATION OF THE APPARATUS TO TELEGRAPHING.

From what has already been stated, it will be seen that at every half turn of the fly bar from right to left, one of the bars is deflected. The terminations of the wires are so connected that every time this movement is repeated the high-toned bell should be struck at all the stations. Standing at the side B B, and turned toward the indicator, one immediately perceives the beck imprint a dot upon the ribbon paper as it moves along. The intervals of time between the successive repetitions of this sign, are represented by the respective distances between the dots that follow in a line upon the paper. On turning the fly-bar from left to right toward the operator, the deep-toned bells ring, and the second ink cup marks down a dot upon the paper as before, not, however, upon the same line with the former dots, but upon a lower one. *High* tones are therefore represented by the *upper* dots, and the *low* tones by the dots on the lower line, as in writing music. As long as the intervals between the separate signs remain equal, they are to be taken together as a connected group, whether they be pauses between the tones, or intervals between the dots marked down. A longer pause separates these groups distinctly from each other. We are thus enabled by appropriately selected groups thus combined, to form systems representing the letters of the alphabet or stenographic characters, and thereby to repeat and render permanent at all parts of the chain, where an apparatus like that above described is inserted, any information that we transmit. The alphabet which is chosen represents the letters that occur the oftenest in German by the simplest signs. By the similarity of shape between these signs and that of the Roman letters, they become impressed upon the memory without difficulty. The distribution of the letters and numbers into groups consisting of not more than four dots, is shown in the alphabet, figs. 23 and 24.

In order to explain more definitely figs. 12 and 13, the following figs. 21 and 22, with their sectionals more particularly described, are inserted.

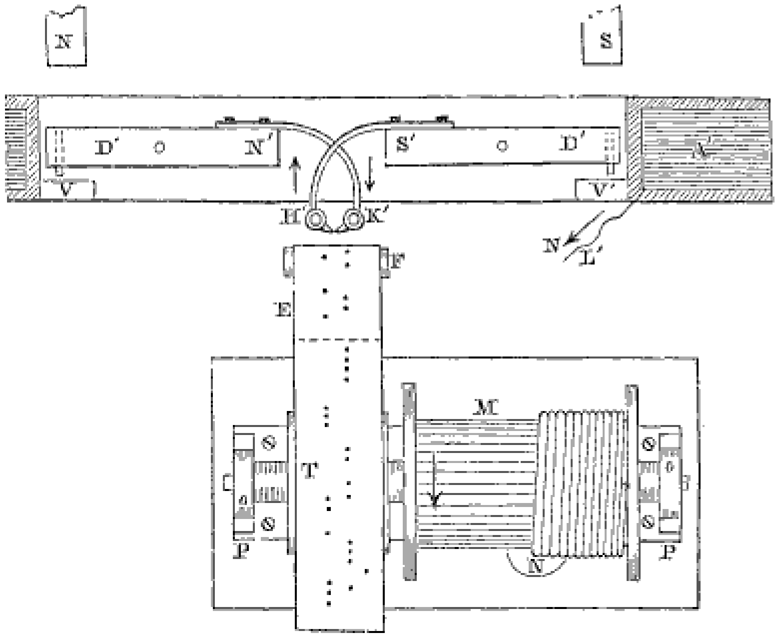
Fig. 21.



In fig. 21, A A represents a vertical section, through the centre of the coil of copper wire; C is the interior brass frame, round which the wire is wound; B B are the sides of the frame; I I I I are four brass tubes, soldered to the interior brass frame, and passing through the centre of the coil to its exterior, with a screw cut in the end of each; D and D are two permanent magnets movable on their axis *a* and *b*. These spindles, *a* and *b*, on each side of the magnets, pass up the hollow of the tubes, and having their ends pointed, enter the centre cavity of the four thumb screws, J J J J, by which they are supported, and delicately adjusted, so as to move easily and freely; L and L are the ends of the wire leaving the coil; H and K are two inkholders, attached to the magnets, which will be explained hereafter.

Fig. 22 represents a horizontal section of the coil, and magnets D′ and D′, as above described, together with the other arrangements of the instrument for receiving intelligence. The magnetic bars are so situated in the frame of the multiplier, that the

Fig. 22.



north pole, N′, of the one, is presented to the south pole, S′, of the other. To the ends which are thus presented to each other, but which, owing to the influence they mutually exert, cannot well be brought nearer, there are screwed on two slight brass arms, supporting little cups, H and K. These little cups, which are meant to be filled with printing ink, are provided with extremely fine perforated becks, that are rounded off in front. When printing ink is put into them, it insinuates itself into the tube of their becks, owing to capillary attraction; and, without running out, forms at their apertures a projection of a semi-globular shape. These little cups are seen at H′ and K′, and in fig. 21 at H and K. The horizontal section shows, also, the position of the magnets in the instrument, with the becks of the pens near the continuous band, or ribbon of paper, E, which is brought in front of the pens vertically from below, over a small roller, F. The paper is supplied from a large roll on a wooden cylinder, upon which is a cog-wheel, and connected with a train of wheels and a vane, to regulate the rate of supply. The paper is drawn along before the pen by being wound upon a cylinder, T, concealed by the paper, and on the same shaft with the barrel, M, upon which is wound a cord supporting a weight, N, below. The shaft is supported in the standards, *o* and *o*, which are fastened to a plate of brass, P and P, also secured to the platform of the instrument. The barrel revolves in the direction of the arrow upon it.

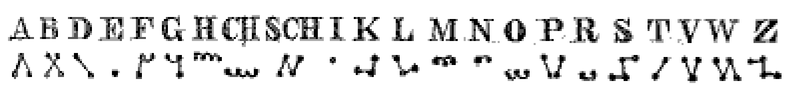
When the electricity is transmitted through the coil of the indicator, both magnetic bars, D′ and D′ make an effort to turn in a similar direction upon their vertical axes, *a* and *b*. One of the cups of the ink, therefore, advances toward the paper, while the other recedes. To limit this action, two plates, V and V′, are fastened at the opposite ends of the free space allowed for the play of the bars, and against which the other ends of the bars press. Only the end of one bar can, therefore, start out from within the multiplier at a time, the other being retained in its place. In order to bring the magnetic bars back to their original position, as soon as the deflection is complete, recourse is had to two small moveable magnets, a portion of which is seen at N and S, whose distance and position are to be varied till they produce the desired effect.

The fluid is made to pass in the direction of the arrows, shown at P and M. Then the N pole of the left-hand magnet advances with its pen K′, to the paper E, and a dot is made, and the S pole of the right-hand magnet recedes with its pen H from the paper, until the other end of the magnet strikes the stop V′. Now, if the letter to be formed requires two dots in succession from the same pen, the circuit is broken, and the fixed magnets, N and S, bring back the deflecting magnets, D′ and D′ to their former position, when the pole-changer is again thrown to the left, and the magnets are deflected in the same manner, as at first. Thus, two dots are marked upon the paper, on the *right* hand line. When the current is reversed, the N pole of the left-hand magnet, with its pen K, recedes from the paper, until it strikes the stop V, and the S pole of the right-hand magnet, with its pen H′, advances to the paper, and makes its dot upon it on the *left*-hand line.

THE ALPHABET AND NUMERALS.

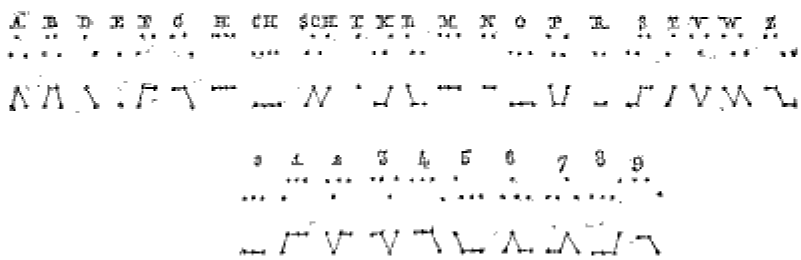
The alphabet was formed, as has been already described, by the making of dots upon a ribbon paper, from small becks holding ink in globular forms at their ends. The alphabet thus written is arranged by some authors as follows:

Fig. 23.



Prof. Steinheil has furnished me with the alphabet and numerals arranged as the following, which must be regarded as their true and proper organization.

Fig. 24.



THE DISCOVERY AND INVENTIONS OF STEINHEIL.

From the foregoing, in regard to the discovery and inventions of Prof. Steinheil, it will be observed that he produced the following facts, viz.:

1st. That he invented a tangible and practical writing electric telegraph, demonstrated by the most complete experiments;

2d. That he invented an electric telegraph, which actually communicated intelligence by sound, methodically arranged, suitable for commercial purposes;

3d. That he discovered the earth circuit, as practically applied in the electric telegraphic art, with all systems throughout the world

4th. That he first organized the system of poles and insulators, for the suspension of metallic conductors in the air for electric telegraphing;

5th. And that he established the fact, by actual experiment, that a current of electricity, generated by a magnetic organization, can be practically applied for telegraphing.