The Practical Telegraphist

or

electro-magnetic

Telegraphy

according to Morse's system,

Initially also a
manual for aspiring telegraph operators
in full. and comprehensively presented
from my own practical experience

By Clemens Gerke
Inspector of the electro-magnetic telegraph at Hamburg.

With woodcuts printed in the text.

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Introduction.

When in 1848 I read the brochure of Alfred Vail, under the title: "Thorough Exposition of the Electro-Magnetic Telegraph. Hamburg at Hoffmann & Campe.", I, myself, was only a prospective pupil in this science, who, relying on the authority of Vail's material, would not and could not add more than what this very original document had revealed to the wider public. But, as I soon enough saw, described the actual practice basically very little, and even this little experience has taught us to reject some things as much too complicated, as unnecessary and impractical, and to put other simpler things in their place; Some things are to be omitted altogether, since simplicity is of the utmost importance in this science, which is rooted in the deepest nocturnal region of nature and is already capricious, and every exaggerated complication only makes the work more difficult and, especially in critical moments, intolerable.

Now, in view of the general interest which electromagnetic telegraphy now finds in the widest circles of the educated public, and in view of the ever-increasing extension of telegraph installations over almost all parts of Europe and North America, I believe that I owe it to this very public, which I introduced, as it were, into the obscure forecourt of the science in question, now, after mature experience, I am determined to lift the curtain that conceals the real essence of it as much as possible, and I am determined, far from all secrecy, to lay down on the following pages all that I myself know about it so far. This, however, is likely to be quite exhaustive - as far as Morse's system is concerned, since the peculiar terrain of the local system made us acquainted with difficulties and obstacles in such abundance as is unlikely to happen to any similar institute so soon, and the fortunate overcoming of which therefore formed a very *excellent* school.

If, however, the existing conditions only enable me to represent electro-magnetic telegraphy according to Morse's system, but also this in its entire extent, then under the existing state of affairs this has undoubtedly its great advantages, since this very system has been the only dominant and proven system in North America, which has been through and through practical for more than 10 years, and even now in Germany it is already beginning to assert its rights everywhere. and even in refined Prussia, where self-invented systems had already been employed, it nevertheless resolutely asserted its precedence on account of its undeniable advantages, especially as far as speed and safety were concerned, and even from the operating officials, such as I heard from the own mouths of several people who had to deal with different matters, as the far more convenient and pleasant to handle.

But In particular, the little work which I have previously published as a translation, a principal component of Morse's telegraph, namely, the so-called *relay*, and in *The practical Telegraphist, or electro-magnetic telegraphy according to Morse's system,* the laying of the line over long distances, were both completely ignored in Vail’s material, and there was no mention at all of the obstacles that occurred or the practical treatment of the apparatus; But if I now also draw these subjects into the sphere of my presentation, I believe that I can give useful hints not only to the inquisitive layman, but also to the aspiring telegraph operator or perhaps experimental dilettante, and especially to enable them to achieve practical successes with a little seriousness and perseverance, which, as all concede, is never or at least very rarely the case from textbooks, as an explanation of my intention, I will confidently go to work.

I.

Of the electro-galvanic battery in general.

As far as this main component and actual impulse of electro-magnetic telegraphy is concerned, I can confidently take up the introductory words from my translation work mentioned earlier, since, with the exception of a small thing, which I will correct at this point, there are no errors in it. - But that introduction begins as follows:

> "The electro-galvanic battery, as the generator of that mysterious fluid which mediates the most important part of the activity of the electro-magnetic telegraph, is found as different in its form and arrangement as the purposes for which it is used. But all of them must and can only be put together according to the same basic rules. It is not our intention, however, to go through the different types and modifications of such batteries individually, but we shall confine ourselves to those which can be used for telegraphic purposes."

> "The effect which the electro-galvanic fluid produces on metallic bodies, iron or steel, by awakening the magnetic attraction in them; furthermore, its decomposing power, by breaking down liquids into their original constituents; lastly, its wonderful action on the organic, especially on the nervous system, of the animal's body is fairly well known. But we know nothing about the actual being and nature of this mysterious force itself. In some of its phenomena it is comparable to the electric machine, in that in both cases the metal exerts a conductive force; both give slight sparks, and, when they come into contact with organic bodies, produce this one shock, being very sensitive to the action of such force. In another respect, however, galvanism and electricity again appear very different. Without the galvanic fluid, it is impossible to produce a so-called electro-magnetic force, since the machine's electricity appears inadequate for such purposes. The former is, so to speak, more solid, more steady, and more bound to its conductors, while the other is far too fleeting, and disappears into the air before it has reached the terminus of a long conduction. The former, therefore, is sure and constant in its services, while the latter appears uncertain and capricious in its manifestations of power.

> The former remains quietly with the conductor assigned to it, while the other jumps over into the first closest metal body, even if it does not come into direct

> contact with it. In short, simple electricity is not in a position to fulfil the purposes which the telegraph demands, and as electricity, though not exactly the same, is not really a hostile force to galvanism, it has been observed that the influence of the latter, at the moment when the galvanic conductor is engaged in telegraphy, is unleashed on him. does not cause any disturbance in the work, and its presence can only be perceived by the fact that from time to time a bright spark, with a sound similar to the crack of a whip, jumps out of the wire."

In this connection I must necessarily remark, that although the comparatively small electrical force produced by an electric machine may not produce any disturbance in telegraphic work under the circumstances mentioned by Mr. Vail, this is nevertheless the case in the highest degree with the powerful influence of atmospheric or even merely telluric electricity, since the work is completely interrupted by such an influence. irritated, or at least made more difficult. But this is especially the case with the outbreak of snowstorms or rainstorms, through the earth's electricity that then occurs, so that, although there is absolutely nothing to be seen in the sky of a thunderstorm, the electric fluid nevertheless rises by means of the metal plates sunk in at the ends of the line, and so disturbs the whole line with its disturbing influence that it not infrequently, as I myself experienced in January, 1849, often for a whole day, it is impossible to correspond; innumerable less important similar cases are not counted. - However, let's return to Vail:

> "The simplest method to develop the galvanic fluid is the following: An ordinary glass bowl is filled with dilute hydrochloric acid in two thirds; then a piece of pure zinc, about 5 inches long and 1 inch wide, dips it into the liquid at one end, and one will immediately perceive an activity, even if only slight, during this contact. If we now take a piece of copper, which is shaped like zinc, and dip it into the liquid, but without touching the zinc, and then bring the two ends of the metals protruding above the glass into contact, we will immediately notice a decomposition of the hydrochloric acid, and this is already a result of galvanism. for it is precisely through the connection of the two outer ends of the metal that ordinary form of metal plate connection is established which is necessary for the development of galvanism. If this connection is interrupted, the action stops immediately; if it is renewed, it begins again immediately afterwards."

> "Another experiment, very simple and easy to try by anyone, is to put a flat piece of zinc under the tongue, and on top of the tongue a piece of silver money; then

> bring the two outer edges of the metals into contact and one will feel a peculiar and sensitive impression on the tongue; a weak push, which testifies that galvanism also develops in this simple way."

So much for Alfred Vail. I won't attempt here to explore the inner mysteries of Galvanism—and its intimately related forces, Electricity and Magnetism[1]—which, until now, we can only grasp through their effects.

Instead, I'd like to briefly offer my personal perspective: these three forces, deeply connected at their core and essentially unified in origin, represent—more likely than not—the true, veiled spiritual principle of life and formation throughout vibrant, living nature.

It is through these forces that all living beings, ourselves included, come into existence and evolve. And it is from these same forces that the atmospheric phenomena—wind, rain, snow, hail, clouds, whirlwinds and waterspouts, and above all, the electric majesty of storms and fiery displays in the skies—find their source.

Even some inorganic creations—like the ongoing formation of gemstones in Earth's depths—likely owe their origin to this universal natural power. Bold thinkers have even speculated that these forces might play a role in the orderly motion of celestial bodies.

In this light, the beating of our hearts, and in their subtlest expression, even our thoughts and emotions, may ultimately be entwined with electromagnetism.

One thing is certain: the cohesion of matter—the very connectedness of things, in the most literal sense—is a daily yet wondrous manifestation of these forces, clearly demonstrated in the artificial process of galvanoplasty[2]. Yes, if we dare to trace fire—and by extension, the primary conditions of life: light and warmth—back to electro-galvanism, then the endless cycle of decomposition and recombination, the constant transformation of the material world from basic elements into complex forms; from decay to the glittering splendor of a flower, a fluttering butterfly, even the radiant structure of humanity—and then back again to decay—is all the work of these shadowy, earthbound spirits. It's a thought fit for endless reflection, mentioned here only in passing, to attune the contemplative mind to the 'magic circle' into which

[1] To galvanize is to "charge something up," i.e. instantiate it

[2] Electro-typing, much like electro-plating but used to great duplicates as in printing processes.

electromagnetic telegraphy will lead it—less through imagination, and more through tangible reality—in the pages that follow.

About batteries in particular.

If we return from this far-reaching mystical field of night to the simple, real reality, then the actual active force, which gives the impulse in electromagnetic telegraphy, and under the same conditions, in plastic reproductions, expresses itself as galvanism by a complex of metals, acids, and earthen vessels, which are called "battery" under the general term "battery," and on account of their duration, constant battery. and of which each individual self-contained complex is called an element, so that a battery may consist of one to a hundred or more elements, according to the intended strength and expression of force. The following will bring a closer understanding of this.

The batteries hitherto in use are divided, according to their originators, into Daniel's, Grove's, and Bunse's, each having its own peculiar composition. Since the former is only used in our country, I will mention the other two only briefly, and in this our more recent method differs from Vail's account, that there only the Grove battery is discussed in more detail as the only one in use, while since 1849 we have completely rejected it and even put it out of action as a local battery for the writing apparatus.

The composition of Grove's battery is as follows: An ordinary strong beer glass is filled with sulfuric acid diluted in water to a few inches below the rim. - A thick-walled zinc pot is placed in this place, without a bottom, and provided with a gap on the side, so that the sulfuric acid mixture can flow all around the zinc. At the top of the zinc pot is cast a strong arm, at first somewhat erect and then about 2 inches horizontally tapering, which reaches over to the next element, and at the end of which is soldered a thin strip of platinum as wide as a thumb, which descends into the same second element and is so long that it almost reaches the bottom of it. In this zinc pot, and consequently surrounded on the outside by the sulfuric acid solution, a porous pot of pipe earth is then placed, the genus of which is usually obtained from Berlin, Vienna, and also very chiefly from London and New York - which is filled almost to the brim with strong saltpeter acid (separating water), but more unpurified, as is obtained from the factory, into which acid the platina strip is then immediately absorbed from the next element, as a connection or conductor, one hangs, and with this the actual, power-developing part would be settled. - But in order to convey a transmission and transmission of this force, a strong copper wire is soldered to the arm of the last zinc pot in the same depression as the platinum strip, and inserted into the opening of a brass double screw, into which it is screwed in from the side, while something similar, applied from the side, is done with the lead wire on the other short column of the same double screw. - On the other side of the battery, however, the platinum is hung by means of soldering to a copper wire bent over the top in the form of a 7 and the lower tip is also countersunk into the opening of a double screw; while the platinum strip hangs in the saltpeter acid of the first pot. These two outlets are now called the poles, in that the force proceeds from the one, namely from the zinc or positive pole mentioned above, and returns to its origin in the closed so-called compass, through the vessel-connection, to the last-mentioned platinum pole, and following the whole wire line. This battery develops a very energetic force; has the evil, however, that the nitric acid decreases from hour to hour in its development of strength, and therefore often has to be renewed in the course of a single day, whereby in addition an intolerably foul-smelling vapor develops, which eats away at all the metals in the vicinity and is highly detrimental to health, which is why this battery should be placed in one and the same room, is quite impossible. - Moreover, nitric acid, since it is used unmixed, is a very expensive article, and precious platinum, although not so easily destroyed by unmixed nitric acid, also increases the long-term cost of this battery. Furthermore, according to Vail's and other textbooks, the zinc pots must also be mixed, i.e., amalgamated with mercury, which is done by sinking them into mercury and aiding them with the brush, which again requires the consumption of a very expensive article (Mercury), the use of which is also known to be injurious to health. Finally, however, the zinc pots should also be boiled and cleaned from time to time in diluted hydrochloric acid. All this combined makes the Grove battery a very expensive and highly unpleasant apparatus for the immediate vicinity, which is why it would certainly have been wise to eliminate it and replace it in other ways.

The Bunse battery differs from Grove's in that the platinum is replaced by a hollow carbon cylinder, and the nitric acid can be used diluted. The composition is mainly as follows, and apart from some other, insignificant deviations, as follows: A pot-like coal cylinder, with a protruding rim at the top, without a bottom, is placed in a glass filled with a little diluted sulfuric acid, so that the edge of the coal rests on the edge of the glass. The latter is enclosed by a pressed or screwed copper ring, to which the arm of a zinc cylinder, reaching over from the next element, has been attached. This zinc cylinder hangs in a clay cell filled with dilute sulfuric acid, and this in turn reaches down into the coal cylinder and is therefore surrounded by nitric acid. To transfer the electro-galvanic flow into the wire, strong copper wires are attached to both outputs as poles, similar to the Grove battery. - The preparation of the coal cylinders is very difficult and, according to Drescher, will proceed as follows:

Well annealed, finely powdered and sieved coke is mixed with coals, preferably baked, also pulverized and sieved, approximately in the following ratio: 2 parts coke to 1 part coals. This mixture is brought into the forms of sheet iron, and annealed at a moderate coal fire. In order that the coals immediately take on the appropriate shape, a cardboard cylinder is placed in the sheet metal mold, which remains stuck during the annealing process. After annealing, a perfectly homogeneous and fairly solid mass must be obtained. If this is not the case, then the right mixture ratio has not been reached. If there is too much coke, one obtains a coal which is very easily broken between the fingers, and an excessive amount of coal gives a non-coherent mass. It is therefore necessary to determine the correct mixing ratio for a particular type of coal by several experiments. Once this has been found, it is not possible to interfere with the following operation. With a tin grater, the cylinders thus obtained are cleaned of the loosely adhering coal particles and then impregnated with a concentrated sugar solution (syrup). After the sugar has become dry, the coals are placed in a refractory vessel (crucible), which, after the spaces between them have been filled with charcoal powder, is well sealed, and exposed to a 36-hour incandescent heat, for example in a pottery kiln, whereby the coal receives its electro-motor power. After this, it is given the appropriate shape on the lathe. When the coal cylinders have finally received this completely, the upper end is dipped in molten wax as far as the metal ring to be applied touches it, which prevents the absorption of the nitric acid, which would otherwise destroy the metal. Then 8 to 10 small holes are drilled in the wall of the coal, through which the nitrous acid developing in the cell can escape, and the preparation is ready for use. If the charcoal is to be suitable for its purpose, it must be quite homogeneous, and free from larger, visible pores, must not rub off in the least, must give a bright-sounding sound, and must be able to fall several feet deep on wood without breaking.

This battery, as is already evident from the above method of preparation of coal, will be very expensive, and as it does not surpass Grove's in energy, it will probably, and rightly so, soon be completely out of use.

I now pass to the so-called Daniel battery, which will undoubtedly soon be the only one in use for telegraphic purposes, and which we also use in a double manner, the practical application of which leaves nothing to be desired, and its composition has been greatly simplified. It consists of the following separate parts: In order to have the two necessary acids available in advance at all times, 2 large glass bowls are prepared, about 2 pounds of blue copper sulfate are thrown into one of them, then the vessel full of pure soft water is filled, and the sulfate is stirred from time to time with a long and strong splinter, whereupon the water dissolves as much of the former as the nature of the two substances permits and is necessary for the purpose; the surplus is deposited undissolved and is used again at the next dissolution. For about 2 days, the now greenish-blue looking substance is suitable for use. The second component is also filled almost entirely with water, and so much good sulfuric acid is poured into it that the well-stirred mixture, dabbed with the finger and brought to the tongue, excites a strong sour tingling taste. Measured with the ordinary aerometer, it must maintain about 3 to 4 degrees of strength, or, to put it another way, one part of sulfuric acid comes to 50 to 60 parts of water. All the textbooks that have come to my knowledge indicate acid too strongly mixed, and one has the harm from the fact that the zinc pots flowing around it quickly decompose and cause new expenses. It should be fairly common knowledge that table salt dissolved in water can be used instead of this diluted sulfuric acid; but I think I may call the experiment I have tried new, instead of any further mixture, of filling the porous pots with pure fresh sea-water, which, of course, is only possible at stations which lie on the sea-coast; but I can assure you that our station at Cuxhaven worked for some time only with pure sea-water for the zinc part of the battery, and even dissolved the copper sulfate with sea-water. If you use cooking salt, it is sufficient for the mixture to hold 2 degrees. Unfortunately, it soon creates a dead crust on the zinc.

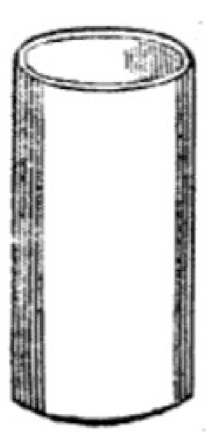
Now that this preparation has been made, we proceed to the composition of the battery itself. One fills a strong beer glass or usually several, depending on the intended thickness of the battery of about 4 inches in diameter and 5 inches in height, after which the size of the other battery apparatus can then easily be measured by half or a little more, with the copper sulfate mixture, places the glasses in a row, and must now have the following apparatus at hand:

First, to dip it into the last glass on the left hand, a bottomless copper cylinder of the following shape:

Fig. 1.

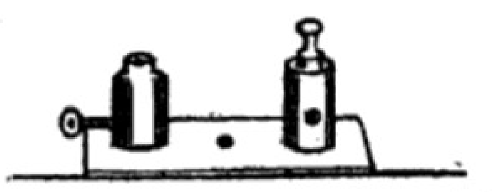
The wire hanging vertically to the left is called the pole, and indeed in its position, the negative pole, or copper pole, in that it (itself copper) proceeds from the copper. - This copper cylinder, therefore, after it has been sunk into the glass, is surrounded by the sulfate solution inside and out, and rests on the bottom of the glass, while the wall of the latter is between the pole wire and the wall of the copper cylinder, followed in the row by a porous pot, or clay cell, the peculiar manufacture of which is best done in the royal porcelain factory in Berlin; but also in Vienna, Hamburg, Celle and others usable clay cells are manufactured. - The form of the same is very simple and something like this:

Fig. 2.



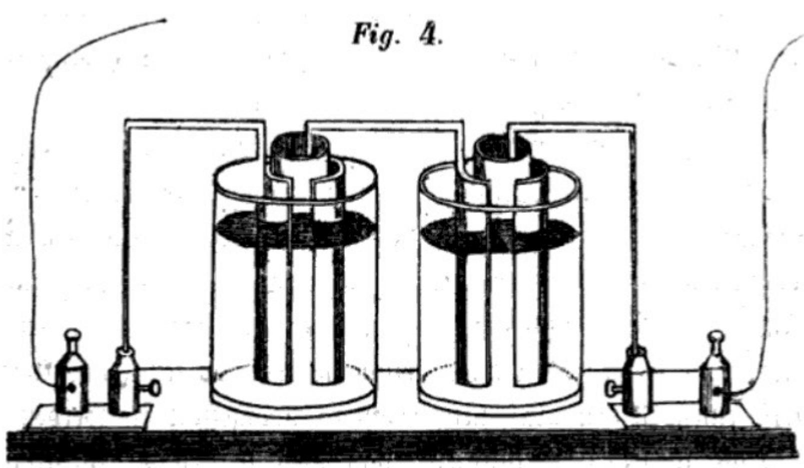
This clay cylinder is now placed in the cavity of the copper cylinder, and receives the dilute sulfuric acid by filling it about halfway with it, so that it does not overflow and mix with the sulfate solution when the zinc cylinder is now sunk into the clay cell. - The shape of this cornet is quite indifferent, round or angular, if it can only be sunk into the clay cell and a head protrudes from it at the top. A brazed copper arm must run out from this head, which either protrudes over to the copper cylinder of the next battery element, and is soldered to it, or also, at the end of the battery, runs into a copper wire, similar to the other side, whereby the positive or zinc pole is then produced. Both poles, i.e., the ends of the low-hanging copper wires, are then in their turn sunk into the upper opening of a double forced screw, which plays an important part in electro-magnetic telegraphy in general, which is why I will immediately add the form of it here. Fig. 3. it is best to make it in such a way that both, both the side and the upper holes, have a screw passage, so that they can be inserted at will for countersinking the pole wire from above, because then the screw is inserted from the side; or the lead wire from the side, as then the screw is inserted from above. –

Fig. 3.



Such a battery of 2 elements - which of course can be increased at will - would then be exempt as follows:

Fig. 4.



The diluted sulfuric acid to this battery must be renewed every morning, whereas the sulfate solution can be used until it becomes clear and transparent. In the evening, as soon as there is no longer any work to be done, the battery is taken apart, the metal cylinders are placed in clear water, the clay cylinders are rinsed clean, and the jars with the sulfate solution are left to stand quietly until they are used again the next morning. - The already used sulfuric acid mixture, or if you want to use table salt, the salt mixture, does not need to be poured away, but can be used again with the local battery. All the other artifices mentioned in the various textbooks are completely unnecessary, and in some cases even harmful, such as, for example, the expensive and highly detrimental amalgamation of zinc cylinders with mercury, which was also used in our country at first, according to the instructions of the American engineer Robinson, until at last we found through experiments that there was no reason at all for such a process; the battery worked just as admirably as usual even without the use of it, and, on the contrary, the mercury only promoted the dissolution and decay of the zinc in the highest degree. -We also found the hitherto applied cleaning of the zinc cylinders by means of hydrochloric acid just as unnecessary; rather, a simple cleaning in the morning, by means of a stiff brush in clear water, was found to be completely sufficient, and thus not only work but also large expenses were saved.

One of the main requirements is to prevent the two different liquids from mixing directly by overflowing, but only from coming into connection with each other through the medium of the clay cylinder, which is why, as already mentioned, the latter and the glasses, each with the corresponding acid, may only be filled about halfway, in order to be refilled later by means of a small glass funnel.

Now the law of nature, recognizable in its results, but not in its actual causes (of which more details will be given later), which produces the wonderful effect of electromagnetism, expresses itself in the first place, that the electric current, which is formed by the combination of acids and metals described above, together with the medium of the clay cylinders, first proceeds from the positive or zinc pole, passes through the battery itself and develops within it by means of the intensification of increased elements, descends into the negative pole proceeding from the copper cylinder, then passes over to the positive pole, and by means of it then rises again upwards, returns to its exit, thus forming a cycle, or, as technique expresses itself, a circuit (*circuit* and *circle* are the same word in German). The term "circle", however, is only to be understood as such only improperly, since the line must just as well form a square, triangle, or any other, or no real figure at all. The main thing is that in order to achieve an intended flow of electricity through the battery and its wire extension, the ends of the two poles must be brought into connection by means of a conductive body. Whether such a current is there or not, one can easily find out, even miles away from the battery, by unfolding the cable, namely the metal wire, and bringing the resulting two ends to the moist tongue, which can be done safely, and where the taste is then easily recognizable by a sharp tingling feeling, whereby some people see sparks in front of their eyes, whether there is an electric current, whether it is strong or weak. It may be necessary to remark here that if several batteries are exhibited at the different stations of one and the same line, they must be placed in such a way that the poles of different names are always opposite each other, so that zinc does not meet and copper meets copper. In our country, for example, the wire diverted from the copper or negative pole goes overland to Cuxhaven and Bremen, and the wire from the zinc goes through the basement of the stock exchange arcades and the zinc plate sunk there into the earth. It is the other way around in Cuxhaven: the wire from the copper pole there leads into the earth, on the shore of the lake, and the wire from the zinc pole overland to Hamburg. In another, one-sidedly changed position, all work is impossible.

Now the executive process, which comes into being by means of a battery manufactured according to the instructions by means of a connection of the poles with a longer or shorter wire line, is recently said as follows: - As already remarked, the function of the electrogalvanic process is: decomposition of the substances and regeneration, consequently metamorphosis. - In the present Daniel's battery, by means of the electric current under the influence of sulfuric acid, the zinc and the dissolved copper sulfate are now converted into zinc sulfate at the expense of both, which is why both parts lose their volume, while the product of their activity is deposited as pure copper in the form of grains on the inner side of the copper cylinders, whereby they become stronger and stronger, similar to electroplating, and can therefore be used for a very long time. Now, since the surfaces of both are changed only very gradually by this process, only the electro-motor force is changed in the same measure, and the battery has therefore been called a constant, i.e., one acting for a very long time in the same force, which is not the case with other batteries. Absolutely constant batteries, however, do not exist in artificial composition.

Daniel's battery, in addition to its long-lasting effect, also has the advantage, which is not to be trifled, that it does not emit a disgusting smell that is detrimental to health, and can therefore be placed anywhere in the station locales, in the immediate vicinity of the officials, while the Grove battery, for example, as already mentioned, can be used by the development of nitric gas, placed near people, becomes obnoxious and highly detrimental to health.

A Daniel's battery of 2 elements, composed in exactly the same manner and form, but in a circumference at least four times larger in the individual parts, is now generally used for the writing apparatus, instead of the former Grove's battery, with the advantage to be considered that it does not lose its strength in the course of a working day, like the latter, and causes only very insignificant expenses. More details about this writing apparatus later.

II.

The Conductors

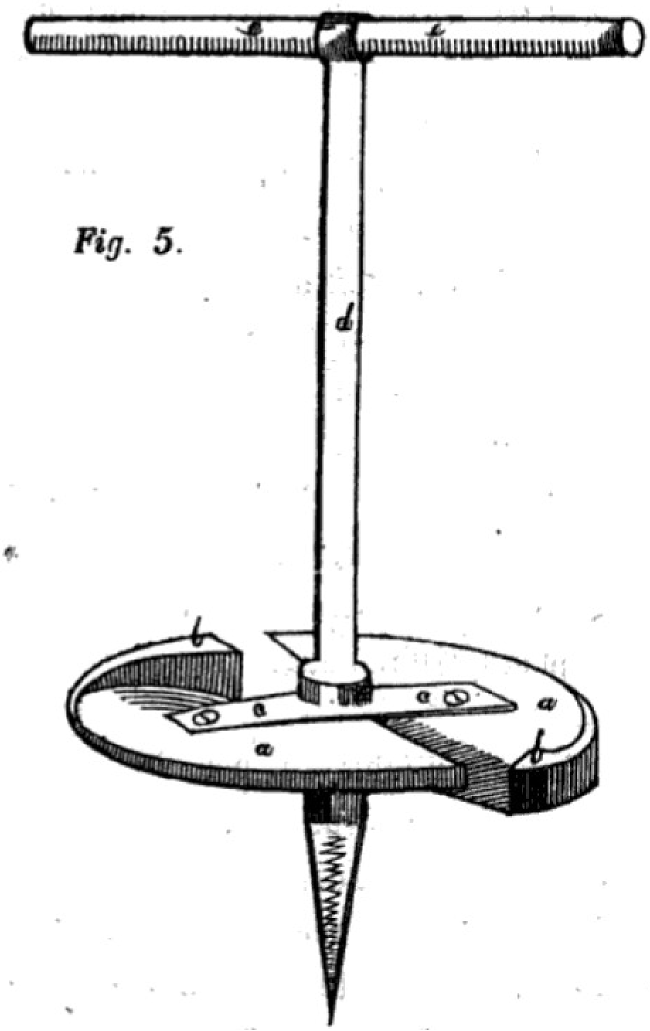
The other principal part of an electro-magnetic telegraph, next to the power-generating battery, is, of course, the transmission of the same from one extreme point of the line to the other, and there the methods employed in this respect are divided into two natural divisions, namely, into conduits above and into conduits underground. Both have their peculiar advantages and disadvantages, and I shall mention them in passing when I explain them in more detail. Before I proceed to this, however, it may be necessary to remark, in general, that the chief difficulty of any conduction is due to perfect isolation. It is quite generally known that, in addition to the metals, the warm, i.e., unfrozen, earth and water are also good conductors, and if not to the same extent as the metals, the enormous mass of the earth and the water completely replaces the inferior conductivity of the latter, and every path which the electrogalvanic fluid takes in its circulation from station to station, and further from pole to pole, into the earth, does not fail to use it immediately in order to be elevated to the further outgoing and to return again by the next, shortest way, through the earth and the metal plate buried at the station place, to the pole exit at the battery, and it is precisely on this natural law that the invention of Professor Steinheil, to be discussed in more detail below, is to use the earth instead of the second semi-circuit of the line and to indicate a way of return to the force artificially generated by the battery by means of metal plates buried at both endpoints.

However, I will here at once take the opportunity to speak out from practical experience against the assertion of Wheatstone, and after him of Drescher, that the conductivity of water and earth are a million times worse than that of metals, since experience of the worst kind has taught me quite differently on several occasions. In the first place, however, I must assert that the earth as such is not a conductor at all, and consequently an insulator, and that every conductive capacity ascribed to it is to be attributed solely to the water adhered to it as moisture. Proof of this is that perfectly dry earth or sand does not cause any conduction at all, that in summertime, in prolonged dry weather, even railroad tracks can be used as telegraphic conductors on the railway, as Ch. Robinson did successfully in the summer of 1847 on the railway from Petersburg to Tsarskoye-Zelo. It follows from this that only water, whether in drippable or liquid form, or in the form of vapor or moisture, must be regarded as the actual conductor, so that all bodies capable of absorbing water, consequently even the best non-conductors, e.g. silk, can become good conductors by this very absorption. But that a stream of water must have neither millions, nor thousands, or even a hundred times more circumference than a metal wire in order to be conductive, I have, as already mentioned, the most striking proofs. - In December, 1848, this proof forced itself upon me under very mysterious and frightening circumstances, two times in quick succession. - The Harburg station reported to me that it was impossible for it to correspond with any of the three stations to the west, since not only was there no answer to a call from there, but also when our station Hamburg, and consequently our battery, (short circuit with Cuxhaven) was excluded from there. - The most natural conclusion as to the cause of this phenomenon was that the wire had broken out there and the end of the break hung in the water, whereby there was of course a circuit together with our battery and our earth's plate on this side, but not after the exclusion of our battery, since the intermediate stations only carry batteries for the writing apparatus. In consequence of this conclusion, I sent a workman out to the line to look for the probable fault, but at the same time with the order not to overlook any irregularity, even the slightest irregularity, and especially to note the time of the repair. Who should believe that it was found along the whole line from Harburg to Stade, 64 miles, notwithstanding the most complete interruption, nothing, nothing at all, but only a single broken glass head on a pole, near the village of Horneburg, whereby, however, through an unfortunate coincidence of circumstances, a perfect earth circuit was formed by the fact that on the end wood of the pile, near the stake, collected some rainwater and sucked it into the wood of the stake as moisture; at the same time the broken glass head, probably blown up by the swelling of the stake, had torn the copper wire that held it together with the main wire in its normal state, and one loose end of it had come to rest in the above-mentioned wet, whereby an equally complete return pipe had then been created by means of the only damp pile wood into the earth. as if a metal plate had been buried in it at the spot. Now, as dry wood is known to be an insulator, the moisture which penetrated into it, which, if concentrated, would probably not have constituted a stream of water only a quarter of an inch thick, could have formed the conductor, and where, therefore, is the theory of a millionfold increase in water and earth to Wheatstone, which is necessary for the conduction? But I had the same case three more times afterwards, and that under my own direct observation; namely, once not long after the first fall on the same route and under the same circumstances, and twice very close to the Elbe, near the crossing by means of the masts, where an iron screw with a ring was driven directly into the post, and the contact of the wire with this screw ring also produced the most perfect circuit, although the pole at the top was still provided with a funnel-shaped zinc roofing, on which, however, as with the roofing of the posts in general, insofar as such is to promote insulation, I do not pay any attention, since the wind plays with the rain in such a way that it splashes the moisture everywhere, and thus also under the roof. But even the preservation of the stakes by such a covering is not of the importance as it appears; for the danger of premature destruction of them does not lie in the wooden parts exposed to the air, but down at the bottom, where they are inserted into the earth, especially where air and earth are divided; if one can attach condoms there to prevent rot, one does well to do so; for the rest, the upper part holds out perfectly with the lower part.

If, after this digression, which is by the way not insignificant, we return to the line in general, then I consider the method of a line above ground to be the more recommendable one wherever there is any guarantee against damage that is at least not too frequent, and not only because any fault, interruption or discharge is easier to find with this device, but also because the wire in the air can be most easily protected against deflections and likewise against damage (the latter, as experience teaches us, by strong, high stakes and strong wire), while in the latter respect, for example, every peasant with a shovel is sufficient to pierce the wire resting in the earth; whereas carrying a ladder with you to climb the piles already causes greater trouble and arouses suspicion. The practical Americans, who tried everything imaginable in relation to the telegraphic sciences, but at the time of the experiments were not yet familiar with gutta-percha, which is now so useful, came back again and again to the lines through the air, and in this way built thousands of miles of telegraphic lines. But their method, which we also followed with few modifications, or rather the method we ourselves used with these modifications, consists in the following, rather simple arrangement:

First of all, pine stakes are purchased, 28' long and at least 4" in diameter at the top, whereby the lower diameter results from the nature of the growth, the average price of which is about 1 to 1 1/6 thalers a piece, including barking, smoothing of the branch ends and charring of the foot ends up to 5' upwards, as a condom against rot. These stakes are then provided with an iron ring at the top to prevent bursting and painted with bold paint, for which it is best to choose the so-called hair whip, a type of foreign resin substance, which is the least expensive (in Hamburg 3 1/4 Schill. Crt. pr. B) and offers the best resistance to the action of atmospheric influences. The pits in the ground where these piles are inserted at a distance of about 150 yards from each other are most expediently made by iron augers, of which the Americans have furnished us with an excellent model. As far as can be indicated by a drawing, it is designed as follows:

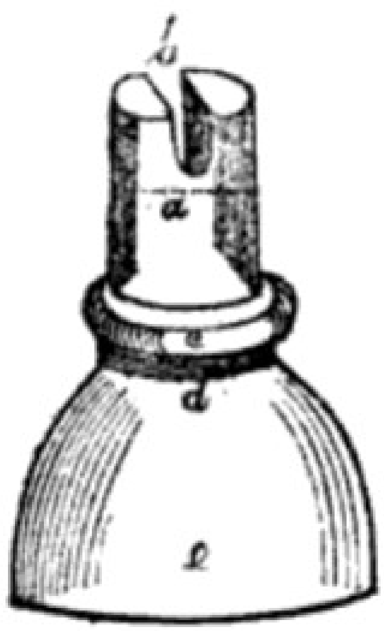
Fig. 5.



The pan, holding 10" diameter, is made of cast iron. a and a, the two split halves run out after the whole round to a sharpness for cutting into the ground. b and b, each the one end of these halves, are not only bent to a sharpness, but each surface in itself, sinking, is about 11⁄2" lower at the bottom than the opposite half, so that an equally wide gap is created through which the loosened earth can push itself upwards. **ce** is an over-riveted piece of iron to give the screw thread of the stem to be countersunk the required depth. In the screw hole in the middle an iron handle, about 6 to 7 long and 1" thick, d, is screwed in at the top with a wooden round crossbar, e, as a handle, and with this auger holes can be drilled not only very quickly, but also, for the sake of the sharp cutout, with very solid walls. After the stakes have been inserted, it is a good idea to tamp the earth quite firmly by means of a long and narrow log, and also to push in as many stones as possible, in order to improve the posture of the stake.

After this simple procedure of placing the carriers of the line, the necessary and most important insulation would now have to be considered. The various methods hitherto employed, such as passing the wire through an eye drilled into the stake and lined with porcelain or other non-conductive material, a type of conduction which is repeated in many variations, was justly rejected by the Americans, for the reason that water accumulates in the eyes in persistent rainy weather. firmly around the wire, then, overflowing, runs down the pole into the earth, and thus carries the electrical fluid with it into the earth, since then of course there is hardly any thought of working in rainy weather. -- In order to avoid this, the Americans resorted to another method. They had a vessel constructed of glass in the following form :

Fig. 6.



a is a somewhat conical cylinder, the upper part of which is about 1" long. b a gap 1⁄2" deep and 3/4" wide, in which the wire comes to rest. **c** is a strong bulge that gives strength and attitude to the whole. **e** the bell-shaped arched lower end, from the upper edge, **d**, to the massive part of the upper cylinder a somewhat tapered round hollow is cast, into which the peg wrapped with some linen is inserted, the other end, driven into the head of the pole, carries glass and wire. This glass head is then held in place by a copper wire wound around the bead mentioned, the double end of which is bent up to the wire on each side and, entwined several times, soldered to it, so that it cannot escape from the gap assigned to it. This arrangement gives thoroughly perfect insulation, as long as the glass head is intact, since the lower bell-shaped part of it remains dry at all times, and in fact the rain can run down it in torrents without causing a discharge in the earth. Since, however, these glass heads are very fragile, and are destroyed in many ways, partly by the swelling of the stakes, and partly by wanton peasant boys, who like to choose them as the target of their stone-throwing, I later took gutta-percha instead of glass, and at the same time combined with the new material three not insignificant advantages of the arrangement. The first and more important is that I had a hole drilled through the two side lobes of the gap, pushed a strong wire pin through it, and thus held the lead wire in the gap without further ado. Secondly, I had the lower part widened so much that it also serves as a screen for the pile heads, and finally, thirdly, I had the inner cavity narrowed so far that the stake could be stuck firmly in it without wrapping it by driving it in. Since the fourth advantage is added that the material retains value at all times, namely according to the present price of 103 Crt., all these advantages, including durability, are only atrophied by the price three times higher than that of glass; but the last-mentioned advantage, the permanence alone, outweighs this price, and completely replaces the surplus expenditure in a short time.

Conduction via currents.

This is probably the place to say something about the routing of wires over currents, which is also to be carried out in two ways. If the width of the river is not more than 1200 to 1500 feet, and if one has reason to fear the destruction of submarine lines by ship's anchors, it is absolutely better to carry the line from bank to bank by means of strong high masts held by iron guy wires, since then the line must of course be so high that the highest masts of passing ships themselves have it in the middle. wherever the greatest reduction takes place. learned from experience after many experiments that an iron wire twisted together from three strands, No. 20, can withstand a very considerable tension without breaking, so that over a length of 1000 from bank to bank it sags only 10 to 12 in the middle.

The application of such a wire is most conveniently done in the following way:

The finished wire is kept ready wound on a coil, through which a strong rod can be inserted for convenient unwinding. The man climbing the mast winds the end around his left arm, and takes good care that he runs free everywhere because of the guy wires while he pulls it. Once at the top, the workman pulls the end through the disc attached there, and now either brings the end down with it, or immediately connects it firmly at the top by means of a forced screw to the other end of the conduction wire rising from the last low pole or from the earth. — In the former case, the point of connection will be in the first or second mast basket (called spreader in boatman's language). As soon as this is done, two men, who carry the coil by means of the stick inserted through it, get into the waiting boat, and a third, perhaps the mast climber, takes care that the wire runs freely when rowing or sailing over to the other bank. If the river is wide, and there is reason to fear passing ships, the wire, of which there must be at least 400 feet of abundance, is allowed to run freely into the water. But if this is not the case, it can be kept afloat as long as possible, and there is then no obstacle to be feared by hooking and the like in the riverbed. - As soon as you have come to the other bank, let as much of the roller run off as the height of the mast. or if there is no supply, one tries to obtain the necessary quantity from the stream, which often consumes a lot due to the strong current, by pulling it in. If this simply does not succeed, the boat must go back and let the wire pass through your hands to lift it from the ground; this way you gain enough and those on the shore can only follow suit. When everything is so far arranged, the mast-climber begins just as before, bringing up the end of the wire, taking good care that he himself and those below who carry the wire take good care that it runs freely, and especially does not hook behind the eyes of the guy wires. As soon as this end has also been brought through the pane at the top, the worker descends with it to the next mast basket; ties something heavy to it, and lets it slide down to a man waiting in the lowest mast basket, who seizes the wire and releases the weight hanging on it. At the lower mast basket a strong iron peg must now be driven horizontally, just below the course of the wire from above, in such a way that the wire does not touch any object, especially no iron rod. - The iron stake is covered with an insulating cap. Around the bulge of the latter, the man sitting below places the wire, while the upper man climbs up again to the top, lies down with his chest against the top of the mast, stretches his arms out as far as possible towards the wire, and pulls it out of the open air by any friction, out of the water or the air, while the lower man immediately takes what he has gained in the following way: that he puts the wire around the insulator, and always keeps it taut so that it cannot slide back again. If the tension of the wire over the current is so tight that the man in front cannot tighten it any further with his bare hands, he attaches a screw with flat pliers as far out as possible, and by means of this convenient handling he tightens the wire again as long as he wants to go, and he does not think he fears that he will be able to that he would break. The real measure is, of course, the height of the ship's masts passing, taking into account the highest tide where it exists. When the wire has now reached its proper tension, the lower worker beats it several times around the insulator, pinches off the hanging object quite far, and makes the connection, for which a constant precaution must already have been made from the first next small post or out of the earth, and the thing is done.

If such wire, twisted as indicated, is given a little fat, e.g. tallow, immediately at the time of turning, it resists rusting in the open air for years. It is still better, of course, to take tinned, or even more advantageous, galvanized wire, provided that it is no less tough than good English iron wire, about which I have made no experiments, as the latter performs its services perfectly. Simple wires of this body content as well as twisted ones keep the tension well, but do not resist the storms and are much more likely to break at the black ice and chewing frost, the two worst enemies of air ducts over currents. I do not think it advisable to use steel wire, since it is no more tough than iron wire, according to the tests I have made, but costs six to ten times as much for the better grades. Such a twisted iron = wire of 1400 to 1500 lengths costs us about 8 Thlr. Pr. Ct. Only it can be observed that when it is turned, it runs together quite uniformly and in a middle swirl.

I have personally had no experience with submarine lines. - According to oral communication from a Dutch technician, however, the following procedure is the simplest and safest one he has tried. Three good, healthy copper wires are covered with a 1/8" thick cover of purified gutta-percha, and then they are twisted together in a superfluous length like a rope, but not twisted, and the resulting structure is again surrounded by gutta-percha in a thickness of at least 1/4 to 1/8". The wire rope with gutta-percha is handed over to a ropemaker, and it is placed as a so-called heart in a three-stranded cable rope well boiled in tar, then the wire is tested for its conductivity and the whole thing is now sunk into the stream. It is best to hang smooth, round iron balls on it as a weight, so that any friction cannot easily cause damage. - If, however, anchors are to be feared, especially slipping ones, and yet one does not wish to depart from a submarine line, it is absolutely necessary: first, to prohibit the prohibition of anchoring at the place in question, and, secondly, it is necessary to sink into the stream 100 feet on each side of the line, strong chains laid on stakes driven into the bank, so that slipping anchors from loose ships can hook behind them, one can then wind up the chain with them, and then let them down again, after loosening has been completed, without the line being touched by it.

However, under all circumstances I prefer the line by means of masts, because a break will only rarely occur, for example through black ice or hoarfrost, and can be repaired within 1 to 11⁄2 hours with good practice. A pipeline under water, however, requires enormous expenses and a lot of work, time and expense for repairs; but these can hardly be avoided in the long run, even with the best precautions, even if one can change by means of the triple wires just mentioned.

Pipeline underground.

We are now moving on to a line underground. This kind of duct is preferred by some to the air duct, because it is not so easily subject to destruction. But this is not the case. While, for example, our pipeline cannot be destroyed at a height of 23 feet above the ground without a ladder and file, in the case of an earth-duct a shovel, which every peasant can carry with him without causing a sensation, is sufficient to pierce the pipeline, which is usually 1' deep, if he so desires, and how difficult it is then to find on distant distances the place where the destruction has just taken place. - More details about this finding are provided below.

The underground lines which have now been used in many cases, and especially in the Prussian state telegraphs, consist quite simply of copper wires covered with gutta-percha, which have been placed in the ground without further coating, relying on the firmly adhering to the sulfur-laced gutta-percha, as it is also asserted that the admixture of sulfur is a sure remedy against the gnawing of rats. mice or beetles (which, however, according to recent experience, has not proven to be effective). Nevertheless, many interruptions have occurred with this type of underground pipelines, which are of course much more difficult to find than with the pipelines through the air. The same could be greatly diminished, however, if the cables were led to the light in certain places, e.g. in the case of railways at the station houses, in lockable boxes, and here connected by the double screws mentioned at the beginning, by the loosening of which a test is made with the tongue or by the electrometer without futile excavations. If this happens one is compelled to have the wire dug free on a whim of chance, guided by the conjecture. A strong needle is then taken, pushed hard against the wire through the gutta-percha, and another wire is connected with it, which in turn is connected with an electrometer, one pole of which ends in an extemporaneous earth circuit, in order to see whether the damage is forwards or backwards by opening and closing the line thus established. Regardless of this, the assistance of the draisine often takes several days, and must be at hand over the fire and soldering iron in order to close the open areas again exactly at once. The perception at the electrometer extends to the following: Suppose, for example, that the wire between Hamburg and Berlin were broken, as a rule pierced, a sharp break would expose only so small an area of the copper wire to the influence of the earth that neither in Hamburg nor in Berlin would a complete earth circuit be perceived. If we now assume a center of H.H., where the wire has been dug free, and the examiner makes a provisional earth circuit by switching on the electrometer and sinking a wire, then if the break between H.H. and Hamburg took place, he would feel no movement in the electrometer, because the power of the battery in Hamburg would then come to an end with the breakage. But to the side of Berlin, where the battery power has not been interrupted. The examiner must now repair the incision made and make a second attempt further to Hamburg, etc., until he finally finds the spot, admittedly difficult enough, and he does well not to ignore suspicious spots, especially freshly churned up soil. But from this it is evident how necessary it is that the batteries should be placed at both endpoints, and not, as some textbooks would have it, at one, acting in the same way.

If the wire is not really cut, but only more or less stripped of gutta-percha, so that there is no actual, total interruption, but only a so-called derivation (which, of course, may be so complete that all correspondence ceases), then other perceptions must be made in the examination. According to the law that the force emanating from the batteries always returns to its origin by the nearest and shortest route, is dependent on nature, it is precisely this conduction which, however, with only small bare surfaces of the conduction offered, still allows a part of the total force to slip through, about which more details will be given below. As soon as the examiner has switched on his electrometer at any point according to the above indication, he will perceive a diminished force on the electrometer when he is already beyond the damaged place, compared with that which he perceived on the station, because a part of the force emanating from there is lost on the next route, namely, through the naked and damaged area, returns to its origin and only the excess passes through, and acts on the needle of the electrometer, but of course with reduced intensity. If the examiner has not yet reached the place of injury when he makes the experiment, he will perceive an unchanged expression of force, and must therefore investigate further.

As to the construction of the electrometers, it is so different that I refrain from giving any further instructions on the subject. - The principle of this is based on the electro-magnetic force emanating through the medium of the multipliers and acting on free-floating magnetic needles, which, depending on its intensity and the direction of the flow through which the poles regulate one or the other side of the polarized needle, rises or falls, and floats over a dial marked with degrees or numerals, it symbolizes the expression of the existing power. In Morse's telegraph system, the electrometer is of particular importance because, even if the writing apparatus, which at the same time gives sign, should not make a sound by adjusting the relay spring, the movement of the needle nevertheless betrays it as soon as someone opens or closes the key at one of the external stations, whereupon it is then caused by negating the spring on the relay, by means of harnessing and unharnessing, the correct relationship to telegraph work is established and writing is communicated.

I will not, however, leave the subject of deduction without having quoted some most remarkable observations from my practical experience, which overthrow all theories concerning them.

In January, 1850, during a hurricane-like storm from the southwest, our electrometer, by its sudden high position, showed that not far away an intermediate circuit had occurred, probably caused by the breaking of a wire or something similar. - Since a look at the Elbe arm on this side did not reveal a break, I concluded that something similar must have occurred on the southern arm of the Elbe on the other side near Harburg, and went there accompanied by a workman. - To my surprise, it emerged from the observations at the Harburg station that an effective break of the line wire could not have occurred, since even with the exclusion of the three western stations, consequently also the power-supplying battery in Cuxhaven (short circuit with Hamburg), not only was such a circuit actually present, although our battery outflow was actually present somewhere in the region on this side of Harburg, but even individual signs of ours had penetrated there. A further investigation, still during the storm, revealed that on the island of Wilhelmsburg, where the line is led over two narrow arms of the Elbe (so-called tidal channels) by means of 100 high masts, the wire had been thrown down by the action of violent shock winds, so that it lay directly in the water for a distance of at least 300 lengths, but without being broken. Thus, notwithstanding this more than complete derivation, the electromotor fluid had slipped through it at the moment, a phenomenon which occurred to me in contact between earth and wire, but never between water and wire, and which in any case may be one of the rare occurrences.

It is to be estimated, moreover, in the case of Morse's system, that a fairly considerable degree of derivation is required to cause total interruption. - As to the special part of our underground conduit, it lies for a distance of about 3000 yards under the pavement of the road, as far as the rampart at the Brookthor, and it became necessary, on account of the manifold crossing of gas and water pipes and their frequent excavations in the alleys, to lay the doubled wires surrounded by gutta-percha in iron pipes, however, they were led in 13 different places, especially at the corners, by so-called siphons. These are cast-iron, conically shaped pots, with folded, tightly attached lids. The wires rise in them from the screwed-in tubes, on both sides and go through 4 holes drilled into a wooden lid that is wedged in a rather high place. On this cover are nailed 2 brass double screws according to the form already mentioned - on the common base, in which the bare and brightly filed ends of the wires, for the easiest and most convenient solution, are screwed one from each side into a double screw, carefully avoiding any contact of an uncovered wire with the siphon. Above this deeper lid, almost at the upper edge, a second, larger, unpierced lid, the edge of which has been thickly covered with the well-known red putty, is squeezed in, and covered watertight. The fold of the iron lid is also provided in the same way, and over all this, after earth had already been poured over, I had a cauldron made of strong sheet metal, a kind of stub to keep the water out, pushed over each siphon, and finally surrounded the whole with fat clay. The fact that deductions arose at first, before the care had been extended in this way, was due to the novelty of the matter, and I shall probably return to this in the discussion of the Relay, and will only mention recently how the usefulness of the so-called short circuit is proved on such occasions. For, for example, while the station of Harburg, which is only a mile away from us, separates itself from the other western stations by virtue of the device already mentioned, i.e., while it connects its conduction wire just beyond the apparatus, so that they are still switched on, with the copper plate sunk there, as at all stations, and thus the force emanating from our battery returns to us from there - a very short telegraph line is created, only one mile long, and it works much more easily and energetically over such a short distance, especially in sickly conditions, than over a longer distance. Of course, under such circumstances I could also have switched on batteries at the intermediate stations, but since these disturbances could always be eliminated in the shortest possible time, I did not find it necessary to introduce further innovations on this account. However, the short circuit plays too important a role in a telegraph line consisting of several stations not to consider a more detailed explanation of this device to be necessary here. - To make this arrangement clear, I would first like to explain the creation of a simple line with only two terminals.

The representation of the second return path of such a power through the earth, as well as the flow of the electromotor fluid through it without wire conduction, appeared to some a mystery; however, the appearance and the successes have long since convinced everyone who is interested in it that the fact is irrefutable, and the very danger of the deduction rests on the same law. The first discovery of this wonderful natural phenomenon is due to the well-known Prof. Steinheil from Munich, and I learned the following about this from his own mouth. He had been commissioned by the Bavarian government to build a railway-telegraph line, and the very obvious idea came to him to use the rails in both tracks directly as a circuit.

But as soon as he connected them with the apparatus for such a purpose, it turned out that the current, instead of passing over to the opposite station, escaped into the earth, and thus the purpose was lost, and from this it was undeniable to him that the earth had the same conductivity as metal, and consequently also as a conductor. The experiment was conducted, and the resounding success has, as is well known, now become the reason enormous sums have been saved in all telegraph installations.

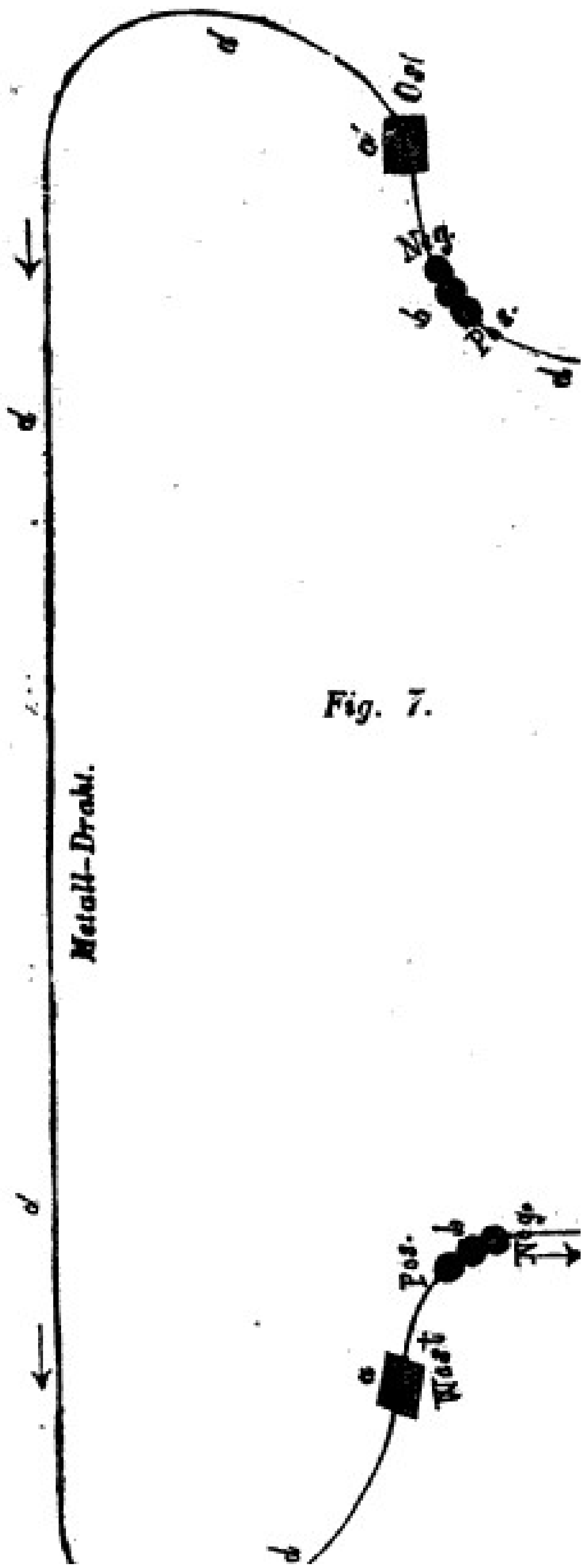


Fig. 7.

The surrounding outline (Fig. 7) shows us the manner in which the metal wire and the earth are used together for the production of an electro-magnetic circuit. In it, the flow of the electric fluid should be closely followed. a and a'- are the two terminus, e.g. Hamburg and Cuxhaven; **c** and **c**' two copper plates, or, as with us, a zinc and a copper plate, the former of which lies buried in the basement of the Stock Exchange Arcades in Hamburg, deep down to the water level, the other in Cuxhaven, close to the banks of the Elbe, next to the bathhouse. - **b** and **b** are the batteries, set up at both termini for the main line. The current goes from east to west in the arrangement chosen here, and as we have actually set it up, in that it flows from the positive pole through the battery itself to the negative, in the direction of the arrow through the wire **d** to Cuxhaven, there through the apparatus and the battery, beginning first at the zinc pole, and strengthening itself by the force of the same, seeks and finds the copper plate **c',** and from there goes through the earth in the straightest direction to Hamburg, and through the zinc plate in the Arden plate finds up the zinc pole of the battery and thus creates the circuit. I take the opportunity here to return once more to the conductivity of the earth in order to commemorate an interesting phenomenon which has arisen in the production of the line of the conductivity of the earth from Altona to Kiel.

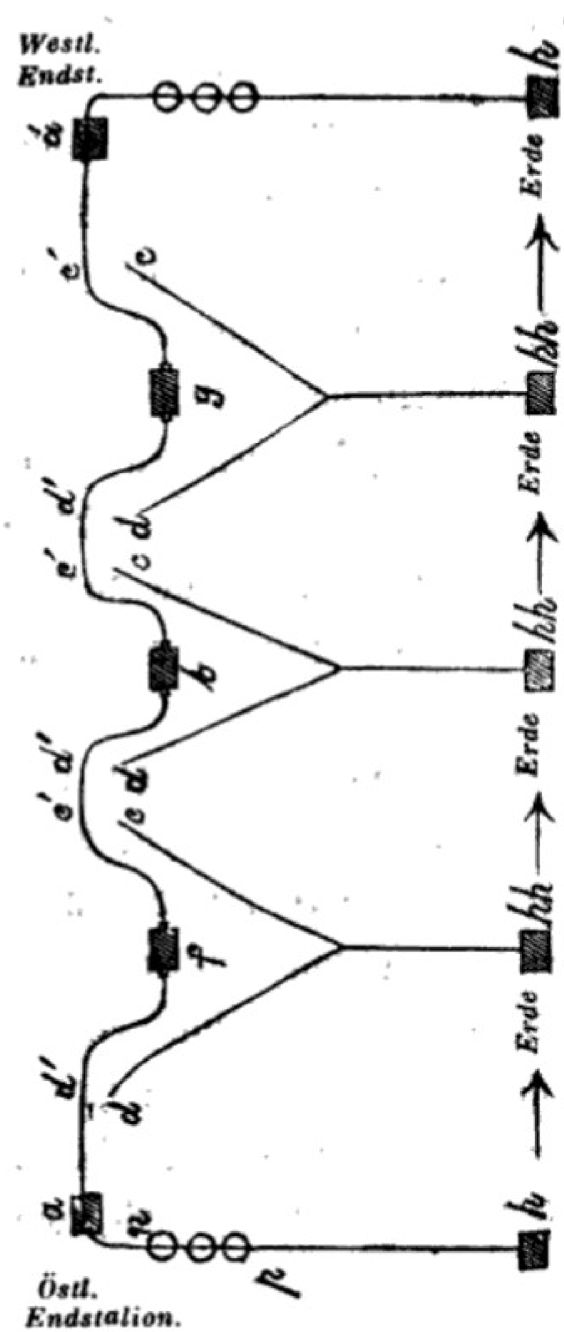
In order to produce a circuit necessary for his work, the engineer placed a copper plate in a ditch filled with peat bog water, and had to experience that, quite contrary to the theory, the circuit failed to materialize. - On the other side of the railway embankment there was arable land, and also ditch water, and in this the best possible connection was immediately made. Now this can only be explained by the fact that the peat bog itself, as a vessel of the ditch water, so to speak, is so completely devoid of all metallic admixture that it lacks any conductive capacity, and this would once again prove that not only, as I have previously remarked, is the earth in itself not a conductor, but also that water, according to its pure original constituents, is not a conductor in itself, which is why distilled water is known to be a non-conductor. The above case could occasionally be of great importance when new lines are built.

As far as the metal plates in the earth are concerned, they are certainly not taken too small, for the sake of safety, and ours are even 5 long and 2' wide, and one also likes to solder a fairly strong copper wire, about 8" in diameter, diagonally, across it, but this is not absolutely necessary, for one can make a circuit in any damp place with a simple metal wire, as soon as it is connected to the end of the pipe, and the other end is sunk into the damp earth, or even better into the water, of course into free-standing water.

In localities where water or gas pipes are attached, there is no need for a plate of earth at all, for every firm connection of the telegraphic wire with any point of the metal tubes immediately establishes the most perfect circuit. But it also follows from this that enemy hands on the lines guided through the air, without cutting through them, can cause a complete interruption of telegraphic work, if they lead a metal wire, however fine and inconspicuous, from the main line into the earth; and if such a statement might nevertheless be called an indiscretion to the wider public, to whom one should not reasonably give any explanation as to the possibility of such disturbances, it was nevertheless necessary, for the note of the operating staff, in order to give them a hint as to the possibility of such disturbances in the event of interruptions occurring, and thus to give them instructions for finding the causes.

I now pass to the intermediate or intermediate stations, which are of the greatest importance in view of the present extent of the lines, and especially the use of them for railway purposes. The arrangement of the intermediate stations in itself is extremely simple, in that, as the adjacent figure shows, only the main wire is led into the station local, and passing through the relay and writing apparatus, and out again, so that this side line forms, so to speak, a loop in which the apparatus is switched on as part of it. However, there are still some things to note about this institution.

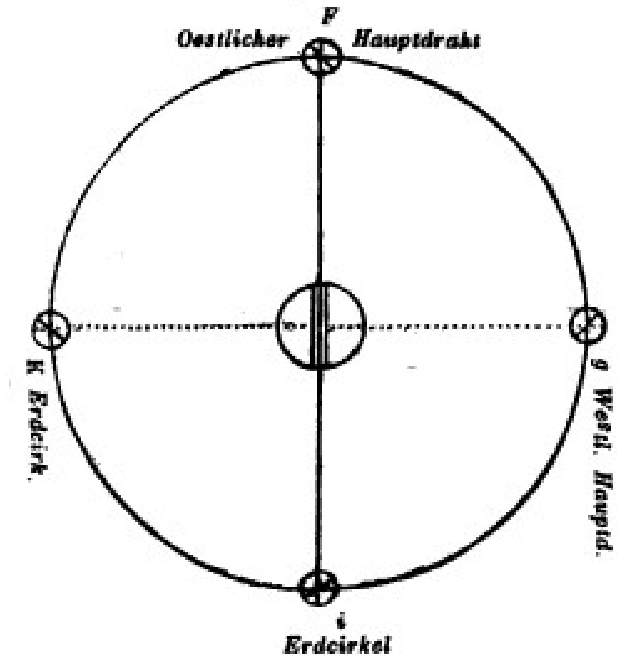
Fig. 8.



Let's take a look. Fig. 8, 5 stations are noted in the same; namely, **a** and **á,** the terminus; **fb** and **g,** the intermediate stations. Since, as already mentioned, work is out of the question without the establishment of a circuit, but to this, according to the now generally adopted arrangement of the earth's circuits, consequently the plates **h** and **h** of the earth belong, it follows from this that if there were an interruption somewhere along the line, e.g., between **g** and **á**, the whole line would be interrupted, and not only the stations **g** and **à** would be hindered in corresponding, and the same case may be applied to all the other points of the line. In order to escape this inconvenience, it is necessary to introduce the short circuit previously mentioned. -

In Fig. 8 the letters **d' d** and **c' e** indicate the points where a provision is to be made for the rapid connection of the main line with the earth plate **hh** required for the short circuit. - The manner of quick and convenient construction is arbitrary, but it is advisable, for the sake of *simplification*, to place the barrier apparatus at one and the same point and not at two different places. This is most easily achieved by directing a wire from the point **c'** very close to the point **d'** (or vice versa), but without directly connecting it with the latter, so that, by the appropriate precaution, the earth circuit can be connected either with **d'** or with **c'**, according to need. The most expedient way to do this is to have a skirted wooden disk made, about 3 to 4" in diameter and 1⁄2" high, through the center of which a strong iron screw is screwed into the worktable to attach it. At four exactly squared points of the disk, according to the figure on the right, four brass screws, so long that they reach through the table, are screwed in, on each of which a nut with a transverse hole is placed at the bottom, for the passage of the lead wire, and screw threads vertically from below, for clamping the wire by means of a forced screw. The course of the inserted insulated wires is as follows:

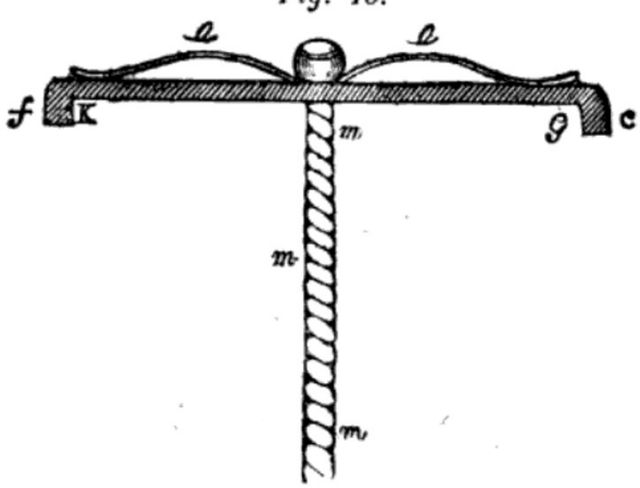
Fig. 9.



The one running from **f** is soldered to the main wire **d'**, and that ending from **g** to the point **e'**, Fig. 8; whereas those emanating from **i** and **k** are both attached to the earth wire **e**.

On the center of the wooden disk, Fig. 9, a brass turner is now held by means of the already mentioned screw, **m**, **e**, around the smooth neck of which the horizontal turner

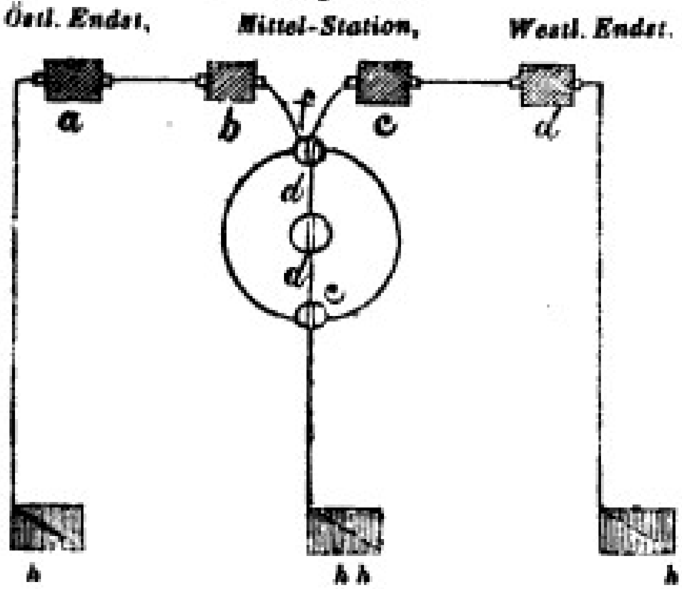
Fig. 10.



can then move freely but firmly, and at the same time it is strongly pressed by a strong steel spring, **I** and **1**, bent smoothly at both ends. The hook-shaped ends of the turner, bent down or provided with an attachment, now describe exactly the circuit of Fig. 9 and can be set to **f i** or **gk** at will, so that a metallic conduit is created from one point to the other, as it were, over the bridge of the horizontal turner; **i** and **k** both correspond to the earth's plate **h h** (Fig. 8), – **f'** to the point **d'**, and **g** to **c'** at the main line; consequently the flow after the short circuit has been established is either from **d'** via **f'** to **i,** or from **c'** via **g** to **k**, and follows from this: in the former case, that the station making the short circuit separates itself from all stations located to the east, and consequently cannot be hindered by any disturbance that may exist there, since the force emanating from the western terminus a' (Fig. 8), according to which the poles of the battery are arranged, returns either via **e** through the apparatus and via **de** into the earth, and from **hh** to **h** and again to **a**, or vice versa; namely, as is well known, the electric fluid returns to its origin by the shortest route. In the other case, however, if the short circuit is made by a position (Fig. 9) from **g** to **k**, and consequently the current goes from **c'** to **ce hh** (Fig. 8), then all the western stations are excluded, and the difference in the exclusions among each other arises from the fact that in the first case, in the first position, the apparatus is switched into the circuit to the west, and is only in connection with the western stations, in that the current finds its way into the earth immediately east of it, but in the second case the apparatus stands conversely with the eastern stations in connection, the current finding its way into the earth to the right of the apparatus, or rather in a westerly direction.

Besides the advantages already mentioned, which this arrangement affords in the event of real interruptions, experience has shown, as already mentioned, that even in the case of discharges, in the event of earth or thunderstorms, the influence of electricity, or other difficulties, a rapid shortening or division of the line into several individuals is of essential use for easier work and mutual understanding. - A similar arrangement is also expedient at those stations where there is a constant division, set up with two apparatuses, in that by means of it, at will, the division can be broken into two, by simple shifting, and the original unity of the line can be established; where, namely, when dividing the line into two, a single plate of the earth is sufficient for both directions and apparatuses, since the electric fluid, from both terminus, returns to its origin in the middle station through one and the same earth circuit, so that the two centers, with a divided line, can run into one and the same earth's plate, which, however, ceases to be as soon as the course of both endpoints is cancelled out into the earth's plate. For such a precaution, however, for the sake of the double apparatus, it is of course only necessary to have two screws in the wooden capsule. This institution is represented by

Fig. 11.



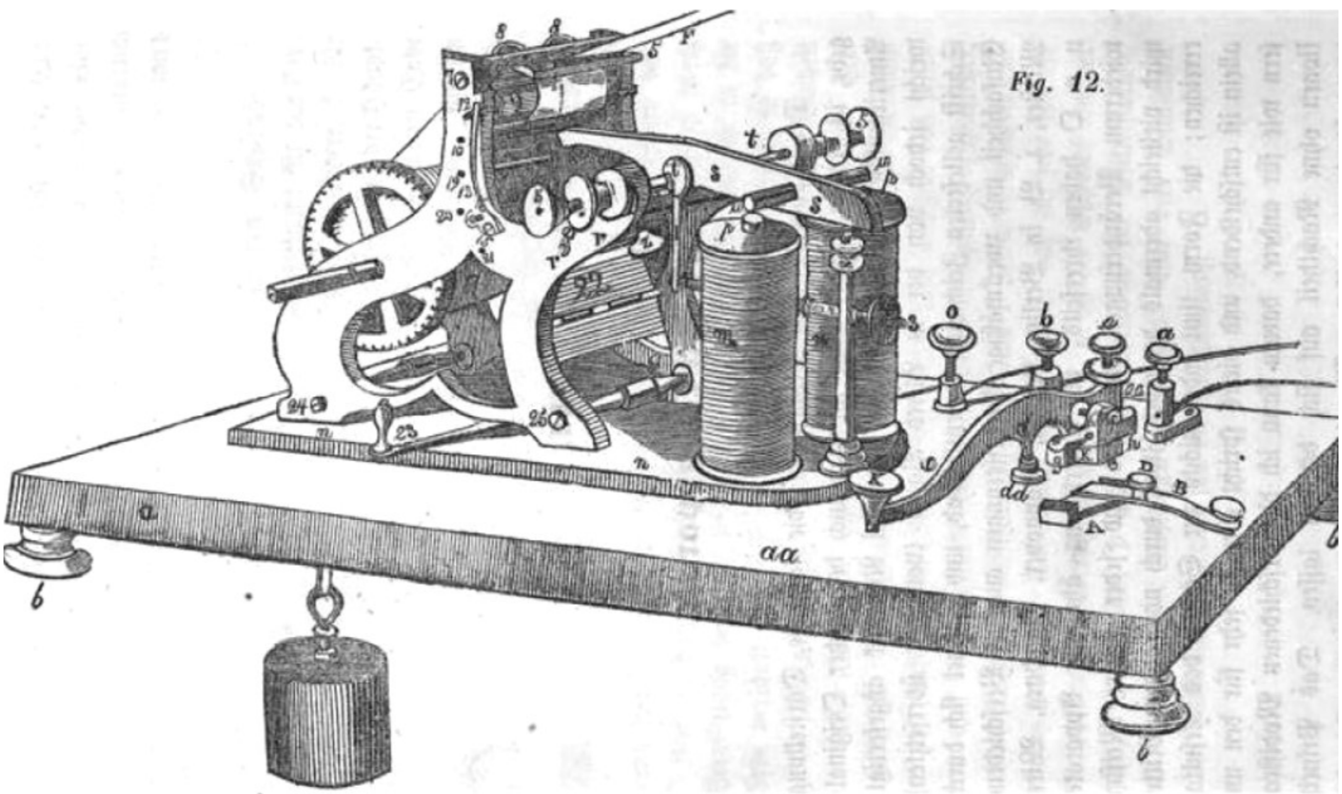
Die eine Schraube, c, ist bestimmt für den Erd-cirkel; die andere, f, für die Begegnung der Haupt-leitung am untern Ende der Schraube unterm Tisch. — Es kommt da-bei abermals der Dreher, Fig: 10, in Anwendung, und ist aus der Anord-

It is easy to see that in the position of the wheel from **f**' to **c**, the electric fluid from both terminal stations runs through the mediation of the latter along the path **d**, **d**, at **hh** into the earth, while at each displacement of the turner, so that it no longer touches the screw heads **f** and **e**, the unity of the line is restored by the lower end of the screw **f**. The fundamental principle of this arrangement is again based on the above-mentioned law of nature, according to which the fluid returns to its origin by the shortest route, which in the present case leads via **f** and **e** to **hh** and **s**. The matter is so simple that I think any further explanation is superfluous. **a** is the apparatus at the eastern terminus; **b** and **e** the two at the middle station, and **d** at the western terminus. All three stations have batteries for the main line, of course.

III-

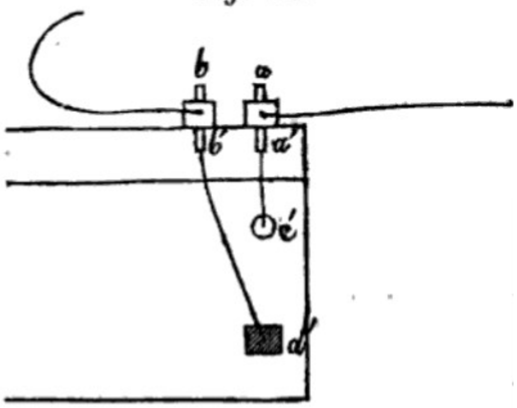
The writing apparatus.

The apparatus from which I give the following illustration is an original American made by Shubbuck at Utica, near New York, which is in use on our line, but differs considerably from the drawing furnished in Alfred Vail's work (which I have translated), and is distinguished by simplicity and expedient improvements. - Various masters, e.g. in Berlin, Leipzig, Hanover, Hamburg, Vienna, etc., have for their part, in the production of similar apparatus, again introduced changes, and every newer master will perhaps achieve the same purpose again by still other means; the form, however, is of no consequence; the result alone is decisive, and this speaks as much for ours as for others, therefore I can leave the various modifications alone without disadvantage. The principle remains the same in general. Now look closely at Fig. 12.



If we first dwell on the so-called key (A), it is necessary to give at the same time a view of the reverse side in addition to the upper view, in order to illustrate the course of the current, by means of the connections, together with the provision for the arbitrary interruption and restoration of the same, on which alone the art of telegraphic writing is based. - The two compulsions pass through screws a and b (Fig. 12), the general frame board, **aa**, which rests on four short feet **b**, to **a'** and **b'**, (Fig. 13), below the base of the apparatus, and is **a'** connected with **c'**, and **b'** with **d'** by means of brazed copper wire, so that, for example, when the electric force enters by virtue of the position of the batteries in **a**, it descends to **a'**, under the board, goes through the wire to **c'**, from there up to **e**, then through the middle part of the key to **d**, here, at the mobile point of contact, to the anvil, **dd**, proceeds under the base of the apparatus to **d'**, and from here, by means of the wire, advances to **b'**, to climb up to **B**, and from there to cross over to the main line, and to follow the prescribed further way outwards. - The purpose of this key, as I have said, is solely to give the telegraph operator an opportunity to interrupt the line quickly and conveniently, and to be able to cancel this interruption again. The further purpose of this manipulation I shall later give in more detail, and for the time being I shall only remark that this part of the apparatus, Fig. 12, is only directly connected with the main line, while everything else has a separate factor to the left of the key.

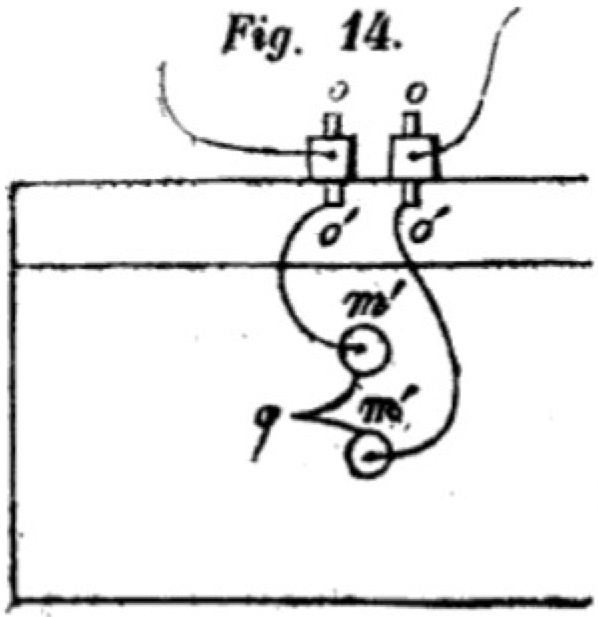
Fig. 13.



The actual key now consists of a brass beam curved in the form of a long s, **e**, behind the 3/4 of the length of which a continuous axis of steel is attached, **f,** in whose hole on both sides the ends of two steel screws are enclosed, which in turn rest in two saddles resting on a common basis, k, (of which, however, only one half can be seen here), **h**, are screwed in, and can be placed. - Both saddles have a vertical incision at the top, by means of which the axle holes of the side screws can be narrowed or widened by two small screws, **h'**, which is very important for the reason that the incessant shaking during work - namely, writing - impairs the strength of the different parts to each other. Shortly before the axles, the key beam below has a sharp hump, the tip of which is armed with screwed-in platinum, and which I will call the hammer, i.e. Immediately below this hammer lies the anvil already mentioned, **dd**, the upper part of which is also covered with platinum, and the lower part of which passes through to **d'**, Fig. 13, and is here tightened by means of a screw nut. - The reinforcement with platinum is done partly because of the particularly good conductivity of this metal, which is of great importance in view of the speed with which it is written, - and partly also because of the extraordinary resistance which this metal offers to the electric spark, which, as is well known, arises when the electric chain is interrupted and closed, and which would easily destroy any other metal by combustion. **k** is the handle on which the telegraph operator lays his fingers while working (writing); and **l** a screw protruding to the rear periphery of the base of the saddles, **hh**, which finds its nut in an inch-long cavity at the extreme end of the key. Under the head of this screw, as with several other adjusting screws, there is a button with a screw gear, which is supposed to serve to secure the screw, but is not of great importance here. The actual screw, **1**, is of great importance, in that it causes the necessary closing of the key. Namely, as soon as the lower end of this screw presses firmly on the base, the hammer of the key is thereby firmly pressed on the anvil, and the chain is closed. If this does not happen, or if it is imperfect, the line is broken and consequently no work can take place (along the entire length). This closing of the key each time (which was at first done by inserting a wedge under the rear end of the key) is one of the first and most sacred duties of every telegraphist, and its violation must be severely punished. In more recent times I have attached a so-called secondary key instead of this screw **1**, which ensures that the main working key never has to be closed after the work has been done. It consists of the following parts: **A** is a figure formed of brass in the form of a T with upturned ends, the upper part of which is about 4" wide, and on one half covered with bone or ivory, as a non-conductor. The stem is formed by a screw reaching through the frame board, from the lower end of which a conduction wire, but without contact with other wires, reaches to **b'** (Fig. 13). **B** is a second, somewhat narrower, flat piece of brass, through the right end of which a screw with a head, **C,** is passed, so that **B** can be pushed back and forth on **A**. From the lower end of the screw **C** a lead wire leads to **a**' (Fig. 13). **D** is a button you can touch. If **B** now lies on the brass part of **A**, the chain is closed; if it is pushed onto the part of the bone, it is open, and the latter must be done every time one wishes to work. As a last main part of the key, the elastic spring should also be remembered, by means of which, when writing, the hammer pressed down = on the anvil springs up again of its own accord and thus does half of the work. This spring, about 3/4" wide and 2" long, is screwed on a small central projection of the saddle base and reaches with its end backwards to the nut, **1**, **1**, where it is enclosed in a notch at the bottom and thus counter-pressure the low pressure of the key from **C**, thus the key when the low pressure decreases again by its low pressure beyond the axis, into the air. Let us now pass to the rest of the apparatus.

The part, in its turn, again divides into two distinct parts, namely, the writing part and the part that receives the written; or, reduced to the simplest term: in pen and paper; Ink is not needed, because the letters are created by impressions that emerge en relief. The actual impulse in the second instance (the first of course forms the battery) is given by the two coils **m** and **m**; they are the ordinary multiplicators, which produce the magnetic force by induction, and are produced in the following manner: Around 2, in the form of a U standing upright, and in the general base of the apparatus, the brass plate, **n** and **n**, The screwed leg of soft iron, **p** and **p**, is a copper bone about 1/3 line thick, spun over with silk, spirally wound in such a way that the initial ends remain long enough to guide them at the base of the coils, through the brass plate, n, and through the rack board, aa, after the forced screws **o'**, **o'** (Fig. 14), and to solder them firmly.

Fig. 14.



whereupon at the top of the screws, **o**, **o**, (one of which is hidden) the other wire wires are plugged in and screwed on. The outer ends of the coils, stripped of silk, are then twisted together and soldered, **q**. **ü** and **ü** are two bone plates, which hold the wire coil together and protect it. it is necessary to remark, in the manufacture of these coils, that the winding must take place in the same direction at both, since in the opposite case two equal poles arise, and a force of attraction does not take place.

The inner end wires now run from **o** and **o** to the so-called local battery (see the article), which is placed anywhere near the poles, and the ends, without selection, are attached to the poles, since it does not matter which pole one hits. Now, for the further organization of the apparatus, from the strong brass framework on the left, 2 arms, **rr,** extend to a distance of about 11⁄2 inches from the coils as carriers of two steel axes, **t** and **t**, in which hangs a flat measuring beam, **s**, through which the actual nib, or rather the pen, is produced, and which in its entirety is called level by the Americans. which could be rendered by the German expression: Wagscheit; but we will call it the Federhalier. Now this pen is the intermediary between the right and left parts of the writing apparatus, and indeed in the following manner. At the right end of it, about 2 inches from the outermost point, is a cylindrical iron, about 2 inches in diameter, pushed transversely, you and u, in one direction and length, so that it comes to stand partly just above the heads of the iron legs, in the center of the multiplicators; on the other hand, however, it protrudes above them, on both sides only a few lines at most. At the other end of the pen, on the left, the circumference of the pen increases somewhat, the shape here is almost a square, and an oblique descending screw passage is cut into it, through which, from below, the actual writing pen v is screwed in, which, made of glass-hard steel, ends in a blunt point, and by means of which the impressions are made directly into the paper, of which the letters are composed, and about what more details will be given later. The remaining part on the right side consists of regulators. In the first place, it is necessary to regulate the horizontal position of the pen in such a way that the armature, **u**, the legs, **p**, does not really touch, but remains so distant from it that a sheet of fine paper can be inserted between them, even when the chain is closed, the magnetism is active, and consequently the armature is drawn down. This regulation is effected by means of an adjusting screw attached to the column w in front of the coil, x, which is recessed into the column, or protrudes from it, as it is deemed necessary to achieve the correct position of the fitting. The second ring below it then gives the correct position of the fitting the necessary strength and security.

A second similar provision is on the pen, about 2 inches in front of the pen at the bottom, and is supported by a crossbar, the steel retaining screw of which is seen on the frame at **y**, which corresponds to a second on the opposite side. That adjusting screw, e.g., goes up from the bottom of the crossbar, and has its ring for fastening above it. The screw itself reaches below the pen, and comes into contact with every precipitation of the latter, which is intended to prevent the pen from being lowered too deeply, and consequently of the writing stink, when writing, while the pen is lowered too deeply on the other side, to the right of the axes, and consequently too sharp a cut of the pen into the paper. by the already mentioned screw **x**. A further regulation of the pen is then given by the screwing ability directly added to it, by means of which the pen can be raised or lowered. Besides these three, however, there is also a fourth precaution which counteracts the magnetic attraction in the legs, **p** and **p**. This consists first of all of a rod about 3" long, hanging from the center of the spring holder between the axes, **1**, and then one, at the same height as the depth of this rod through the column, w, easily movable, square piece of metal, **2**, the outermost end, **3**, terminating in a screw on which a knob with a screw thread passes, **4**, by its screwing and pushing onto the column, the square-shaped pole is pushed out of the column. At the other, left end of the latter is an eye, and likewise in the hanging pole, **1**; in these two eyes, on each side, the end of a steel spiral or so-called spring is hung, which can be tensioned and released by means of the screw knob, **4**, and this spring in its turn counterplays the magnetic attraction in the legs of the multiplicators, or coils. If it is very tense, the force of the local battery must also be very strong to overcome it; if this is weak, one can help by slackening the spring. Its main purpose, however, is to convey the precipitation of the pen quickly and reliably during writing, at every interruption of the line where the pen must strike down in writing in order to create the spaces between the intermediate groups. For while the legs in the coils, which have become magnetic, pull down the fitting, the spring is somewhat tensed by means of the rod hanging down in the center, 1, and when the force of attraction subsides, by opening the key, the spring finds no resistance to contract, and consequently gives the pen the impulse of precipitation, and pulls the pen away from the paper just as quickly, when it is tightened by means of the fitting and shank when the chain is closed.

All that remains for us to do now is to look at the two adjusting screws **5** and **5** on the axles of the spring holder. -- Your purpose is very important; the treatment is extremely subtle. By means of this, the pen, and consequently also the pen, is given the appropriate position, so that it hits on the roller over which the paper passes (f. below) just in the middle of the notch cut in which the signs are given the appropriate relief. Then the axes are also given the proper firmness, which must be maintained by the right center, which is easily found by experience, between an exaggerated clamping, since the spring holder cannot move freely, and the apparatus does not respond, and too much leeway, which also has a disadvantageous effect. A wreath screw behind both screw heads then represents, after the correct position, the strength and the persistence of the same in the assigned position.

“Now that the printer and its pen have been sufficiently explained, we pass on to the paper.

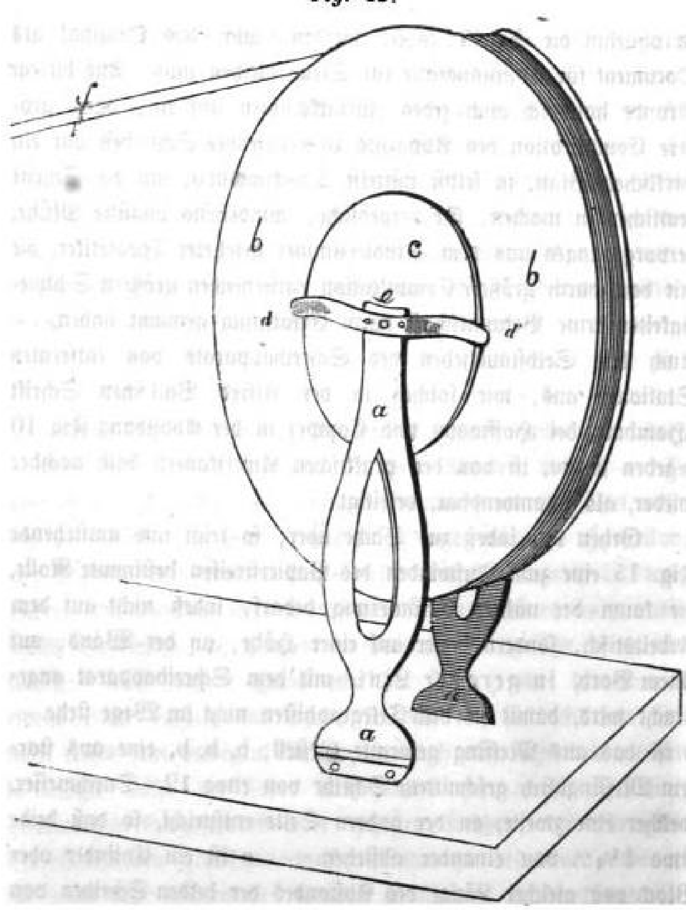
Because the pen, or more precisely, the key, is not fully mobile like the human hand, and can only move up and down, it was necessary instead to move the paper to prevent things from being written over each other. This can be visualized as follows: if our hand or arm and the pen were clamped in a block, so that we could not move it from left to right, and we still wanted to write, the paper would have to be pushed or pulled evenly from right to left under the tip, to properly space the letters.

This immobility of the key thus creates two requirements: namely, the movement of the paper tape in the printer itself, and uniform movements, according to a timing measure with which the writing telegraphist must align—indeed, accommodate—his timing of movements."

Now, in order to produce these requirements in the simplest and most expedient way, the inventor abandoned writing in rows on a larger sheet, since the writing must be copied anyway, and the original must also remain on the spot as a document in case of collision. For this reason I consider any return to writing on a real sheet of paper, which can be achieved by greater complication of the apparatus, even by means of printing ink, in order to make the writing clearer, to be a vain, or at least useless effort, arising from the study of learned theoreticians, who have not made any acquaintance through experience with the greater difficulties arising from increased complexity.

Also, the self-raising of the writing apparatus from distant stations, as given in Alfred Vail's work (Hamburg by Hoffmann and Campe) in the illustration Fig. 10, was soon afterwards abolished by the practical Americans as unnecessary.

Fig. 15.



If, however, we move on to the point, Fig. 15 shows us a roll intended for winding up the strip of paper, which hardly needs further explanation, but is not placed on the work table, but rather at a height, on the wall, on a shelf, in a straight line with the writing apparatus, so that it does not stand in the way of the telegraph operator. a is the frame formed of brass; **b**, **b**, **b**, a disc cut from thick sheet brass, about 12" in diameter, to which a second one corresponds on the other side, so that both stand about 1-1⁄2" apart. **c** is a cylinder or block of equal length of the distance between the two discs, which on the one hand gives them the necessary constant attitude to each other, and on the other hand forms the basis of the paper roll itself. One must imagine it covered by the brass discs in the following illustration. From **d** to **d'** lies an arc-shaped steel spring, the ends of which are firmly attached to the corresponding brass disc, and prevent the sideways swinging of the disc in its entirety. Its center must be thought of as hollow over the end of the axis, in that it is fixed on both sides of it, on the head of the scaffolding, with steel screws. On the other side, instead of this spring, there is a hat, unscrewed in the form of an inverted and half-closed u, which prevents the axle from slipping out of its course. All these precautions, however, are also intended to give the roller a safe and steady movement, which is absolutely necessary for the safe and level movement of the paper, and this in particular contributes to being able to place quite a number of lines, close together, on the paper strip. - e is the one axis of the Noller on this side, and f is finally the strip of paper itself. - It is about 1" wide and is made in a length of 600 to 800 cubits in such a way that a piece of machine paper of the same length and tightly rolled up is cut off on the lathe to such strips by means of sharp chisel. However, it is absolutely necessary that the edges are smooth, because jagged and rough edges prevent the paper from passing through safely, comfortably and evenly; it falters and the writing is consequently absent. The most convenient arrangement is to let the written paper run freely into a rather large box under the work table, from which it winds its way out comfortably when rolled up again. A gap in the table forms the way in and out of the box. In some lines, a second roller with weight has been attached somewhere on the left side, which immediately picks it up again. But I think the former is more expedient, since cases arise where the telegraph operator cannot immediately read everything written comfortably, and therefore has to read it later; it may also be momentarily held at the moment when it is written from abroad, and thereby be induced to leave the apparatus for a moment to accommodate copying later. In all these cases, it is convenient to have the paper in a box to pull out for later reference. Let us now follow the further course of the paper through the writing apparatus. First he passes through a brass plate divided transversely into two equal halves, **5**, in which, lengthwise, but not quite to the end, a narrow gap is cut. This brass plate is in the form of a small bench, with a seat somewhat drooping down, not quite half an inch wide, the back of which is 1/4" high. To this backrest are riveted two screws, which in their turn reach through the square-cut gap of a brass square beam, **6**, which is the support of the bench, and by means of two side screws, **7,** of steel, supported and strengthened on the outer upper part of the scaffolding. and this, resting on the continuous screws, can therefore be pushed to and fro, also by separating the two parts of the bench, made wider, according to the desired position, or the width of the paper; to be able to write the former line to line. To the continuous screws are again attached two buttons, **8**, with screw gear, by means of which, according to the correctly invented position of the paper, the bench can be fixed by screwing it on.

From the gap in the bench the paper reaches a roller, 9 around which a groove of the depth of a few lines is cut in the middle, in order, as already mentioned, to give the signs to be produced by the impression of the pen the appropriate relief to make them legible. This first roller is joined by a second, which is placed more aft, to the left, and a little lower, in such a way that it nestles directly and very closely against the former; this second roller also has a channel parallel to the former. At the outer rear end, close to the axle, or cone, is attached a shoot, into whose broad teeth another nub engages, to which we shall return later. This second roller also moves - but in a direction opposite to the former - by means of steel tenons, in narrow boreholes cut in the frame, **10**.

However, in order that the two rollers may be firmly and yet elastically connected to each other, a curved, strong spring, made of hardened brass, **13**, is screwed to the frame on both sides of the frame, the upper end of which rests firmly against the protruding pin of the upper, notched roller, but which, however, according to the thickness of the paper strip, allows the roller to be pushed back. However, in order to be able to reduce or increase this connection as required, a broad arc, **15**, is attached at the bottom, from the retaining screw, **14**, connected to the spring, as it were, as the root of it, the right end of which rests on the oval head of a steel screw, **16**, by the upright position of which the arch is pushed upwards at its end and thus, by means of the circular shape, the other end of which is held in place by the screw on the left, is pressed more strongly against the pins of the roller, and the latter is thereby pressed more firmly against the other, lower roller. - We will see how important this institution is later in the discussion of the obstacles. - The equipment of the roller just described has now been changed many times by newer mechanics, and in terms of solidity it has probably also been improved; the present institution, however, has been fully fulfilling its purpose for years and may be adopted in good faith.

We have now only recently to consider the mechanism by which paper is regulated and set in motion once in all, and then especially with regard to the measure of time.

The main impulse for this is the weight, which hangs on a strong gut string, which reaches up to the roller on the apparatus, **17**, through an opening cut in the work table, and is wound up by means of it. On it is the roller wheel, which strives to turn from right to left by means of the weight.

This main or roller wheel now engages at the rear of the pinion of a second pin, the pins of which we perceive on the frame at point **19**, and whose pinion lies just behind the frame.

On the opposite side, which the shaft of the cogwheel reaches, a cogwheel is also attached, close to the frame, which, as already mentioned, engages with the drive on the lower roller, **10**, and thus turns this roller right to left, while the impulse exerted on the upper roller moves it from left to right. and by this opposite motion pushes the paper between the two. -- Then follow two wheels, whose position can be perceived at the tenon points, **20** and **21**, on the frame, and the first has the pinion on the rear, but the second on the wall of the frame on this side. The teeth of the latter engage with the pinion of a so-called vestibule or wind-wing, about 3" long and 1" wide on each wing,

22, by the rotation of which, as the work runs, regulates and moderates the time at which the paper moves. This wind blade is at the same time used as an escapement, in that a stopper attached in the form of a crank, **23**, resting softer directly on the base plate, reaches to the rear frame, where it is attached by means of an eye to a long screw, between the head of which and the eye rests a spiral spring wound of wire, through the elasticity pressure of which the stopper acquires a certain solidity. and does not allow itself to be pushed back by the motive force. - The actual escapement is effected by a small vertical rod soldered onto the horizontal rod of the stopper, which presses against the wind blades when the stopper turns to the right, so that the horizontal rod touches the frame on the right and prevents them from rotating. - This stopper has a small handle at the front, by means of which the telegraphist handles it. - As soon as it is time to write, he pushes the stopper from right to left, and the work immediately starts moving, the paper slowly pushes itself through the rollers; as soon as the last word has been spoken, which is always the name of the writing telegraphist, he turns the stopper from left to right, and the work comes to a standstill, but with this the purpose is achieved in the simplest way. The lower two screws on the frame, **24** and **25**, to which two others on the opposite side correspond, have no other meaning than that they are the holders of two twisted columns, which extend from one half of the frame to the other, and give them strength. In the middle of the base plate two other screws are attached, which reach through the frame and are tightened at the bottom by means of strong nuts, whereby the apparatus and the board are firmly connected together.

We now have only to consider the weight. The same should weigh about 25 pounds when using a simple line. It is more expedient, however, to use a so-called pulley, such as we use at our Hamburg station. The weight in this case is from 160 to 170 pounds, and hangs on 9 strands that run through 8 tubers, 4 at the bottom and 4 at the top. - In this way you get a weight that, even with strong correspondence, requires at most 3 to 4 winds up a day, while the simple one has to wind up maybe 10 to 12 times. Both kinds of weights, however, are arranged in such a way that they can be lightened or made more difficult by lifting out or inserting individual pieces, which is of great importance for regulating the time by which the course of the paper is to be regulated, especially as the purity or impurity of the clockwork acts essentially on the faster or slower course of the clockwork.

And with this the writing apparatus is analyzed in all its parts, and we can confidently pass on to the second, no less important part.

IV.

The Relay

Although this word is also used and proclaimed elsewhere to be of French origin, I believe that I am correct, in sight of the source from which it has come to us, namely, from North America, if I adopt the English spelling and, according to our assumed usage (in German), designate the apparatus as neutral gender, which also forms a natural distinction from the older meaning of the word relay (preamble).

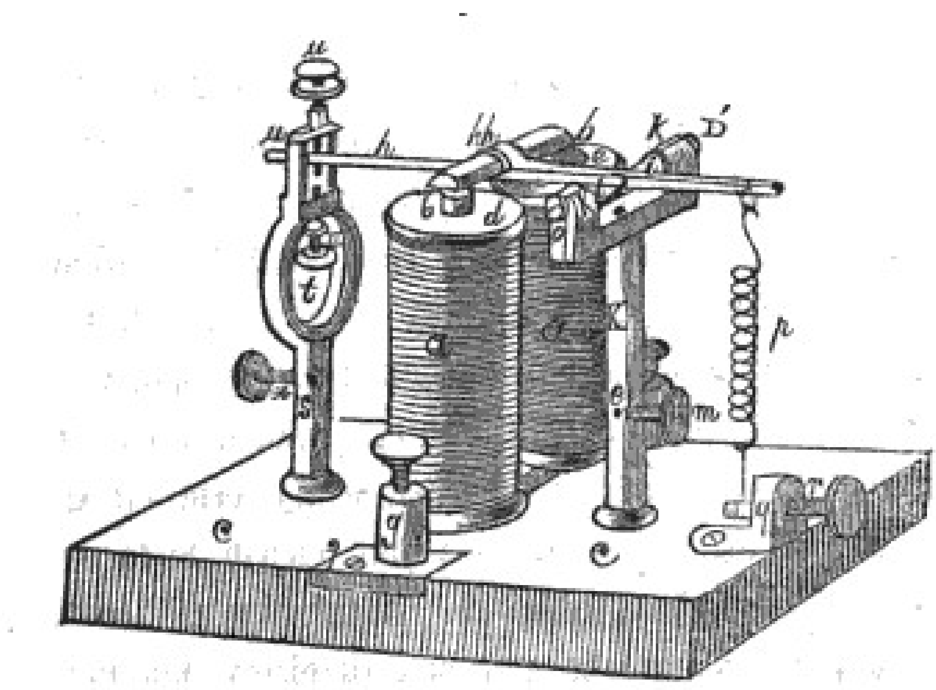
This relay has also been copied by various mechanics in Germany, and has been substantially altered in its external form; the Americans, however, who will not be denied practical sense, have reduced the principle, which is in itself very simple, to the simplest forms, and although the instruments of Halske in Berlin and Lordefink in Hanover, which I have had occasion to see, not to mention many other replicas in Leipzig, Vienna, etc., exhibit a greater elegance and complication, I am nevertheless convinced from experience that the replica has not been surpassed by the chronometer manufacturer and watchmaker Mr. Bröcking in Hamburg, who deviated the least from the American model as far as practical value is concerned, neither in relation to the relay nor to the writing apparatus, although at the same time it cannot be overlooked that if this mechanic supplies a complete apparatus for 100 Rthlr. Pr., Others about twice as much are paid for it.

When Mr. Robinson arrived in Hamburg from North America and first demonstrated Morse's system of telegraphy in the great hall of the Stock Exchange Arcades, the basic principles of the writing apparatus, but not of the relay, were well known, and Mr. Robinson, because he intended to revert to a larger sphere of activity such as Hamburg in Germany, tried to conceal the small inconspicuous instrument as much as possible. by keeping it hidden in a covered box even during its operation. - Even later, and even at the time when (in April 1849) we received a visit from Professor Steinheil from Munich, and Mr. Robinson was active in Berlin and Vienna at the establishment of the telegraph lines there, the latter had not yet released me from the word given to him to keep the secret, and I was therefore also allowed to accede to Professor Steinheil's wish, to get a more detailed explanation. - But this is what the words of the latter refer to in Dingler's politechnische Journal, 1st February issue 1850, pag. 191:

"In Hamburg they make a secret of the effectiveness of the relay." But when he then adds: "However, it is already described in the American Journals of Science and Arts, by Prof. Silliman Vol. of May 1848, p. 58. In any case, the principle is not new; for five years ago, August 30, 1844, I received a privilege (patent) in Bavaria for telegraphs through whose chain passes a constant galvanic current, the interruption of which causes the signs, which is the most essential thing of the relay."

On the one hand, Professor Steinheil asked me for clarification on a subject with which he was well acquainted, and felt hurt by the failure of a closer discussion, and on the other gives an explanation based entirely on error with the words: "Through the multiplicator of the relay the current of the chain passes constantly, while the current of the Grove station battery passes through the multiplicator of the writing apparatus only as long as the chain is interrupted." Both are false, as will be shown by the following description of the construction and purpose of the relay. - After this introduction, let us now pass on to our subject itself.

The relay is not a Morse invention, but I have not yet been able to find out the name of the first inventor, but I think that the credit goes to Mr. Alfred Vail. Before the invention of the relay, the writing apparatus described above was used alone, in that the current which fed the whole chain was conducted directly through the multiplicators of the writing apparatus, for which a very strong Grove battery was used, and had to be operated, in that, in addition to feeding the whole chain, as much force = was required to produce the impressions on the paper, which, of course, required a significant electro-magnetic pulse. - But the problem arose here, that in order to obtain this impulse through one and the same battery, the line had to be fed with a much greater force than was actually necessary to produce simple mutual signals. It was therefore a matter of separating the two requirements, and of setting up a separate battery for each, on the one hand to use only a minimum of force for a slight signal for the main line, and then again the impulse produced by this weaker signal for the writing apparatus proper, only on a very short double-wire line in the station location itself, or close to it, and thereby to devote all one's energy to the business of writing alone, without having to feed a long wire line and at the same time the earth's half-circuit. This is the basic idea and basic intention of the inventor. In the execution of this there was a second not insignificant advantage, namely, an easy and convenient regulator was found for the inevitable variants in the force flowing through the line, which sometimes arise from earth electricity, sometimes from the influence of thunderstorms or thunderstorms, sometimes from imperfect insulation, and then again from rain, storms, fog, and other meteorological or telluric influences. all of which have a more or less disturbing effect on telegraphic work, in that the impulse is sometimes stronger, sometimes weaker, which must necessarily and for the most part be compensated for even during telegraphing. No other apparatus, however, is so suitable as this one for overcoming these difficulties quickly, conveniently and surely, about which more details are given below.



We now ask the reader to look at those which this little miracle faithfully represents in the picture. The silk-spun copper wires of the two coils a and a (multiplicators) again circle in a spiral coil, just as in the writing apparatus, two iron legs, **b** and **b**, each about 3/8" in diameter and 2-7/8" high, the base of which is inserted into the two ends of a flat iron strip, and by means of this again in the middle on the bottom of the wooden plate, c c, screwed in from below. The wire of which the coils are formed is of a finer kind, such as that of the writing apparatus, and in itself, without silk, scarcely exceeds the thickness of a strong horse's hair. -- The coils include the two lids **d** and **e**, about 2-3/4" high and hold 1-1/4" in diameter; the winding requires great care so that the wires connect firmly, both in relation to the core, the iron legs, and among themselves, namely, the spiral sequence. The ends of the beginning are tightly wrapped together and soldered; at the two ends of the resolution -- after they have been wound several times under each other to prevent them from jumping loose -- it is well done to solder a somewhat thicker copper wire on each side, by inserting the naked end of this wire under the brass plate, **f**, which is embedded in the wood, at the end of which a small groove is filed into it, in which the wire has room to lie. - On this brass plate, which corresponds to a very similar one on the opposite side, a small locking screw, **g**, is soldered, into whose horizontally continuous hole the wire of the main line is inserted and screwed in from above. The current then passes through the brass plate, passes into the lower end of the coil, passes through both, and goes out again on the other side in the same way (or vice versa, according as the current is ordered). The relay is therefore in this way an interconnected part of the main line, which continues to the key of the writing apparatus, and by means of this, as we have seen, can be interrupted and restored. And this would now be one half of the relay's function, namely, by means of the multiplicators **a** and **a** in the legs, **b** and **b**, during each closure of the chain, event. of the key to excite magnetism, just as we have seen and explained in the case of the writing apparatus, only with the difference that there, because of the impressions to be made on the paper, a much greater force of attraction is required than here, where only the slight touch of two platinum pins is intended, the position and purpose of which I shall now speak.

The magnetism of the legs in the multipliers just mentioned, if it is to have any other meaning, must of course find an object of application, of attraction, and this is again given to it in the armature, **h h**, which is soldered to a spring holder, **h** (level) about in the middle, which is held in suspension by the magnetized legs, just as in the writing apparatus. and may not directly affect them here either. This floating up and down is mediated by the axis, **i**, which in turn rests on a column, **k**, worked out in the shape of a fork at the top, which sinks its base into the wooden plate below, has a transverse hole in the middle, **1**, with a forced screw on the sides, m, into which hole the lead wire of the local battery is led and screwed on. The two tines on the fork column **k** are just like a key on the writing apparatus, each notched lengthwise, and both halves thus formed are held together by means of a continuous screw, so that they can be placed narrower and wider. In both ends of the axis, **i,** a depression is drilled, into which the points of two screws, **o** and **o**', reach from both sides, which reach through the notched tines, and in these have a screw passage, by means of which the spring holder can be given a firmer or looser position. Of course, this process can also be reversed by giving the axles pins, which, being very thin and made of hard steel, rest in tap holes, cause very little friction. In the front right is attached a spring, **p**, by means of the elasticity of which the changes in the electric current, and the variants of stronger or weaker magnetism produced by it, can be easily regulated in the multipliers. In front there is a small metal plate with a button, q, reaching through an arched brass mound, between which the latter and the hill is pushed a rather strong spiral wire, r. Behind it is a small round brass disc, raised oval on the outer side, and behind this again a pin is inserted across the metal rod, so that when the button has been pressed and the spiral wire has been pressed together, the rotation of the whole has some inhibition. The spring, p, is fastened at the top and bottom to a silken thread, by shortening or lengthening it by means of rolling it up or down by turning the metal rod over the spiral spring, lengthens or shortens it. It is easy to see from this that the magnet and this spring-spring hold each other's counterplay. If the magnetic force in the legs of the multipliers is strong, the spring must be tensioned more, and it may even happen that another stronger spring must be used, since the expansion capacity of a weaker one is not sufficient to overcome the increased attraction of the magnets. As a rule, however, one would do well to choose very fine elastic springs. The right relationship between the two is there if the fitting is tightened and knocks down quite quickly and precisely when the chain is closed, i.e. knows how to overcome the average tension of the spring; and when the chain is interrupted, i.e. when the magnetism disappears, it opens just as precisely, so that the spring force is strong enough to overcome the excess weight of 3-3/4", together with the armature behind the axle, on the short arm of 1-1⁄2" in front of the axle. Let us, therefore, suppose that the rear part of the spring holder with the armature had a preponderance over the other part of two lots when the chain was open and the spring was tensioned, and that we now tighten the spring, with the chain open, just close to it, so that these two lots are overcome, consequently the valve strikes open or goes up, it is easy to understand that only a thought of magnetism needs enter into the multiplicators to change that suspension of the pen, which borders on equilibrium, in favor of the posterior, longer part of it, and to draw down the latter; whereas, on the other hand, when the action of magnetism recedes or ceases, by means of interruption of the chain, the spring will again have the advantage and the fitting will spring up. From this description it is now evident with how astonishingly little force one can correspond by telegraph by means of this apparatus, and in fact, by insightful treatment of the relay, we have been able to receive the longest dispatches from outside in the case of imperfect connection or disturbing derivation on the outer line, often with only one thought of force passing through the multipliers.

We must, however, now pass on to the actual point of this arrangement, without which all that has just been explained would be of no importance; and this point lies in the rear column, s, with the curved arch, t, and the upper chair, u. Notice how at the top, at the back, the end of the pen reaches through the chair and still protrudes from it with a point; and within this little chair the real point of life of the whole telegraph is concentrated in two small platinum pins, or also a pin at the bottom and a plate at the top, which touch each other with every knockdown of the pen, and separate again with every impact. - Shortly before the end of it, where it lies in the little chair, it passes from the round to the square form, on which square a piece of ivory is attached at the top as a non-conductor (insulator), while at the bottom a platina pin or plate has been soldered on. This is opposed by a platinum branch extending from below within the arch by means of a brass screw, and to be shortened or lengthened by means of this, which can be given a fixed position by means of the above-mentioned screw and counter-screw z, as soon as the correct distance of the latter from the upper part has been found. - There is also a similar provision on top of the head of the column, namely, a pass-through screw with head, w, together with the second head for fastening. The end of this screw meets directly with the ivory plate, or rather the other way around: the latter meets the end of the screw at each impact, whereby the closer or wider rest of the armature on the legs of the magnets and the distance of the points of contact on and under the spring holder can be regulated. At the bottom of the rear column, is the hole along with the compression screw, x, as in the front of the relay, for attaching the other end of the local battery wire. As soon as the main line is closed, and consequently the legs, which become magnetic, exert their force of attraction on the valve on the relay and pull it down, the force of attraction overcomes the (correctly tensioned) pulling force of the spiral spring at the front, the valve strikes down, and consequently the two platinum points of contact in the chair, u, meet each other and close the chain of the local battery line; As already mentioned, one end of this line reaches once into the column k, points 1 and m; from here the flow goes upwards, through the tine of the fork and the axle into the spring holder, across the fitting, and so on to the square point of the fitting and the platinum particles. - But if the piece of ivory were not attached to the brass as an insulator, then of course even with an open chain, i.e. even if the two platinum surfaces did not touch each other, the flow would find a way through the head of the column s, and there could be no question of opening and closing, and consequently of dots, dashes and spaces at all, in that in this way an uninterrupted closing of the local chain would take place, which would at most be interrupted for such a short moment when the pen is knocked up and down that it could only resemble a clinking, especially as it is a rule that the margin between up and down is only a very insignificant one, about which more details are given below. The small ivory plate, however, prevents this completely, for as the pen holder deflects, the chain is interrupted, but just as the magnets pull down the fitting and the platinum surfaces strike each other, it is closed, and the flow goes through the brass column s downwards to point x, steps here into the screwed wire, and along this on to the writing apparatus, steps into the multiplicators there, produces magnetism by means of them, pulls down the armature on the pen there, thereby beating the pen upwards, and brings the impressions onto the paper. Everything as described above: lines when the chain is closed for a longer time, when the point is shorter; with a longer interruption, long spaces. With shorter spaces, short spaces.

It can now be seen, from the above statement, that the local battery and the interposition of the relay are by no means in direct contact with the main line in terms of its length, since the only possible point of contact would be at most between the leg and the armature, but the latter, as already mentioned, must not touch each other, and even if they did, the conduction wires of the multiplicators of this real part of the main line are known to be covered with silk and thus, as among themselves, so also isolated from the thighs. The magnetic force developing in it is, therefore, so to speak, an emanation of the winding of the wire, an immaterial sweating through of the incomprehensible and undecipherable force, in the development of which no direct contact takes place, nor must it take place, if the process is not to be disturbed. It is therefore evident from the understanding of this state of affairs with what great right the Americans called the apparatus a relay; namely, a minimum of force causes the occurrence of a much greater force, through which the actual writing can only be carried out, and this force is caused partly by the much larger battery-vessels as well as by the short wire line inside the local. I would like to mention here a very recent discovery of mine. - The relay suffers a loss of its power due to the violent alteration of a potentiated atmospheric electricity that passes through thunderstorms, whereby it then loses its circumference (see about this at the end of the work). To remedy this evil, it is only necessary to pass the local battery power through the tangles of the relay for a few minutes, and the latter is thereby so refreshed, as it were, that all previous weakness has disappeared, and the lost normal circumference is restored.

Finally, the following remark: As soon as the relay shows a dark red spark at the points of the meeting of the Platinum parts when it strikes together, then this connection is dirty; i.e. not that dust or dirt is effectively deposited there - which also happens - but it is more important that burnt platina particles are present there, which impair the conductivity and therefore make the work more difficult, often quite impossible. - To correct this error, make a few strokes with a fine but completely blunt file over the platinum points, and then take a flat, bare steel surface and rub those points with it in a horizontal direction, and the work will be relieved from that hour on. - It is still a special mistake if magnetism has settled in the legs, often also in the armature of the relay, what the Americans call fixed magnetism. This phenomenon sometimes occurs after a strong thunderstorm, and such unseemly force can only be dispelled by heat. To do this, you can simply hold the faucet over a light for some time, and then rub off the blackness with paper. The legs, however, around which, as is well known, the silk-spun wire is wound, are unscrewed, and placed for about ten minutes on a hot iron plate, e.g., on a stove or stove, but care is taken that the wire is not damaged, and the multipliers will afterwards be found completely purified. - A relay afflicted with magnetism will always perform poorly. In general, however, the legs must be worked very carefully, and before they are wrapped with wire they must be annealed again, but then no more touched, as every file stroke changes the character of the soft iron.

I will now try to give the layman an idea of how it is possible to write by telegraph by means of this now fully described arrangement; but first try to help the concept, and explain how it is conceivably possible, without using an atom of time, to produce a signal in distant places, and this is done most simply by examples from ordinary life. In the first place, however, I must ask you to abandon the idea that electricity is a materially comprehensible force, a body moving away from the station of departure, or something similar, which has to go through a path here and there in order to perform a task assigned to it. One cannot get away with this assumption, because then all comprehension ceases, since no *body*, even the very finest, the light, cannot pass through a space without using time. Moreover, as we have learned, the electricity would have to run not only to the destination, but also back again, i.e., form a so-called circuit in order to fulfil its mission, and this alone proves that there can be no question of running, streaming, or flying of a body here, and that one only incorrectly uses the expression *through it*, when one speaks of the application of electricity for telegraphic purposes, because one has no other expression, no word for it, to designate the actual being and essence of this phenomenon.

But that cause and effect, even separated by larger spaces, can coincide without loss of time, may be illustrated by the following example: Imagine a line, a wire, or the like, stretched out in a long hall, in a riding arena, or the like, at an even greater distance; at each end, however, attached to the outermost end of the head is a strong steel spiral (spring) spring, one end of which compresses against a fixed wooden wall, while the line, the wire or the like. through the inner coil of the spring, as I said, is attached to the head end. Imagine, then, that a rod proceeded from this head of the spring and rested on a board, which was marked lengthwise with letters. Good! In accordance with how the spring is tensioned or slackened, the end of the rod would naturally have to move up and down on these letters, now stopping at this letter and now at that, as the tension becomes stronger or weaker. Now imagine further that this same tension and slack were to take place at the other, distant end of the line: would it take time to perceive the impulse and alphabet given on this side on the opposite side? Certainly not! - But let us now extend the space at will, invent a means of removing friction, and the effect must remain the same with the same cause. If possible, I will make this more illustrative: Imagine a long rod lying on the ground: one pushes on this rod, and just as one layer at one end, it must move at the other end at the same moment, or the body of the rod would then have to shrink in on itself like a telescope. Of course, these examples are by no means directly applicable to our telegraphy, for our stretched wire is by no means subject to any physical movement, nor is it the wire alone that mediates the correspondence, but screws, plates, forks, in short, the most diverse forms of metallic bodies, are also involved, whereby consequently there can be no question of any movement; rather, I wished only to make the often-expressed doubts regarding a strictly simultaneous departure and arrival of signals at two or more very distant points comprehensible.

As far as our electro-magnetic fluid is concerned, I repeat that in relation to it one can only use the term current, which I have often used, and that it is really only a holding point to designate something for which one has no other word. But I ask: if someone stabs us in the big toe with a sharp needle, the painful impression is reported to the brain at the same moment by means of the nerve, and again at the same moment the mouth says "Ouch!", and again, as the report returns to its exit in a circuit, we withdraw the foot, all this at one and the same moment: - can it be said that a fluid flowed from the needle through the toe, through the nerve, to the station of the brain, and again from this station at the same time to the mouth to express the pain felt, and back to the toe with the command to withdraw the foot? - Certainly not! There is certainly a report, for if the nerve had been cut, as the wire of the telegraph were cut, nothing of a feeling of pain would have been reported to the brain. Thus, in order to help the faculty of communication, one can speak of a flow of the fluid through the wire, but in truth it must be something else. - Proof of this is also that you can't intercept anything from such a fluid. Meant in this way: imagine the line in full flow, and the station points **a**, **b**, **c**, and **d**. In **a** and **d** are the batteries; let's assume that from **a** to **b** would be a mile, from **c** to **d** as well; but from **a** to **d** eighteen miles, and now their keys opened at the same time at full current, a considerable portion of electricity would necessarily have to be captured in the middle between **b** and **e** on a sixteen mile road, as it could not escape from either side. But this is not the case, but as soon as the chain is opened, everything is gone, just as in a dark room, when the light is blown out, all the light is suddenly gone, and suddenly returns when the light is lit again. - Of course, light is also ascribed a current, and it is asserted that stars can still shine for us which were extinguished and destroyed thousands of years ago. Whether this can be assumed in good faith remains to be seen, the simple human mind cannot comprehend such a thing. I will here take the liberty of giving a quotation on this subject (namely, the electric current) from the recently published work of Dr. Grieb, "The Wonders of Electric Telegraphy, Stuttgart by Scheible," in which this author treats it with a great deal of ingenuity. - After he has put forward several unsound hypotheses, he drives page. 57 so on:

> "One might ask, what evidence is there for the assertion that something substantial is moving along the telegraph wires? There is no real proof that anything material moves. The rushing streams and the flying arrows are merely imaginary beings, though the former are a hypothesis, and the latter an example. However, there is still another way of explaining the apparent passage of this invisible agent; it is hypothetical, it is true, but nevertheless, taken as a whole, it has the presupposition of a greater truth for itself, and therefore most men now prefer it to science. Our investigation would therefore be incomplete if we did not point it out in a few words."

According to this view, the metallic conductor, in this case the telegraph wire, which connects the outermost plates of the voltaic battery, is not an artificial road on which the electricity runs; but the wire exhibits electrical phenomena in its whole length only because its combination with zinc and copper, moistened by acid, causes during a certain period of time a new arrangement of its own molecules (propositions), in consequence of which the wire participates in new properties, namely, those properties which we have electrical properties. the whole of physical science is full of the fact that we cannot change the arrangement of the constituents of a mass without bringing about a corresponding change in the properties of the mass formed of such atoms. Soot and charcoal, coke and water-lead, owe their different properties solely to a different arrangement of identical carbon particles; and a further modification of these, gives them the completely different and characteristic properties of the diamond. But the electrical differences between two wires, one of which appears as an electric conductor, but the other not as such, are certainly no greater than the optical differences between a piece of coke and a diamond crystal, or between carbonated lime, which does not crystallize in the form of chalk, and appears crystallized in the transparent Icelandic spar. We can, in fact, give no limit to the extent to which a modification of the molecular arrangement may affect the properties of a mass.

Nor can such a view really be overturned by the objection that a metal wire is a rigid body, the constituents of which are so firmly connected with each other that they admit of no movement in relation to each other, nor any alteration of their relative position. The opinion that only liquids and gases offer the mobility necessary for a change in the molecular arrangement is now generally abandoned; and in fact, the expansion and contraction of a metal mass under the influence of heat and cold is a sufficient refutation of it. - The tubular iron bridge over the Menai Strait, between the Principality of Wales and the little island of Anglesea in England, crawls forward and backward several inches like an enormous snake or snail during the twenty-four hours of St. John's Day. The mighty glacier is transformed from a unit of small, watery snow crystals into a mountain of bright ice. Every schoolboy is familiar with the same phenomenon when it develops in the formation of a grinding track on a snowy surface. In copper mines an iron hammer is found to have fallen into a pool saturated with copper-containing salts, and after the lapse of a few years it has been converted into a copper hammer: all iron has disappeared and has been replaced by copper up to the center, without the shape or mass of the rigid body having changed during the process of transformation. During the production of steel from iron, the latter is buried in charcoal powder in the same way, and the whole is made red-hot; then the charcoal penetrates the rigid iron and through it penetrates its whole mass.

These examples, and we might cite many more, are applied to changes in the structure of solid masses, which are far more significant than those which we need to assume to take place in an electric conductor; so that we must not hesitate to assume molecular changes of a simpler character than possible. --- The change which is likely to take place in the telegraph wire may be similar to that which we may assume with reasonable certainty to have occurred in the case of magnetization. Iron takes place where the characteristic phenomena are easier to observe and more familiar to everyone than with electric conductors. At first glance, a magnetic rod and a magnetic needle seem to have magnetic forces only at each end or pole. On closer examination, however, it is found that they possess the opposite northern and southern magnetism in alternating succession along their entire length. We can compare it to one of the lines or stripes of a chessboard or a mosaic floor, which are made up of alternating pieces of color that follow one another. However, there may only be two colors, such as blue and white; so that one cube, or one square, is always blue, the other always white. - A piece of non-magnetic iron becomes temporarily magnetic when it is placed near a permanent magnet, e.g. a pole stone; and while it is so magnetic, iron exhibits the same alternating succession of opposite magnetic particles as the magnetic needle. We cannot compare magnetic iron with an aggregate of compound green particles. It becomes magnetic as soon as each of them separates into a blue and a yellow part, which follow each other alternately in series. If the dipping ceases to be magnetic, because the pole stone has been removed, it is a matter of whether the blue and yellow particles have reunited, and the whole becomes uniformly green again. In the same way, it is believed that the wire which combines the zinc and copper of a Volta battery, in consequence of its combination with these metals, so long as they are affected by the acid, has been converted along its whole length into a series of alternately successive electro-positive and negative electricity. The arrangement is exactly the same as that of the magnetic rod; only it is not an alternation of opposite magnetisms, but a succession of opposite electricities. They remain separate as long as the compelling force of the battery asserts itself against them; but no sooner is the wire removed from the battery than the separate electrics unite, and all electrical phenomena then cease. We can compare the telegraph wire, when it is removed from the battery, to a string on which purple globules are strung together, like a string of pearls. When the wire is in contact with the battery, each purple globule separates into a red positive-electric and a blue, negative-electric one. The red and blue spheres now follow each other regularly along the whole line, and remain separated as long as - in the language of another theory - electricity flows past; but as soon as the connection with the battery is broken, they again merge into the compound purple globules.

According to this view, there is no dispatch of electricity to deliver messages from station to station. The message telegraphed from Hamburg to Berlin, for example, is not carried away by the Electricity, which, coming from the former city, leaves its hieroglyphic script in the latter while it flies past and back to Hamburg; but the telegraph wire now arranges its own components from one end to the other with inconceivable velocity in such a way that in regular succession one electro-positive molecule always replaces an electro-negative one, and the hand on the corresponding dial is affected only by the small part of the wire which surrounds the common. It is to be compared as if a number of men were lined up from Hamburg to Berlin; lined up man to man, and everyone holds a signal flag in their hands. The flag that serves as a signal in Hamburg has not passed from hand to hand along the line. No man has done anything but observe the flag shown to him by his neighbor on one side, and show his neighbor a corresponding flag on the other. The flag unfurled in Hamburg was there from the beginning, although it was unfurled, and remains hidden there until the next message is telegraphed from man to man.

Let the reader think of this explanation as he will, he will not be able to deny the important fact that, by means of a wonderfully simple arrangement which permits us to dissolve some pieces of metal connected by a long wire, we may at once, at a distance of hundreds of miles, develop a force which speaks for us, writes for us, and, as far as the transmission of our thoughts is concerned, destroys space and time; but this annihilation is of course not complete, but only in relation to practice may it be so called. Shakespeare's Juliet refers to the "lightning" that ceases to be before one can say, "there is lightning." The velocity of electricity along a copper wire is exactly 288,000 English miles in one second. From this it may be calculated that in a little less than a five-hundredth part of a second we could telegraph to our counterparts.

The most impatient correspondent will probably be satisfied with this speed, and we can confidently investigate how electricity is used to produce signals."

So much for Dr. Griebe, and I now take the liberty of continuing my presentation.

It is a phenomenon to be taken to heart that the telegraphic chain interrupts its operation at all points at the same time, just as some opening of it takes place somewhere; and in the same way it immediately regains its activity, just as the connection has been restored. [3]) When I say at any point in the chain, it follows that this also applies to some, even the most distant station, e.g., for us in Cuxhaven, or Bremen, and yet in Hamburg we will be immediately interrupted when the chain is opened, and immediately be active again when it is closed. - This interruption and closing can now happen in the most rapid succession one after the other, and the effect will always be the same. Consequently telegraphic writing is nothing other than a continual opening and closing of the circuit, whereby-depending on the longer or shorter intervals between them, the closures produce dots or dashes, and the openings produce smaller or larger spaces between those elementary signs.

It is, therefore, (a cycle of) action and passivity regulated by certain laws by which writing is produced.

If, for example, *Cuxhaven* station opens and closes the key four times in quick succession; about as if someone were to play four quarter notes on the fortepiano, ♩♩♩♩, the armature at each relay of the line will strike up and down four times, in consequence of which the two platinum contacts of each also strike in the same way,

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[3] In the case of the Prussian telegraphs, the chain is open, or interrupted, until work begins at some point in the line. An institution against which many things = are to be turned with reason.

and again through the chain of the local battery, which has been interrupted four times and restored four times, the force will pass through the electromagnets of the printer and make its armature move up and up and down four times as well. And with each stroke the stylus is pressed against the paper moving on its roller, so that there are four dots on the paper strip next to each other.

If the paper moves along while the key is held down, a long dash will be produced, its length determined by how far the paper moves. Conversely, with the key open a gap of equal length will appear, i.e., no mark will be made on the paper.

Finally, as each of these four strokes are made, the extreme end of the printers pen will strike loudly on the head of the front pillar, so that it can be heard at a considerable distance, and therefore no bell is needed to perceive the signal.

But I chose this signal of four strokes, because in our alphabet it means the letter **H**, which in turn has the meaning "Station Hamburg" for our line, consequently as soon as we hear this signal, we (Hamburg) must then free the clockwork to advance the paper and write whatever the caller sends next.

For the time being, it does not matter from whom the call originated; we only replied with **"I I"** (aye, aye) and one's own station sign.

Similar to those four dots, dashes are produced by closing the circuit twice as long, approximately analogous to half notes of music, on which two quarter notes are also to be reckoned; and from these dots and dashes, as elementary signs, the letters are then put together, as we shall see later in the alphabet.

A finely trained ear can now distinguish every letter by the sound, even read words, and this even at the relay, which in itself gives a fine sound.

I would like to remark here in passing that in our arrangement the writing station, by engaging its clockwork and letting the strip of paper run, can see what it has written itself; especially useful in the case of difficulties presented by the line, setting up another machine, introducing a new roll of paper, setting up a new line, etc. This is of particularly great advantage when sending numbers, to confirm their correctness without inquiry or repetition.

Even the student can use this to observe and verify their own writing.

The establishment of some German telegraphs - e.g. the Prussian ones - are, as already mentioned in passing, of a different kind. By a certain arrangement of the line, one's own writing apparatus is excluded from self-writing, so that the pen does not strike with the writing. — What is gained by this I understand the less because only one battery is active each time, and therefore twice as strong batteries are required as in our facility, where both final batteries (and Bremen and Bremerhafen included, even four main batteries) act simultaneously.

It is now evident from the above description that on a continuous line, provided with the same apparatus at each station switched on, the same sounds must be heard at the same time and the same signs must be produced when the clockwork of the writing apparatus is set in motion to advance the strip of paper, which the Austrian Government in particular has wisely used by (at least initially) having a control station set up for each line. where everything telegraphed is collected and entered into a special protocol for control; for, since the multiplicators of the relay at each station are an effective part of the total line through which the electric current must pass through, and consequently performs all functions, just as and better still as at the end point (since the difficulty increases with distance), consequently all stations can receive one and the same writing at the same time, and this is understandably an essential advantage over all other systems. I have already mentioned somewhere before, however, that our stations are designed to be able to exclude each other suddenly, as happens especially in thunderstorms.

Finally, it should only be mentioned that the table on which the apparatus is set up must be very heavy and massively worked so that it does not tremble. The leaf should therefore be at least 3" thick, about 11⁄2 wide, 5 long and about 3⅞ from the ground. Sliding shutters for small tools are to be attached to the right and left. And with this I believe that I can leave this subject after an exhaustive treatment.

V.

The electrometer.

(Also called galvanometer.)

As this instrument does not belong exclusively to the Morse telegraph, but is also used in every other electro-magnetic telegraph system, and is not exactly absolutely necessary, but only very useful, I will confine myself to mentioning the principle according to which its composition is made, on the basis of the American electrometer.

As a basic condition of this, the multiplicators again appear. However, as these do not have to develop such a high degree of magnetic induction in this case as in the case of telegraph apparatus, the wires are not wound around iron legs, at least not in ours; the forms, however, are very different. - Namely, an elongated double frame with somewhat high edges of light wood is made, around the inner base of which the spun copper wires are wound firmly and regularly next to each other, in the same direction. - The base of this coil has an elongated notch-like cavity on the inside, through which the inner needles can later swing freely around their axis, and this double coil is then inserted into a clean box provided with the necessary adapting precautions and clamped with small crossbars, and further pressed down with a hammering lid hanging on hasps, which in turn is replaced by two, on the edge of the box with a protruding hook that borders the eyes. In this lid is cut a round opening, almost equal to the circular periphery of the needles, which bears on its outer edges a dial divided into four by 30 degrees, on which the needles, moved by the force of induction, float up and down, and finally find a position corresponding to this force. - At the bottom of the box, in the center, there is a brass box, screwed in with a conically shaped recess, and corresponding to this on this side a second one, in the form of a head, which is screwed into a brass crossbar, which is attached over the box in such a way that the induction wires run across it. The brass (flat) cross-rod is fastened to the edge of the box by means of screws, resting on small loose eyes at the top and bottom. - Between the two bushings mentioned now rests a fine, very precisely straightened steel spindle with screw gear at the top and bottom, on which two arrow-shaped, magnetic steel needles are screwed on; however, the mutual position of the needles must be such that the unequal poles are opposite each other, which is why the two equal poles on each needle are marked by a blue tarnish. These steel needles now serve, as already remarked, as the outer needle, describing the periphery of the dial in its oscillation, indicates, according to the higher or lower point of view, the stronger or lesser force of the battery, and at the same time the variable telluric and atmospheric influences; namely, in that the induction effects of the multiplicators connected with the outer line on the magnetized needles cause them to vibrate, and finally, according to the intensity of the influence, they take their position higher or lower on the dial.

But their functions in the Morse telegraph are, as I shall explain in more detail later, of a quite different and more important kind, especially in the case of derivations along the line. Halske's and other galvanometers, which are often used, hang on a fine hair instead of moving on a metal spindle, which, however, considerably increases the sensitivity of the instrument; however, the oscillation of every disturbing influence, e.g., the opening and closing of the chain, before the needle comes to rest again, is so protracted that observation is often quite intolerably delayed. I will only remark recently that according to the connection of the end wires with the main line (for the inductors of the electrometer are, as I have said, a part of it), the left or the right tip of the needle rises or falls with the force flowing through it, but this is very indifferent in the end, since the field of the dial is then divided into four equal parts. and in such a way that from both right angles marked zero, 30 degrees after the apex, and again 30 degrees down to the sole, are counted and noted. -- Finally, Morse's electrometer differs from others in that it is not placed horizontally like these, but vertically. If the needles have lost their strength due to thunderstorms, they are strengthened again by stroking a magnet. - The mobility of the needles can also be helped by a very slight weighting of them on the side that falls when the chain is opened.

VI.

Of the obstacles

However extraordinarily wise and cleverly thought out and executed Morse's telegraph system now stands before the eyes of the connoisseur as well as the layman, it could not escape the fatality of all electro-magnetic telegraph systems of having its defects, that is, in other words, its impediments which are invariably founded in the nature of things. But it is one of the essential advantages of this system that, right next to the obstacles, the means of overcoming them are immediately offered, especially in the relay. -- These, however, concern only a part of the general difficulties; but I intend to traverse the whole circle of them as far as I can, and may well affirm that there is scarcely a single obstacle which has not touched us in practice.

Every artist, machinist, craftsman, or whoever it may be, has the apparatus or apparatus subordinate to his supervision in front of him, beside him, around him; he surveys with a single glance the whole field of his work and work, and can try to overcome the obstacles that confront him in the familiar context Not so the driver of the telegraph. His workshop is 10, 20, 30, 50, even 100 miles long, and just at the time when he would most need to send out his orders by the winged messenger on this route, the latter refuses him his services; and the very fact that he denies it is the sure mark of the obstacle. It is not uncommon for him to be told on entering the station: "The telegraph is not working," or, "It is working very difficult; something must have happened." The experienced telegraphist, and in general the one who has penetrated into the spirit of the matter, will now know at once whether the obstacle lies outside or inside the station, whereas the less initiated telegraphist who knows only how to write and nothing but how to write, will be embarrassed at any moment, even if the line outside is in perfect order, since the influences of the weather only too often necessitate a modification of the conditions of the apparatus, which must be quickly and correctly recognized, and just as quickly put into action.

The first and most serious obstacle is, of course, the formal interruption by destroying the wire. But the phenomena that occur in this way can be of two kinds. The first and ordinary denotes that state as when one opens the key, i.e., thus: the line is absolutely without current; the armature hovers loosely above the multipliers, the electrometer takes a low position, everything is silent and dead, the telegraph is dead, is a corpse, and no closing or reclosing of the chain produces any sign of life in it, it is hardly there at all for the moment. This state of affairs, however, does not always occur when the line is destroyed, but much more often the case that by means of the destruction of the wire, there is much greater force, so that the electrometer rises to the highest point of the scale allotted to it. - How is this possible? one asks. The matter is this. Let us think, for example, of the Hamburg station, where the wire leads over the Elbe on high pylons after about 14 miles of pipework. If this wire, which crosses the current, breaks very close to the mast on this side, the station of Hamburg is without earth, and the former state of affairs occurs. But if it breaks in the same way on the otherworldly mast, the end of this side naturally falls into the stream and thus forms a circuit with Hamburg; i.e., the force which emanates from our battery, and which should normally go to Cuxhaven, finds the shortest way back to our plate by means of the water of the Elbe, in which one end of the conduit hangs, and thus forms a very short circuit. But it is precisely for the sake of this brevity of the circuit, since the fluid does not have to feed a wire that reaches far out, that the power increases to the maximum, and one can, after a duly strained pen on the relay, write quite excellently for one's own plaisir at the station. The stations on the other side of the Elbe, however, have no circuit under these circumstances, and will, on their part, as just mentioned, be dead and silent, without movement, unless the precaution indicated in Fig. 8 is in place to allow them to make a short circuit, whereby Hamburg, which is in any case excluded for the moment, will not be affected any further. Such a short circuit, however, must be wisely lifted from time to time, in order to find out whether the connection has perhaps already been re-established in the meantime. If, on the other hand, the first case of rupture occurred, as assumed, Hamburg remained without a circuit, then all the stations on the other side would have their circuit from the Elbe, and could work on it quite well, although the force will be somewhat diminished by the exclusion of the Hamburg battery. But of course it can also happen that the wire breaks in the middle of the stream, and both ends hang in the water, in which case one has circuits from both sides, and in the end one would not even know that an interruption had occurred, unless a vain call for the outstations, the position of the electrometer, and a change in the clamping force on the relay gave sufficient testimony to it. If, however, there are unfortunate malignant deductions between the station and the fracture, it is indeed difficult to distinguish whether there is a derivation or a fracture, or both. - Derivations, however, are seldom so total and so sudden that it should not be possible to distinguish them from a break with a false circuit. If we now stop first of all at the latter, then the intermediate stations are of great value for estimating the region where it may have occurred, for the stations are instructed in such cases to make short circuits on both sides, and to announce on the side, where the break is not, that an interruption has occurred on the other side. what the station nearest to the fracture experiences when one makes a short circuit from it to the point where there can be absolutely no more force, which is expressed under the formula: I have no circuit with -? However, in the case of lines above ground, an agreement must be made to send at once certain men who are firmly engaged for this purpose (i.e., in the case of lines which are not on the railway), if possible on horseback, in order to seek out the break and for the time being to bring both ends of the break back into connection by means of a simple wire connection, so as not to interrupt the telegraphic correspondence for too long. but after that the definitive repair was to be arranged. The dispatch of such messengers, however, must take place as far as possible from both stations in the midst of which the damage occurred. It is much more difficult to find such a fracture under the earth, which has already been discussed at the beginning of this work; but for the sake of the importance of the matter, at the risk of repeating myself, I will return to it here in detail. One would do well to pay attention to suspicious, freshly dug or pierced spots. For the rest, however, it is good for this kind of interruption - especially for this kind of interruption - if there are active batteries at both endpoints, and the line is constantly circular, i.e., flowed through by electrical force, in order to find by taste the direction in which the interruption took place. Often the fault is quite obvious, and not infrequently even on the station itself, which one might find oneself obliged to look for in the distance. It is therefore advisable to have a provision for the convenient dismantling of the wires where the cable flows into the ground. Then, after taking it apart, take a third, loose wire, put one end of it in damp earth or water, take the other end in one hand and the end of the wire running out of the station in the other, and press both together, but without touching each other, against the moist tongue, and one will immediately taste. whether or not power emanates from the corresponding station locale. To make matters worse, you can also taste the other side by changing the ends of the wires. If there is no taste to be felt from the outside, then of course the fault lies outside, and the experiment must be repeated at suitable places, after the interrupted connection near the station has been carefully restored. If, for example, one comes from the west and investigates to the east, one will feel taste from the western station until one has passed the fracture; behind it the taste from the west will have disappeared, and that from the east will take its place, but between the last two points of experimentation there is no question of error, and the distances of the experiments must be shortened until the point is found.

If you take the decency to cut the wire, you can also push a strong needle through the gutta-percha, in such a way that it touches the wire sharply. Then attach a longer wire to this needle and stick the end of it into damp earth or water, thus making a circuit with the West Station. Now go a little further to the east and push a second needle through it, tie it again with a wire, and make short circuits to taste by means of a second loose wire. If one has not yet passed the rupture, one will have no taste, since the first short circuit conducts the force into the earth. But if you have already passed the break, you will have a taste, namely from the east station, and you must now go back and repeat the experiment until you have no taste of the east station, then the break must lie between the last two test stations. - But the pinpricks have to be carefully closed again with a hot iron, otherwise leads would remain.

This is the easiest way to find the fracture and you don't need a battery or electrometer. - If it is found that no force emanates from the station, then all connections are to be examined closely, for which taste can also be used, and it will soon become clear where the error lies. By the way, one should not forget that the fault can also be due to the earth's plate, which can occur especially in the case of newly applied sandy soil at railway stations; for if the plate is not very deep, and the sand in which it was buried dries up in the summer, the circuit will suddenly disappear, and the telegraphic work will be interrupted. I was told of a case belonging to this by a Dutch engineer, where the slab had been sunk into a well, but not deep enough. As soon as water was diligently fetched, the plate hung in the open air, and the telegraph could not work without knowing why. After a few hours everything usually returned to the usual order, and at first one could not explain this phenomenon at all, until at last one came up with the idea of looking where the fault really lay. Indeed, even if the plates do not lie so deep in the earth that they remain untouched by frost during severe winters, this may also cause an interruption, since it is well known that ice and snow are non-conductors. In all such cases one must think of interruptions, if one does not wish to remain perplexed.

We now pass on to the derivatives which occur both in lines in and above the earth, and are to be regarded as one of the first and most dangerous hostile forces and disturbers of order in electro-magnetic telegraphy. The reasons for this are divided into two special sections; first in originally badly procured insulation, and then again in individual special coincidences that arose later. The former is by far the worse, since this kind of derivation is usually distributed over many individual places, and consequently makes a complete repair of the whole line necessary. These bad insulations include, for example, those where the wires are drawn only through so-called eyes in the piles, even if they are lined with porcelain, gutta-percha, or other non-conductors. It turns out that in rainy weather these eyes run full of water, so that the wire floats completely in the water. As soon as this condition has occurred, the superfluous water runs down the pole and conducts a part of the electrical fluid into the earth. If this is repeated on hundreds or even thousands of poles, nothing remains at last, and the telegraph is finished. For this reason, it is absolutely necessary for pile lines to attach bell-shaped insulators to the head of each post. But even with these, if they consist of glass, porcelain or earthenware - through fractures, which are mainly caused by swelling of the stakes, or by shepherds' and other boys who like to aim at the glass heads with small stones, leads of the worst kind can arise, in that the wire comes to rest on the wet wood after the insulator has been destroyed, or even a blasted fastening wire accidentally gets into the usually close to the stakes, which can then create a totally false circuit. On such occasions, therefore, when one goes to look for such a derivation, one must take particular care that each insulator is whole, for even a piece blown out is suspicious. For all these reasons, as already mentioned, I have lately had insulators made of gutta-percha for the poles, in which the precaution has been taken at the top of the jaws of the gap in which the pipe is to lie, to push a wire over the pipe, as then it can never slip out. Destruction of this insulator by throwing is now completely out of the question.

Less bad is the otherwise so much feared passage of the line through tree branches. It is better, however, if such things do not happen, but we have always been able to work quite well up to now, although in the beginning all the branches were cleaned away and a single one was not infrequently paid 1 to 4 thousand pounds to be allowed to take it away; but there is no doubt that young offspring have long since returned, without our feeling any disadvantage from it.

What else could produce derivatives in telegraphs above ground cannot be given exactly, as every locality has its peculiar adversary. On the average, however, it can be assumed that any and every other connection from the wire down to the earth, which does not pass through the curvature of the insulator, causes conduction, at least in rainy weather.

Now, if it happens that the wire is thrown down completely from one or more stakes, so that it touches the earth in its bend, then in dry weather a part of the force large enough to be able to work, though with difficulty, may slip through; in rainy weather, however, dew, or in general only damp earth, the interruption is complete, and therefore, as soon as the place is found, one has nothing more urgent to do than to pick up the wire from the earth and put some support under it. In addition to the more difficult work, in that the outstations do not answer at the call, the precipitation of the key when working does not exactly coincide with the striking of the magnet on the writing apparatus; furthermore, the necessity of an often repeated adjustment of the relay, so that the tension of the spring on it must be changed at every moment - for the main station, i.e., where batteries stand for the main line, it is also indicated by the increased position of the electrometer and at the same time a very considerably increased attraction of the magnets on the relay, so that often an ordinary spring is not at all sufficient to overcome it by tension, and then you have to have stronger springs at hand, or remove the fitting a little more from the legs. It must be expressly remarked, however, that these symptoms only appear very concisely when the place of the discharge is near, i.e., within one or two geographical miles of the station, and this arises from the fact that the force emanating from the battery returns by a path shortened by the conduction, without being able to wander out into the distance. If, however, the point of discharge is even more than half the distance of the total line, then on the contrary, the force on one side of the fraction (on the further distance) will appear considerably less, since the battery, now acting in isolation, has a much larger circuit to feed than usual, since no derivation has taken place. On the other hand, in the other, opposite ward, the symptom first described will appear. With careful attention to the electrometer and relay, however, it will be possible to receive and transmit reports even with a fairly high degree of conduction. The electrometer, if it is otherwise sensitive, will still give a sign of life with every movement at the outstation; the relay must then be placed at the outermost point of limbo, and will then for the most part fulfil its duty even under such circumstances.

It is, however, a rule that has been tried and tested by experience, that in the event of discharges and also in persistent rainy weather, the points of contact of the relay are to be removed a little further from each other than usual, and even the armature over the legs of the relay can bear a somewhat wider shutdown, so that the former remain a little further away from the latter than usual when precipitated. However, all this must not be much. In dry weather, the approach can be standardized up to the nose of a fine sheet of paper, without the relay sticking, as is usually expressed technically; this is to be understood: if the points of contact of the platinum part do not separate from each other in exact succession in accordance with the opening of the key, which then results in the dots being absent and instead of their dashes there are dashes, so that of course nothing can be read. I will come back to this later.

The leads on the wire in the ground, as has already been mentioned in the subject of complete interruption, are much more difficult to find, and, if they have not been caused by direct damage, the whole line must be taken up and better covered wire placed in it. There is, however, a difference to be made whether the wires encased in gutta-percha were sunk in tubes or without them. In pipes (the most expedient is to choose clay ones that do not conduct) the danger of drainage is not so great, unless they are not tightly cemented and water penetrates into them; then, of course, the danger of drainage, especially in the case of iron tubes, is much greater. - In cities, however, where multiple pipes intersect, the insertion of the wires into tubes is indispensable, since the soft, unprotected gutta-percha coating would too often be exposed to the danger of being damaged during the various pick-ups of the pavement.

The first task in the construction of a telegraph line in the ground is, of course, to endeavor to obtain well-insulated wires, and these must therefore be tested beforehand. This test can be done quite simply in the following way: Place each bundle of wire covered with gutta-percha in a spacious barrel filled with water, so that both ends protrude from it. One end, stripped of gutta-percha, is now connected to one pole of a small battery, the other is out of the question, but must only float freely and untouched in the air. The other pole of the battery is then connected to one pole of an electrometer by means of copper wire, and a piece of copper wire long enough to be immersed in the barrel filled with wire and water is connected to the other pole of the latter. When all this has been done, the preparations for the experiment are ready. The whole outer surface of the wire is surrounded by water and consequently surrounded by a good conductor. Where, therefore, this conductor, the water, touches a naked spot, finds a connection with the whole of the electrometer, there is also a mass of water produced, and it is enough of the last-mentioned wire, the second poles of the battery, to produce a circuit, the presence of which will then be immediately perceptible on the needle of the electrometer. If, on the other hand, the whole surface of the copper wire is completely insulated by the covering, there can be no circuit, and consequently no movement can take place at the electrometer, since the second end of the wire covered with gutta-percha ends freely in the air. An insignificant circle, about 8 to 14 degrees, i.e., if the needle of the electrometer rises so much when the test wire is immersed in the water, need not be repeatedly ignored in several experiments belonging to one and the same line, since such trifles do no harm in telegraphing, and besides, the wire is also placed in the ground and not in water. If the deviation of the needle is greater, and one believes that one must fear unfortunate consequences, it is well to remove the gutta-percha wire from the barrel, gradually unwinding, while the circuit is in activity. You watch the electrometer very closely, because just as the damaged area is highlighted from the water, the circuit will have disappeared; one now examines the last highlighted piece, repairs the damaged area, and checks whether it has been successful by lowering it again. - This procedure is, as you can see, very simple and cannot be missed.

However, the greatest possible care must be taken when sinking into the ground, so that no damage occurs, and therefore a safe person must be present, as the workers are seldom to be trusted. If it is placed in tubes, they must be wide enough and the edges not sharp, so that no scraping occurs when they are pulled through. The places where the wire is assembled and soldered require careful wrapping with gutta-percha. The best way to obtain this is to cut gutta-percha into strips, heat them over a coal fire and immediately wind them around the bare area and then gently brush up and down the gutta-percha lengthwise with a moderately hot (not red-hot) soldering iron, pressing and stroking in between with wet fingers. A further test as to whether the wrapping has been successful cannot be done well, so it is better to do too much than too little in this work in order to be on the safe side. In towns, where the wires must necessarily be placed in tubes, it is well to let the tubes rise doubly from the depths in many but suitable places, e.g., at corners of walls, and to surround them with closable boxes. The ends protruding from the tubes are then connected by means of forced screws, so that they can be easily taken apart, and tests can be carried out in the event of any discharges; the same happened with lines on railways, and where otherwise underground cables occurred, in order to be relieved of the costly and time-consuming excavations in the event of a disturbance. From experience, I can only advise against setting up connection points in the ground by means of siphons, because it is precisely these that attract the water, since they can never be closed so tightly that it would not find its way somewhere, and the repairs then never end.

If, however, leads do occur, the easiest way to find them is to take apart the wires in the above-mentioned precaution, and leave the ends free in the air, but then check with the electrometer in the station office to see if there is movement on the needle when the key is opened and closed. If this is the case, continue the experiments backwards, towards the station, and remember the last checked spot. If there is no movement, the damage is between this and the last place, and must be checked there. - But I interrupt the telegraphic work only insignificantly during such repairs. Until a stretch is dug up, I tie the wires again, then open the circuit and have some tube ends pulled off, place the wires on stones or hold them freely in the air, and then look at the electrometer again; if there is no more movement, the damaged area is overcome, and must be repaired from there to the junction.

For longer distances, of course, one must be careful of other means, the taste is deceitful in the case of partial derivations, and is sufficient only in the case of real interruptions or total derivations; one must therefore take an electrometer with one on the journey, which is adjusted according to the one available at the station in question, one now makes a short circuit at any point in the line, switches on the electrometer on the side of the suffering station, and recognizes by the degrees which are shown whether the force of the battery there passes through, or else on the distance up to that point, returns to the station in whole or in part, since then there will be no or only a slight influence on this side. - If the position is completely or almost as at the station, then one has not yet passed the place where the derivation is available and therefore continues to search. But it is impossible to explain everything theoretically; Experience and reflection must do the best, for this part of electro-magnetic telegraphy is the most difficult and sublime of all. Calm, patience and reflection are indispensable, one must not want to rush anything, otherwise one will often spend time and effort in vain.

Where two wires meet at the entrance to a station, namely once leading in and once out, as is indispensable at all intermediate stations, even on account of the earth's plates, one must immediately think of contact with the wires in the event of obstacles or even complete exclusion, and the whole line, insofar as it is doubled, must be carefully checked to see whether contact also occurs. It is similar with the short circuits at the intermediate stations. The telegraphist, however, must know exactly the connection of the line at his station, and does well to make a drawing of it and always have it at hand, in order to probed and correct the errors in case of disturbances. -- But in general -- I repeat, every telegraph operator must have the spirit of the whole thing if the telegraphic work is to go well together.

About the influences of telluric electricity, especially during thunderstorms.

Next to the derivatives, the influences of terrestrial and atmospheric electricity are periodically the greatest adversaries of electro-magnetic telegraphy, and thunderstorms are not the only ones to be reckoned here; although it cannot be denied that these are by far the most dangerous due to their destructive power, since they like to follow the lines above the ground as soon as they have been struck by a lightning bolt to the station premises, unless their way is blocked early enough. The assertion of some ignoramuses, however, that the wire attracts lightning, is based on a complete misunderstanding of the laws of nature. The positive and negative polarities, represented by the thunder-cloud on the one hand, and the earth-body (properly of the well-conducting water) on the other, seek a union, just as the electricity flowing from one pole of the battery seeks the other, and indeed this from the thunder-cloud vertically, and then at the same time helically. As soon as the tension of the electricity in the cloud has reached such a degree of intensity (inner strength) through the natural process still unknown to us, that it can force an equilibrium with the earth, it descends, and indeed by the next way, and for that very reason vertically. If an obvious medium is offered to it in this very way, then it is seized, especially because it is poured over by the heavy downpours usually associated with thunderstorms, and consequently by a conductive body, and following it the way to earth is sought. Hence the so-called hammering into towering objects, but also the manifold non-hammering into such, but directly into the water or the damp earth. But these are always the real thing sought, and a lightning bolt that has once found the earth is harmless, because the whole earth with its waters is a good conductor. But since the electricity of the cloud is only desirous of a good conductor, as already remarked, and in so far as such a conductor is nearer than the earth, it must theoretically be admitted that a lightning bolt whose mother-cloud at the moment of equalization, for example, from a tower 100 feet high, measured vertically, stands out at an angle of less than 100 feet, can be attracted by the lightning rod of the tower, so that it descends on it. But it is very easy to notice how much leeway is given to chance that it does not happen. - The probability of a wire running only 20 to 23 feet above the earth is therefore much lower; for, on the one hand, at the moment of impact, the cloud must have a distance angle of less than 20 to

23 feet, and on the other hand, once the lightning has come so close to the earth, it also easily attracts it down the rest of the way, especially as a body as small a large body as the wire offers it little surface. It is therefore always noticed that the lightning does not strike the wire directly, but first a pole, which is usually dripping with pouring rain, and jumps from this to the conductive wire, and then runs on until it weakens on its way, draining something into the earth at each pole, or seeks and finds some opportunity. to escape completely into the earth on a good metal conductor.

There are now two kinds of danger here. In the first place, that he melts the wire on which he travels by his incandescent heat, and this happens when the wire has so little body, is so thin, that the heat can overwhelm it. A strong wire, such as ours, of nearly 1/4" diameter, resists melting by lightning, as was most evidently tested in one of the most terrible thunderstorms, where a single blow split 40 of our piles, and ran eight miles to the east, and more than five miles to the west of the explosion. If one does not want to attach a lightning rod to every pole - and that would be a little too much to ask - then one has only to protect the station, and I think that this should be done in a double way; once in order to divert the lightning from the station when it reaches it, and then again to give the stations a means of being able to sit outside the room at once, except Connection, with the line along which the lightning travels. As far as the former is concerned, various suggestions have been made for this purpose, including from Professor Steinheil, and indeed against me personally in the following way: "Take it, he told me - two round copper plates of about 7 to 8" diameter; cover one of them with insulating silk, in such a way that it is folded over at the edge and glued tightly, so that no mutual contact of the naked copper of the two plates can take place between each other. Then the other plate is placed on this silk cloth; at the outer center of each plate a strong wire soldered crosswise in order to connect both with the main line, to be able to switch them on, as it were, and on the other hand, two very fine copper wires are soldered to the outer sides of the plates, close to the edge, in order to lead them in and out of the station premises in their extension or extension, as it were as a loop. Then everything is placed in a watertight lockable box, the wires are led out through suitably placed holes, and the whole is fastened to the outside of the building, or on a pole near it. If the lightning now travels along the line and reaches the station building, it follows the quantitatively most presented wire, which passes through the silk cloth, and goes its way along the line, disdaining to follow the wire, which contains only a very small body, into the station premises, while the electro-galvanic fluid does not penetrate the insulating silk, but naturally follows the wire, no matter how fine, and performs its function on the telegraphic apparatus." In this respect, however, this device had the theoretical appearance in its favor, and I therefore did not hesitate to attach a device of the kind described above to the station building in Cuxhaven, and with all possible caution, especially with regard to the box, which was built strongly, firmly and densely of mahogany wood. As long as it was summer and dry weather, things went on quite splendidly. But as soon as autumn came with its damp fogs, difficulties in telegraphing gradually appeared, which I did not know how to interpret at first; but one fine morning our station at Cuxhaven had completely disappeared from the ranks of the living, and it was only now that I had an inkling of what might have happened to us, and therefore I hurried there in the first steamboat. In examining the present conditions, I immediately found the existence of an enormously strong circuit; i.e., a fabulously strong force, from which I immediately concluded that all the electromagnetic fluid produced by the battery remained in the room, and nothing went out to the outer line. In order to prove this to the telegraph operators who doubted it, I cut the line outside the balcony straight through, without the slightest change being seen inside. Then I reconnected the line, switched off Steinheil's lightning rod, and from that hour on the line was in perfect order. An investigation carried out on the said lightning rod showed that the silk had attracted moisture, and that this had taken over the conduction of the force, so that the Cuxhaven station worked on its own power, on its peculiar local circuit of the battery, from pole to pole; but the force emanating from the Hamburg station had gone into the ground from the box of the lightning rod near the station.

One might perhaps object to me here that the silk need only be impregnated with some fat, with gum or resin, to prevent this; but I think that there are many objections to the whole arrangement, if only because in order to reach the second plate, the lightning would have to strike through the insulator and destroy it, which would then result in a repair each time, which is why I preferred to take another precaution, constructed according to the same principle. I have two brass square plates, about 8" long and 4" wide, connected by four pieces, 3 to 4" long, turned wooden sticks, by means of fastening by screws, at four corners of each plate, so that the whole resembles a little box open on all sides. In the middle of these plates are two bell-like brass mounds, soldered in such a way that the concave sides are turned towards each other. The other surfaces are covered with hackle-shaped points that are turned towards each other from both inner sides of the plates at about half-inch intervals. Finally, in the center of the outside of each plate there is a button with holes for inserting the main wire and a screw for clamping it. The fine wires entering the station are then soldered somewhere at the outermost edge of each plate, or inserted through a hole drilled there and tightened. The course of the thunderstorm beam is then exactly like Steinheil's precaution. He makes use of the opportunity offered to him by natural law to jump from peak to peak and from bell to bell, between which there is only an air space of a few lines, which of course present no obstacle, while the electro-galvanic current must necessarily make the detour through the station premises in order to go back to the second plate and so on into the distance. and to reach the earth's plate at the terminus. This kind of lightning rod was installed at all our stations, with the exception of the one in Hamburg, where it is not necessary, as the line has to go a distance of 2400' under the ground and through 13 siphons, whereby a possible lightning beam is sufficiently opportunity to escape into the earth. Since, however, the apparatus is sensitive to every, even the slightest influence of electricity, and the electrometers in particular suffer as a result, I have, as already mentioned, added a provision for shutting off to every station, including the one in Hamburg. - The setup is - according to my information ready= tied, very simple as follows:

On a strong, solid board about 6" long and 4" wide, I had brass screws with strong, elongated round heads screwed into the four angles, in the shaft, above the thread, a small hole drilled for the passage of the wire, and were now cut (after both wires, which had been brought in as a loop from the outside, in the region of the table, or wherever else the apparatus is considered suitable for attaching, and thus four ends have been created) - the wire end leading in and out again from the outside, but on to the two upper screws of the board the two leading to the apparatus and on to the battery, fixed in the two lower ones. The line would now of course be separated and interrupted. Further, however, on the two upper screws, on each of the heads mentioned, a double hook is attached, made in the form of an anchor by means of a hanger, which has exactly the length that one inner hook hits the head of one of the lower screws when knocked down and can be sunk into a hole screwed in there to a suitable extent. On the leg of these lower screw heads is then attached a small perpendicular force-screw, in order to prevent the hooks from jumping out of their cavities by screwing them on. In this position of the hooks, the chain is closed. At the top, at exactly the same distance as the lower screws are from the upper ones, a fifth screw is set into the board in the middle, which has been provided with two eyes at the head, so that the other two anchor points of the double hooks can fit exactly into the same and be pressed tightly when swinging around up to 3/4 of the bow. If this happens, the station where it happens is excluded, the line is shortened, but not interrupted. By turning the hooks again after the lower screws, the station can be switched on again at any moment. When, for example, a report arrives from any station that a thunderstorm is approaching somewhere, or it is noticed from the conduct of the electrometer that telluric or atmospheric electricity exerts a disturbing influence on the apparatus, the station (and as a rule all stations) excludes itself, after it has been notified, if possible, to the other stations. and is now doubly protected against the harmful effects of electricity.

These combined precautions have now rendered us the most essential services, especially with regard to the dangerous atmospheric influences of thunderstorms, and not infrequently have been worked out in the consciousness of safety even in full thunderstorms. - However= it is somewhat difficult under such conditions, since every discharge of the thunderstorm, even if the lightning does not touch the line at all, has a disturbing effect on the normal course of the telegraph by making irregular movements. This, however, is only momentary; you calmly write the unfortunate word again and continue working. The receiver, of course, has his dear need, and must have his hand constantly on the relay; but it is precisely this friend in distress that leads over many things and does not so easily abandon the practiced.

Underground lines naturally suffer much less from the direct influences of atmospheric thunderstorms; nevertheless, by virtue of the connection between the atmosphere and the earth, in which the plates are sunk, they are not free from the disturbing effects of the latter. These, however, as a rule, resemble only those from which the telegraph, which is carried on poles, has to suffer at times even in winter, namely, from the subterranean thunderstorms. - These manifest themselves in very different ways; but as a rule by a force not infrequently increased to the point of tremendous, so that it often seems as if the batteries were amplified up to twenty times. - At other times, however, the force disappears again so completely that one would think that the line has been broken. I will come back to this later. We have observed the former phenomenon especially in winter at the beginning of a snowstorm, and there is nothing to be done about it, given its considerable intensity, than to wait calmly for the course of the event, and during this time to separate the apparatus from the conduit by means of a shut-off, because every violent alien force is detrimental to them.

VII.

Treatment of the apparatus.

I now pass on to the chapter on the small movements of the stationaires (telegraphists) necessary for the encounter of disturbing influences, and this is undoubtedly one of the most important sections of this textbook, since no constant telegraphy can be thought of without the correct judgment of the causes, and equally the correct application of the necessary antidotes. - Although it is now almost impossible to foresee all the cases of disturbance that lie within the realm of possibility, as can occur in such a mysterious and complex work, and perhaps for many years new such phenomena may still appear, and new experiences may always have to be collected, I may nevertheless assert, without being immodest, that we, precisely because of the difficult terrain, and the novelty of the matter, I have gone through a good school in this respect, and have learned many things through necessity and reflection to overcome the difficulties, so that I am in a position to be able to give many useful hints on this subject.

I repeat here first of all that it is absolutely necessary to make every telegraphist thoroughly familiar with the principles of electromagnetic telegraphy in all its aspects. He must not only know *that* something is so, but also *why* it is so, and why it must be so. A mere writing-automaton will never be a capable telegraphist; and learning the letters alone, even if accomplished to perfection, by no means produces a competent operator—although a skilled calligrapher (for in telegraphic writing there is calligraphy just as in any other form of writing) has a considerable advantage from the outset.

It is therefore necessary to lay a sound foundation for this even in the very first lessons, and one must therefore choose as instructors only such officials as are themselves able to perform competently, and who also know how and why they do it in the particular manner they do;

Conversely, students should be selected who already write well with a pen, and above all, before they are placed at a machine, they must know the telegraphic alphabet perfectly, for any pausing to think while producing a letter can and must not be allowed.

The first requirement at the beginning of instruction—just as when a child first takes up a pen—is that the two forefingers and the thumb should not be bent, but rest extended in a supple position upon the key's knob.

The knob, therefore, should not, as some mechanics have done, be made in the shape of a melon—long and tall, butt should have the form of a smooth surface, rounded at the top edges, and preferably made of ivory.

The three working fingers must not grasp this knob tightly or clutch it anxiously, but rest upon it with the arm extended and moving freely.

The second requirement is to make the pupil aware that the hand must not be held stiffly; rather, skill depends chiefly on the wrist, which during writing must be kept in continuous supple motion.

For each dash, the forearm sinks slightly, and in making dots should rise again. This produces an elastic touch, the opposite of which is a stiff pressing or squeezing key lever, which results only in illegible and uneven writing.

The so-called "firm execution"—where each character is distinct and well-spaced on the paper strip — is achieved only in the former manner.

Now since nearly every pupil, as experience shows, willingly becomes accustomed to pressing with bent fingers and later has difficulty weaning off it, one must from the very first lessons insist seriously on preventing this objectionable habit from arising.

Another important requirement is correct timing: that is, striking and releasing the key in rhythm, so that the proportion between dots, dashes, and spaces is exactly maintained, producing writing that is easy to read at the receiving station. This requirement should first be made as clear as possible to the pupil, and from the outset the practice should be governed by the exact rules on which it is based.

As a general standard, the dots—regarded as the basis of rhythmic movement—should be made in their normal sequence like the ticks of a small pocket-watch, when they are used as parts of the same letter. Each dash may be given the duration of two, or even three, dots; thus, when making a dash, the key should remain closed for as long as it takes to make two or three dots

The space between two letters should be at least equal to the time (or rather the space) of a dot; the space between two words should be the length of a dash.

Paragraphs of writing are marked by a long series of dots; likewise an error, where one must strike out what was last written, is indicated by a series of dots—i.e., at least more than six in number.

Should a pupil happen to have a grasp of music, one may compare the dots to quarter notes, dashes to half notes, the space between two letters to a quarter rest, the space between words to a half rest.

The space between two dots, or between a dot and a dash, or between two dashes, is formed properly by the opening and closing of the key, and—with correct, not sluggish movement of the clockwork—it is impossible to make dots so quickly that no spaces appear between each element and the next.

At times of interference and also over very long distances, it is necessary to write quite slowly, firmly, and with clear expression.

A common fault among pupils is a trembling, poorly accented striking of several dots in succession; or a too-light striking of dots, especially a single dot or a pair of dots before a dash, such that they are as good as swallowed. Learners also tend to leave too large a gap between a dash and the following dots, particularly in certain letters (such as D); or too large a gap between two separate dashes; or to hold the last dot in a letter too long. The instructor must watch for these bad habits from the very beginning and work to eradicate them before they become fixed.

In general, it is necessary to strike the elementary signs calmly and firmly one after another; the key must be firmly closed with each stroke and here the aforementioned so-called supple manipulation is useful.

With imperfect, only light touching of the platinum contacts on the key, the signs—especially the dots—transfer incompletely, or indeed not at all, and the writing naturally becomes illegible as a result.

Altogether, however, composure, reflection, and patience are estimable and nearly indispensable qualities for a telegraphist. Impatience, haste, discouragement, and especially forcing the work when difficulties arise, only make the trouble worse.

As soon as the ability to write correctly and neatly (beautifully) has been acquired, and young literate people learn this in four or six weeks with diligence and good instruction, it becomes necessary to consider the proper setting up of the apparatus and the adjustment of its individual parts. However, only approximate, not universally applicable, rules can be given in advance.

First of all, care must be taken that the tip of the pen on the pen strikes exactly into the middle of the groove on the roller, and that the axis of the pen has only a very small margin of movement. which is usually to be arranged by the front screw (x), which, however, must be touched with every precipitation because of the necessary loud stroke. -- The lower screw (z) behind the axle on the left is then to be placed in such a way that the pen deposits only moderately, so that the pen moves only a maximum of 16" away from the paper with each movement, otherwise the time required for knocking down would naturally be greater than the interval between two strokes of the key, and thus the signs would not have time to express themselves legibly. - As far as the actual mediator of writing, the writing pen, is concerned, it must be placed in such a way that it does not completely reach the base of the groove or notch in the roller around which the paper turns, but remains a very little away from it. The tension of the spiral spring on the front column must be adjusted according to the strength of the Local Battery. If this is weak, the spring is tensioned a little, so that the magnetism does not have to overcome too great resistance. At the same time, it is to be seen that the paper roller lies in a linear direction with the roller; if the paper does not run fast enough when the paper stock on the roll runs out, for the sake of reduced turnover, one must never try to help by tightening the paper strip with the left hand, but this sleeve must be done by means of the key on the clockwork, with which the weight is winded up, otherwise the paper will easily run crooked. Setting up the relay is very simple. If one has given the axes on the spring holder the appropriate, but never to be exaggerated, leeway, and the two points of contact (platina) the appropriate mutual position, then one has only to see that the space between the two points of contact is no greater than that a fine sheet of writing paper can be pushed closely between them. as a regulator, to obtain the appropriate length, strength, and tension, whereby it can only be indicated in general that it is well to choose a low battery force, and to choose springs correspondingly weak, which, when tensioned, i.e., when the armature is pulled away from the armatures, occupy about 34 of the space between the two attachment points, so that in case of abnormalities of force development in the multipliers, there is hardly enough time for further tension. If, furthermore, the armature has also been given such a position over the magnet that the space between the two can be filled exactly with a sheet of fine post-paper, then everything that needs to be done has been done for the normal state, and we now pass on to the abnormal (sickly) state, and will go through the most common obstacles and their encounter in turn.

First of all, of course, one tries to see if everything is in proper condition by writing on one's own apparatus, and until it writes while it is working, one cannot expect it to write from outside. - Nevertheless, one must not expect this to always be true, and especially in stormy weather and rain it can very easily happen that one has to strain the pen on the relay, if it is to write from the outside, much more than when writing oneself; indeed, even in the case of the various outstations, the force and tension to be regulated according to it sometimes differs quite considerably. The following unpleasant phenomena now occur in particular:

One notices, for example, that the needle on the electrometer moves, from which one concludes that someone must be working from without, but nevertheless, no writing comes to light, no writing comes to light, and here one usually has to infer earth or atmospheric electricity playing its game, and there is nothing to be done. than to wait patiently until these influences have disappeared.

As soon as the dots are absent in the writing to be received, and only the lines appear, but in the place of the dots spaces arise with slight hints of dots, this may arise from various causes. The first and most common is to be sought from outside in a work that is too easy and imperfect, but of which we have already given hints, and if, on the other hand, we get legible writing from other stations, and a lowering of the spiral spring on the relay and even that of the writing apparatus does not help, we are entitled to interrupt the writer and remind him to work more firmly. But if this is not the case, the first thing to think of is a local battery that is too weak, for a clear expression of the signs depends on its normal strength. One can then temporarily slacken the spiral spring on the writing apparatus a little, but afterwards one must examine the battery, and then as a rule finds that the copper sulfate solution is exhausted and the water is almost clear, and one then does well to renew it. However, it can also be the case in other ways. that the pen on the pen holder has gradually receded due to the incessant shaking while working, or that the axis of one or both pens (namely, the writing apparatus and the relay) are clamped too tightly. - Furthermore: that the fitting protrudes too far from the magnets, so that they cannot exert the appropriate attraction; or the adjusting screws in front of and behind the axles of the large pen holder do not have the normal position, so that the pen does not have the proper leeway to strike up and down; All conceivable cases, one of which alone or several together, can produce the aforementioned obstacle. Indeed, it is even conceivable that dirt (dust) has settled between the various points of contact, both on the key and at the points of contact of the platinum pins on the relay, and that the normal connection is thereby impaired, which is why it is the rule everywhere to give both points of contact a file stroke with a blunt file from time to time; the most common cause, however, is always the too tight tension of the spring on the relay, since, influenced by various influences already mentioned, the force in the line changes easily and often, and therefore requires regulation.

On all the occasions mentioned above, the dashes almost always come more or less distinctly, since the impulse is not so quickly cancelled out as in the case of the dots, and for this very reason it is also customary to have a long series of dots made by some outstation in an effort to eliminate the cause ("make dots", as the Englishman says).

Incidentally, it goes without saying that with every obstacle that occurs, the connections must also be checked, especially at the locking screws, or whether naked wires, especially at the local line, touch each other. If, in addition to the dots, even the dashes are omitted, then one or the other, or more of the above-mentioned causes, must be combined and regarded to an increased extent as a cause, and then appropriate measures must be taken against them.

But it is a much more alarming phenomenon when the dots are absent, and instead of them irregular long and short lines appear on the paper in confusion, so that there can be no question of understanding this phenomenon, in its slightest and most harmless appearance, is due to too little tension either on the hairspring on the relay or, however, what is rarer on the writing apparatus; or also in the free movement of the pens inhibited by pinching. Worse and more persistent causes are to be sought in momentary deductions of the above-mentioned kind on the outer line, and indeed the closer the worse - and to ward off such influences from the station location requires special caution. - What can be done against this, in particular, is to move the valve on the relay a little further away from the magnets, so that the force of attraction increased by a close conductor (for a distant one does not have an amplifying effect on the relay) is weakened by such a distance. In addition, one has to keep a close eye on the electrometer, and to constantly correct the hairspring on the relay as needed, and especially to keep it at the maximum of tension, so that the magnets can only just manage it. There may be cases where even this does not help, because the dissipation has reached too high a degree, and one must try to help by reducing the size of the battery, i.e. weakening it. - By the way, one must also always have stronger than the usual feathers in readiness.

Moreover, even without conduction, there are cases where the force of the line is so increased by telluric influences that all but one or two elements must be excluded, but it is not necessary to take the battery apart on this account, but only the two ends of an arc-like curved copper wire are inserted from the inside of the zinc part of one, passes over to the interior of the copper part of the other element, and thus skips over a few or more elements according to your will and need, until you have found out the required degree of force that you need. - Touching the magnets and the armature too closely or formally can also cause marks, as can joining the platinum pins too closely on the relay, leaving no room for the upper pin to strike; all things that can surprise and upset the beginner. In rainy and foggy, generally damp weather, it is usually a good idea to enlarge the space between the above-mentioned points of contact on the relay a little, whereas in dry weather, especially in frost, it is almost impossible to place it close enough, so that one can hardly perceive a movement of the pen holder while working, even by paying close attention.

0In cases where there is no agreement as to whether there is a real interruption or only a discharge at the line; in the same way, if one fears that perhaps the poles of the foreign battery may be confused, one would do well to try to remove one's own battery altogether and work alone with the external one. *) If the line is really broken, then of course there can be no circuit at all; but if the apparatus then strikes even at the slightest voltage of the relay spring, this can only be the effect of the external battery, and there is no question of a real interruption. For if the line is really broken, and the battery on this side is removed, it is impossible for a circuit to exist, and without a circuit one can again produce no magnetism, and consequently no attack can be achieved. Even a confusion of the poles outside can no longer cause any disturbance in such a complete elimination of the battery (whereby the loosened wires must of course be reconnected), since the position of the poles is in itself quite indifferent, and must only be in harmony with a second battery. - The manifestation of the force is then of course very diminished and small, and this will be noticed in the necessary tensioning of the relay spring; but the acceptance was only an experiment, and as soon as you have learned what you wanted to know, you can put the battery back on.

> *) Of course, this can only be said to be the case if everything is done according to the regulations given in this textbook, and not, for example, as is done on the Prussian telegraph lines, where only one battery is used at all times. However, it is unmistakably useful if you work on both batteries at the same time, and can therefore also write on your own strip of paper. I only mention, for example, that when giving away numbers and ciphers, one only has to let the paper run in order to save the annoying retrieval and collation, which requires a great deal of time and effort. It is only necessary afterwards to compare the manuscript with the writing on the strip of paper, in order to be immediately convinced of the correctness or of any errors.

Less important obstacles are, for example, that the paper does not want to slip through the rollers; the reason for this is to be found in the side springs (13, 16) which press the upper roller. If the oval adjusting screw cannot provide a remedy in the manner previously mentioned, then for the time being some body must be inserted between the tail of the spring and the screw, which raises the former more and thus presses the spring more firmly against the pivot of the roller, but later has a stronger spring made. - If the rollers do not want to turn, the spring presses too strongly, and must be moderated by changing the position of the oval side screw. If the pen makes holes in the paper or refuses to make a long line, it is too long and must be brushed back a little.

Should it happen that all attempts fail and one cannot write, then for such cases a good writing apparatus, but preferably also a second relay, must be at hand, in order to change one or the other, according to the circumstances, especially the relay, which is the cause of the obstacle; it would be possible, for example, that any of the fine wires in the multiplicators would have broken, especially where they end under the forced screws on both sides, which will have to be investigated later.

A phenomenon which is very surprising, especially to the beginner, is the reversal of the poles at the relay by means of telluric or atmospheric electricity, which is immediately manifested by the fact that the writing apparatus strikes down when the key is opened, and when it is closed again, thus doing exactly the opposite of what it does. There is no other remedy against this reversal of the poles than to change either the poles on the battery or the wires on the relay. Now since the former would have to be too cumbersome, and moreover would also have to be done in accordance with the other terminus, the latter is much more advisable. However, since this reversal, according to my experience, often occurs five or six times in a few hours, I have invented a very simple precaution in order to avoid the somewhat cumbersome alternation of the wires by unscrewing and fastening them again, by means of which one can only use a lathe made of ivory, and covered with brass plates at both extreme lower ends, similar to Fig. 10, in order to change the wires at the moment. Since, however, this matter is not insignificant, and anyone who considers something similar necessary can and will easily invent a provision for this purpose, I will not go into further detail about it here.

With regard to the relay, it may only be mentioned recently that much depends on a correct tension of the spiral spring on it, not only in the case of difficulties to be overcome, but also in quite ordinary times, since the stroke (call) from outside will never be heard if the tension is insufficient. But since the force in the line varies almost continually through external influences, the needle of a good electrometer will indeed give the eye noticeable signs that something is going on with every movement, with every call from without, but not the pen on the writing apparatus; for if, for example, the spring on the relay is too weakly tensioned in relation to the force in the line, the valve remains stationary even if the line is interrupted and nothing is heard. Now, however, the spring itself may become weaker, as well as the force in the line, so that even when the key is opened, a minimum of it remains in the thighs; or, what is still more likely, by momentary dissipation (secondary closure) between the dispenser and the receiver, leaves a small circle for the latter, so that the fitting, if the spring is comparatively too little tensioned, does not deflect, however often and often it is called from outside. To prevent this evil, the station-operator must step up to the apparatus quite often, observe the electrometer, and adjust the spring on the relay. The latter is most conveniently done by tightening the spring on the relay until the valve pops off the magnets, and then immediately weakening it again to such an extent that it closes again; then gives way a very little bit and then leaves it as it is. - In such a position, almost to the extreme point of tension, with every movement from outside the valve will at least spring open, even if not close again, and a sign of attention is then at least given; one looks and also gives the station signal on this side out into the distance at random, which, in the event of a call being made, will result in something further. This procedure is especially recommended in times of distress and in rainy and stormy weather. Of course, cases can also occur, and they very often occur, where the force emanating from the battery is completely withdrawn and weakened by telluric action, so that the force of the magnet is no longer equal to the relay spring; then both fittings spring open, and you have to tension down the spring. However, it can be seen immediately on the electrometer whether the effect is due to the influence of a station or to telluric influences.

The obstacles mentioned here will include just about everything that usually occurs in the ordinary, but also in some unusual course of events. This is not to say, however, that unforeseen defects cannot occur in practice, which the telegraphist, if he has penetrated into the spirit of telegraphy, will know how to find and remedy for himself by a business-savvy consideration of cause and effect.

I will only mention recently that the electrometer can also suffer a loss of its effectiveness through the action of telluric electricity, so that it appears sluggish in its movements. The cause of this is usually to be sought in the weakening of the magnetic needles, which can be strengthened again by brushing them again (from the center to the tip) on a steel magnet, or, in failing that, only on the magnets of the writing apparatus with the chain closed. One would do well, however, to stroke only one side of the needle, which is usually blue, and the apparatus will soon resume its function. It has already been mentioned that the needles, which are hung by a hair, are all too unstable and swaying for telegraphic purposes, and almost never come to rest, whereas the axles resting in conically drilled metal bushings indicate just as surely, and have much more steadiness than the former.

What I have to say about the alphabet may be taken by the reader from the following essays, which I have already published elsewhere.

About the written language

of electro-magnetic telegraphy according to Morse's system.

In view of the great and general interest which electro-magnetic telegraphy, after its present introduction into practical life, also finds among the great public, it may not be inappropriate to give some more detailed data on the very next practical results of it, the alphabet, for which in particular a report in the March issue (1850) of Dingler's Politechn. Journals of the alphabets known up to that time, in that the conclusions which Mr. Steinheil draws from it, as if the alphabet proposed by him, on account of the small need for elementary signs, which is by far more expedient, is entirely based on error, as I shall demonstrate with the most concise proofs, as I shall show as close to it. Professor Steinheil, in addition to his own and the one now, as far as I know, adopted everywhere at the same time as Morse's system, designed by the undersigned, and further introduced first here and then by Mr. Robinson, also gives the older Morse alphabet, which was rejected by me at the very beginning for the reason that, apart from the individual elements of the letters, even within these the empty spaces (spatia) have multiple validity, and thus want to be observed as a third element, as it were, next to the dots and dashes, as can be seen in the alphabet of c, o, r, y, z and the & following, which must of course make the art of telegraphic writing extremely difficult, and at the same time can give rise to dangerous errors.

I may, therefore, omit this alphabet here, as it is out of the question; for the sake of completeness, however, I prefer to follow Professor Steinheil's communication here almost literally. - Only a few inaccuracies in the aggregation and other errors have been corrected, including that which exists in our alphabet, and certainly more than Steinheil's sch or Morse's & necessary? added; especially since Morse's &, according to the length of time, consists of 5, but our et consists of only 3 elements.

Gerke.		Steinheil.		Morse.	
Dreierlei Zeichen.		Zweierlei Zeichen.		Viererlei Zeichen.	
1	. — — .	1	. — — —	1	. — — .
2	. . — . .	2	— . — —	2	. . — . .
3	. . . — .	3	— — . —	3	. . . — .
4	. . . . —	4	— — — .	4	. . . . —
5	— — —	5	— . .	5	— — —
6	. . . . . .	6	— . . .	6	. . . . . .
7	— — . .	7	. — . .	7	— — . .
8	—	8	. . — .	8	— . . . .
9	— . . —	9	. . . —	9	— . . —
0	———	0	— — —	0	———
A	. —	A	— . —	A	. —
Ä	. — . —	Ä		Ä	
B	— . . .	B	— . . —	B	— . . .
C	— . — . .	C	— — .	C	. . .
D	— . .	D	— .	D	— . .
E	.	E	—	E	.
F	. . — .	F	— . .	F	. — .
G	— — .	G	. . —	G	— — .
H	. . . .	H	. —	H	. . . .
J	. .	J	.	J	. .
K	— . —	K	— — .	K	— . —
L	. — . .	L	. — —	L	———
M	— —	M	. . .	M	— —
N	— .	N	. .	N	— .
O	. — . . .	O	— — —	O	. .
Ö	. —	Ö		Ö	
P	. . . . .	P	. — — .	P	. . . . .
Q	— — . —	Q	— — .	Q	. . — .
R	. — .	R	— —	R	. . .
S	. . .	S	— — . .	S	. . .
T	—	T	— .	T	—
U	. . —	U	. — .	U	. . —
Ü	. . — —	Ü		Ü	
V	. . . —	V	— . .	V	. . . —
W	. — —	W	. — . —	W	. — —
X	. . — . . .	X		X	. — . .
Y	— — . . .	Y		Y	. . . .
Z	. — — . .	Z	. . — —	Z	. . . .
Ch	— . — . .	Ch	. . . .	Ch	
?	. . . — . .	Sch	— — — —	&	. . . .
	152		111		119

At first glance, however, Steinheil's alphabet seems to deserve preference, since it requires only 111 elementary signs, while ours requires 152. We shall presently see, however, that this advantage is only an entirely apparent one.

The advantage of one alphabet over another is to be measured—besides by certainty of comprehension—only according to the greatest possible saving of time to be used in telegraphing the same. And therefore, during the initial conception of ours, alongside the setting forth of all possible combinations of 2, 3, 4, and 5 elements, I first determined which letters, in a text, are used most frequently on average—which one learns best from experienced and practiced typesetters—and according to this finding, I then used for those occurring most often the simplest number of elements.

Now, with the tendency toward time-saving, it is not only a matter of the number of elements to be used, but also—and indeed particularly—of the duration of time needed to form each individual one of them when telegraphing; and it thus becomes immediately evident that much more time is needed for a dash than for a dot. It is, in fact, a rule that the duration of one dash is to be reckoned as equal to that of two dots, and in practice it is common to take somewhat more. It was therefore necessary, in designing the alphabet, to pay particular attention to employing dots and reducing dashes—a point which Professor Steinheil evidently did not consider at all, and for which reason his design proves to be thoroughly misleading.

If we now undertake the effort of sorting the elements in both alphabets by their kind, we find that our alphabet—counting zero as two dashes—consists of 52 dashes and 101 dots, whereas Steinheil's consists of 57 dashes and 54 dots.

If, as I have said, two points are calculated on a line, the former contains a time period of 205 points, the latter of 168 points.

Now it must also be taken into account that Steinheil's alphabet lacks the letters ä, ö, ü, x and y, which are included in ours, together make 8 strokes and 17 points, or a period of 33 points; therefore remain, these are accounted for by our alphabet 172, while Steinheil's contains 168.

If the alleged advantage of Steinheil's alphabet is almost eliminated by this proof, then finally another, and indeed much more alarming, circumstance comes into consideration. A close examination of his alphabet reveals four different combinations of elementary signs, each of which has a double or triple meaning; namely — — · means at the same time c, k and q in Steinheil; — · d and t; — · · f, v and 5; — — — o and the zero. Although it has not even exhausted all the possibilities of the combinations of four elementary signs, but has left — · — · (our c), for example, unused, this identity nevertheless arises solely from the fact that Mr. Steinheil took it upon himself not to include more than four elements in one and the same letter, without considering that the saving of time would certainly not depend on the number, but depends on the genre of elementary signs; and so, for example, his 1, 3, and 4 contain every 7 in terms of duration, and the sch even 8 elements (namely, divided into points), while he carefully avoided using 5 points, for example, our p, consequently his calculation was entirely based on deception.

But now, in relation to a criticism of both different alphabets, it is necessary to take into account the necessity of using the fifth element (but only the dot, not a line) for the 6 more letters created on this side by avoiding Steinheil's identity, whereby the total number of elements in our alphabet would then have to be increased again. so that to calculate 34 elementary signs in our favor, divided into points, and thus our advantage (i.e. in terms of time savings), if we had also applied Steinheil's identity. But how impractical the latter is in telegraphic work, and can even be dangerous, is easily shown when one considers that in the case of the proper names that occur so often, in dispatches and ship reports, it is by no means possible to guess from the context which letter was meant by the sender, and could, for example, be inferred from a report addressed to Karl Schmitt. the receiving telegraph clerk, who worked according to Steinheil's alphabet, could just as well write Carl Schmidt, or an address could be posted as Fogel and written out as a bird, and the dispatch could thus very easily fall into unauthorized hands.

But even in the ordinary text dangerous errors could arise from this. Who does not remember, for example, the well-known anecdote where a regimental commander ordered two forage cutters from the next town, and was sent two Fuder tailors on account of his bad orthography, which could also easily happen because of the Steinheil identity of t and d.

In practice, moreover, cases occur as complicated as the imagination can conceive; and what is gained everywhere with this so-called simplification? Basically, nothing at all; for in the overall application, Steinheil's alphabet has, as shown above, no advantage at all with regard to the saving of time, and this is really the only thing that matters. -- Nor are Steinheil's combinations arranged according to the practical experience of the typesetters about the most common use of the letters, whereby in the long run again enormous losses of time arise. For example, I refer only to our **e** (.), a sign that Steinheil has chosen for the **i;** but I ask: which of the two vocals occurs more often: the **e** or the **i**? and for which letter the simplest possible character had to be taken?

Just count both letters on a single page of a book and the answer will surely be in our favor. If, moreover, I were to be strictly just, and assume three dots for each dash, as is done in practice by every good telegraphist, the impracticality of Steinheil's alphabet would become even more striking.

The situation is similar with other propositions of Prof. Steinheil, whose great service to telegraphy is not to be diminished in the slightest. If, however, in the same journal mentioned at the beginning, he proposes to work with two keys, in order to be completely exaggerated by the dashes, since in this way one key would have to make simple colons and the other colons, I am convinced from experience that every increased complication of the telegraph system makes the treatment more difficult and the results more doubtful; as well as the fact that a speed in telegraphing, which is equivalent to ordinary writing with the pen, is as a rule quite sufficient; and where this is not the case, it can only be enforced by the creation of double lines, but not by more artificial and complicated apparatus.

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It may finally be, especially for new telegraph enterprises and their officials, useful to set out the technical terminology and the conventions required for mutual coordination, as we have partly inherited such from America, partly have ourselves developed and adopted in the course of time. There are only a few of these, and therefore no alphabetical arrangement is necessary:

Work – Common expression for telegraphing; thus, for example: “it works poorly today,” i.e., there are difficulties in telegraphing.

Send, hand over, or work away – To telegraph a dispatch to an outside station.

Receive – To write down a dispatch that is being worked in from an outside station.

Let run off – Let the paper tape run off.

Answer – Return the attention signal after a call has been made.

Hear (not hear) – Promptly return the attention signal after a call (or do not return it, hence: “they do not hear!”).

Write (write a bit!) – For telegraphing.

Strike – The dropping of the armature onto the magnets.

Synchronize (it is not synchronized!) – The simultaneous or non-simultaneous striking of the armatures on the relay and the recording apparatus.

Transmit – The transfer of force from the relay to the recording apparatus.

Range – A relay has much range when the **coils** (*Knäule* = wire windings) develop considerable force, so that the spring can be tightened and loosened for a long time without the recording apparatus ceasing to strike.

Tighten – Namely, to tighten the spring on the relay.

Loosen – To relax the spring on the relay.

Work firmly – To press the key hard when working, so that each elementary signal at the receiving station comes out clearly.

Work so – The silver part (*Argentheil* — unclear; possibly “Argentheil” = “argent part,” referring to the silver contact surface or silver-alloy contact in the telegraph key).

Rub – When the relay fails, i.e., when it refuses to strike up and down exactly and instead remains lying, producing dashes on the paper.

Interrupt – To open the key during reception as soon as the writing, or a single part thereof, cannot be read.

J. J. J. (the English “aye, aye, aye,” or rather Y. Y. Y.: “Yes, yes, yes”) – Understood.

R. R. R. (*repeat*) – Not understood! Repeat!

F. F. – Continue (after repetition of the last word understood, and after an interruption has occurred).

G. G. G. – All stations! (To call all stations when there is news of general interest, e.g., political news or important events.)

Furthermore, the following should be noted: Before beginning work, the telegraphist produces a rather long series of dots; and the same is done when the writer becomes aware during the work that an error has been made. After the dots, he then repeats the last correctly given word and continues the text thereafter.

And with this, this item should be pretty much exhausted fine. The following seems to be worth mentioning:

Each station connected to one and the same line is given its letter from the outset as a signal and substitute for the name, which can then be heard at the stop and easily distinguished. Just as a station wants to report something to another specific station, the same is called upon, after a few preceding points, by striking its agreed signal letter several times; e.g. Bremen: B. B. B. B.; to which the telegraphist in B., as already said above, answers ·· ·· ·· ·· —··· —··· —···; whereupon the caller says ·· ·· ··, makes a series of dots and then now begins his dispatch. If the expected answer, i.e., the sign of attention, is not immediately given on the call that has been issued, the call is repeated several times; and after several more unsuccessful attempts, another, usually nearer station, is called, and the requested station is summoned through it. It happens very often that one hears better from one station than from another. If the calling station is an intermediate station, it can also make short circuits (see the article p. 41) under such circumstances. At the end of each dispatch, the working official then gives the number of words to be charged, if it is a paid dispatch, and adds his name and the place of departure. The latter, after duly procured practice, only by means of the first letters. It is not necessary to add the time in the case of short lines, since there is no time between giving away and receiving, and the receiving official may only add the latter to the tender, in order to know the departure. It is different, of course, if the dispatch has to be transmitted to intermediate stations, where an indication of the time of departure must of course not be missing.

As to the other institutions, the laws and tariffs of the telegraphs of different countries differ considerably, and every one may, without prejudice to order, do as he pleases. Now I would like to remark that it is very expedient to introduce at the stations of one and the same line, that from time to time, at least every quarter of an hour, even without anything to report, the station signal is given as a signal that the line is in order, and is answered in the same way by the other station. as a sign that one is attentive and that everything is in order. Everything else belongs in the service regulations.

And so I leave the reader with the consciousness that I have deliberately concealed nothing that could contribute to the clarification of this interesting subject, and that it was within the realm of my knowledge. - May the work be received with the benevolence to which everyone is entitled to claim who with all modesty places the whole small treasure of his knowledge in the hands of the public, and deliberately concealed and concealed nothing, in order to leave individual parts deliberately covered with night and darkness - as is usually the case with practitioners in other subjects.

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After I had finished the manuscript of this work, and had already handed it over to print, I received private reports from various quarters in North America that for some time now they had begun to print the dispatches with Roman initials (so-called capital letters) on strips of paper, cut them off and deliver them to the recipient in the original. I immediately suspected that here again an American grandeur was at play, but nothing would be gained for the speedy promotion. Closer inquiries confirmed this suspicion. - The situation is as follows. Prof. Morse has the exclusive privilege in the Union for his system, which is unsurpassed in terms of rapid transmission, and he therefore has no lack of envious people who are now striving to surpass his invention by other systems, in order to gain the right to create telegraphs and to procure customers. The printing apparatus just mentioned is now a specimen of this endeavor, and in order to win over the public, this cutting and delivery of the original dispatch to the recipients was an excellent means of duping Brother Jonathan. The apparatus invented for this purpose is pretty much like Siemen's pointer apparatus; each letter is pressed by a key, and with it the strip of paper advances each time by the space of a letter. - A precise description of the construction of this apparatus, however, does not belong in the plan of this work. It will not be without interest, however, to learn that, after receiving news of this innovation in the United States, Berlin did not hesitate to immediately acquire the necessary apparatus and to carry out experiments with it. Practical use was even made of it on one line, but it was removed after only a fortnight, as the loss of time proved to be too great, and there was no practical gain in it, especially since there could be no question of cutting off the strip in order to send it as a dispatch to the other place.

Thus Morse's system once again justified itself as unsurpassed, and when one can telegraph as quickly as one writes with a pen, one would think that all desirable things had been achieved.

To the realm of wishful thinking, however, belongs a news story recently received from New York, of an invention in which whole columns of text telegraphed in a moment. Although this news report suffered from internal contradictions, for example, that its user could write with oil paint, etc., a commission was immediately set up in Brunswick to examine the invention. Their verdict was that it was of great importance as a theory, and worthy of further research, but in practice, it offered no benefit, since the alleged successes were not easily repeatable, despite all the care taken.

However, the improvements in electro-magnetic telegraphy that are still being sought remind us of the many voiced efforts to improve the musical staff. They failed because of the perfection and expediency of the existing system, and in spite of all the praises of newly invented and supposedly better systems, the old has not yet been suppressed, and will probably maintain its prerogative for all time, since it corresponds perfectly to its purpose.

Supplement.

The importance of gutta-percha for electro-magnetic telegraphy is well known; nevertheless, there is still so much uncertainty about the treatment and durability of this plant substance that I find myself compelled to make the following scientific report, which has recently appeared in the journal of the Austrian Engineers' Association, accessible to a wider circle.

On the gutta-percha and its application in the volcanic stand for the insulation of copper wires; by Baron H. Gershom, chemist in Vienna.

As I was induced by chance to consider the practical application of gutta-percha, I became quite acquainted with the properties of this body, and I do not think it uninteresting to briefly mention some of my experiences in this regard.

Such a communication should be all the more welcome to the readers, since just now, after the decision has already been made in favor of the underground telegraph lines, objections have been noticed, which have also given rise to the chemical analysis and the scientific examination of the behavior of the volcanic gutta-percha.

As is well known, the name gutta-percha is of Malian origin. Gutta means a substance that sweats from a plant, and percha is the Malay name of the tree that provides this product. According to Hooker's information, this tree is found in the forests of Jahors, on the tip of the Malay peninsula, and in various parts of the island of Singapore, and often has a diameter of 4 or 6 feet. The extraction of juice is still carried on very crudely, and may soon result in a deficiency of this product. For instead of merely making incisions in the tree and thus obtaining the draining sap, the trees are felled, peeled off, and the milky sap collected, which coagulates in the air, and is brought into the trade in skin-shaped pieces, kneaded together into breads weighing 4 or 6 pounds.

In this primitive form, the gutta-percha has a flamed, yellowish-white color, playing into dark chocolate brown, but is always more or less contaminated with earth, sand, wood and leaves, and always contains a considerable amount of water, so that after the release of these mechanically added substances and after melting, a compact blackishbrown mass is obtained with a loss of 26-29 per cent. This loss includes 21⁄2-3 per cent of water and a very volatile resin oil.

The melting of gutta-percha must be carried out with the greatest caution and certain movements, otherwise it will easily be burned or decomposed, whereby it takes on a sticky character. The completely purified anhydrous gutta-percha has a dark black-brown color, has great strength and elasticity, and when cut with a sharp knife, it has a bacon-like appearance, and isolates the electricity quite excellently.

After the lapse of several months, however, the surface of the anhydrous gutta-percha, on a cut surface, tarnishes considerably earlier, not unlike the ripe, fresh plums, which appears to be a hydrate, and may prove that this body has a constant tendency to absorb water; for pieces in which the drainage is not carried to the most perfect degree possible by melting are also elastic and compact, but of a light brown color, and in such pieces I have not yet been able to perceive any change, except when dark veins, and consequently completely drained parts, have occurred. In such veins the above-mentioned change was manifested, and the insulation was already perceptibly weaker.

The purified gutta-percha described above consists of plant acid, pure gutta-percha, acidic water, casein, a yellowish resin soluble in ether and a resins soluble in alcohol, as well as a considerable amount of extractive. Gutta-percha, treated with ether and alcohol, dissolved in carbon disulfide, precipitated and washed with alcohol, dried at 800 R., gave 86.5 carbon and 13.5 hydrogen in the analysis.

Gutta-percha thus appears to have a pretty similar composition to rubber, which, according to Faraday, contains 87.2 carbon and 12.8 hydrogen; but it differs from the latter by its less elasticity, and by the peculiarity of being plastic at 80° R., but becoming solid again at ordinary temperature.

Gutta-percha dissolves in turpentine, resin, gutta-percha, tar oil and hydrogen chloride tree; in these solutions, after evaporation of the solvents or by precipitation of the gutta-percha, a large quantity of the solvent always remains in it, which cannot be separated without decomposition of the gutta-percha; a perfect solution is obtained by chloroform and carbon disulfide, from which it can be precipitated immediately modified with alcohol, or it remains after the volatilization of the solvent.

A dehydrated and purified gutta-percha solution by means of chloroform, or rather by means of carbon disulfide, clarifies itself completely after about two days, even in the most concentrated state, when the brown extractive substance sinks to the bottom and the solution acquires a translucent light yellow color. If the solvent is immediately removed from such a solution, the gutta-percha remains as a dirty white, translucent, very elastic, compact mass, which is an excellent insulating agent of electricity. But even in this body, the above-mentioned change in surface becomes apparent after a few weeks. Ordinary, water-containing unmelted gutta-percha always remains dark brown in the dissolutions and does not clear up, except in an extremely diluted state.

Gutta-percha is much more difficult to combine (vulcanize) with sulfur than rubber, and it is not thereby improved as the latter is, but certainly only worsened, since the sulfur deprives it of its strength and causes it to decompose very rapidly. Even the small admixture of only 1 to 3 per cent of sulfur not only discolors the darkest gutta-percha, but changes it into a very inelastic and compact, light, dirty-yellow body, which, although it has a kind of metallic sheen on the cut surfaces, is very quickly covered on the rest of the surface with a whitish powder consisting of sulfur and decomposed gutta-percha. This white powder is produced more quickly and in greater quantities the more the gutta-percha is sulfurized (vulcanized). Once this excretion has occurred, and the gutta-percha has been exposed to moisture for a long time, it loses considerably of its power of insulating electricity, and it is therefore to be assumed that water penetrates into the open spaces from which the sulfur has emerged.

In the process of vulcanization, sulfurous acid is produced, which undoubtedly also causes the discoloration of the gutta-percha, and certainly promotes the more rapid decomposition of it, by converting itself into sulfuric acid by absorbing oxygen. It is evident that the insulating capacity is impaired by this, and must in the end cease altogether, even if not quickly.

If a few grains of sulfur are added to the solution of the gutta-percha by means of carbon disulfide, the brownest solution will discolor, especially with the application of sulfur flowers. Even sulfur dissolved by carbon disulfide does not discolor it alone, but after evaporation of the solvent shows the same properties as gutta-percha vulcanized with an equal quantity of sulfur. By kneading at an elevated temperature, at about 5-80 atmospheric pressure, a much softer, less elastic, light and, depending on the quantity of sulfur, a quickly decomposable product is formed.

If 4-6 per cent of sulfur is kneaded into the gutta-percha at a temperature of 70° R. without the application of high pressure, the mixture acquires a dirty yellow color and is of a soft, sticky nature. In this state this body insulates the electricity well, but after only 1-2 months it becomes brittle and brittle, and loses its insulating capacity.

It is remarkable that if even a small amount of sulfur is added to the solution of gutta-percha by carbon disulfide, the latter completely brings about the separation of the extractive substance with a resin which dissolves in alcohol, together with the casein. The upper translucent layer takes on a faint yellowish-white color, and even at very concentrated dissolutions one can see the partial excretion of dark-colored masses after a long and quiet stand; undoubtedly a proof that the sulfur has a decomposing effect on the gutta-percha. The same is observed as soon as even the smallest amount of sulfur, e.g. 14 per cent, is added to melting gutta-percha; for at the same moment, as in the above dissolution, it contracts into innumerable firm, dark, small knots, which can neither be divided nor brought out with the greatest difficulty, and even the best gutta-percha loses considerably of its quality as a result. If the sulfur is not previously mixed as evenly as possible by kneading at a temperature of about 70 - 80° R., but is applied to melting gutta-percha, the place where the sulfur goes decomposes in such a way that it burns and forms a sticky, tar-like, black mass, which, if it is not removed immediately, spoils all the rest of the gutta-percha.

As gutta-percha is used vulcanized for the coating of telegraph wires, and I had to familiarize myself with the method of preparation, my attention was drawn to an essay by Dr. Steinheil (Polytechnic Journal, Vol. CXV., p. 260), in which, at any rate, a great error is made in the manufacture of it, since such a product cannot be obtained under any condition according to the manner indicated. than is required. This is because 3-5 per cent of sulfur converts the gutta-percha into a soft, dirty-yellow mass, which becomes completely unusable in a very short time. Only if about 1--8 loths of sulfur are added to an anhydrous gutta-percha (the drainage prescribed by Dr. Steinheil is merely a release of the mechanically added water), molten gutta-percha to 100 pounds, can the required product be produced.

If the quantity of sulfur prescribed by Dr. Steinheil is added to the gutta-percha, then, according to his own statement, a part of the sulfur is evaporated again by the increased temperature of the increased vapor pressure, which precipitates as sulfurous acid not only to the detriment of the gutta-percha, but also to the nuisance of the workers; and a useful product will never be obtained in this way, since more or less sulfurous acid always remains in the gutta-percha, and although it is bound with the dye of the extractive substance, it always has a highly destructive effect on the gutta-percha.

I do not see the purpose and the benefit of vulcanizing the gutta-percha used for wire coatings; but if you want to vulcanize gutta-percha, you get the best possible product if you add as many solder sulfur to the anhydrous gutta-percha as Dr. Steinheil prescribes pounds.

Vulcanized gutta-percha not only loses more and more of its insulating ability, but it also has a detrimental effect on the copper wires, in that they are soon covered with sulfur copper, whereby the conductivity is weakened. Even after a few weeks, this change can be detected, just as in about a month the gutta-percha in which the wire was located is penetrated by sulfur copper at about 1⁄2 to 1 line deep. Galvanized iron wires will not suffer these changes, at least not to such a great extent, because metallic zinc is difficult to combine with sulfur, apart from the fact that the telegraph lines would be much cheaper.

It can be safely assumed that the vulcanized gutta-percha will not deliver the hoped-for result in the long run. With galvanized iron wires laid in metal tubes (iron or lead) and coated with a composition of gutta-percha, tar 2c., one would undoubtedly achieve a certain result at considerably lower cost, and would not have to send considerable sums of copper and gutta-percha abroad. Asphalt combines very advantageously with gutta-percha, increases the insulating capacity and prevents decomposition.

Supplement to page. 101.

I have recently discovered an easy method of finding derivatives. You send someone a distance ahead and have the wires dug up, taken apart and both ends placed free in the air. The person who remains behind does the former, and puts the end coming from the station together on his tongue with a short improvised circuit, in order to assure himself of the flow of force. If this flow is there, he also places both ends of the conduction on the moist tongue, and if taste appears, this is a proof that there is a derivation between the two points, for it is precisely this derivation that predisposes the taste in the property of a circulus, whereas if there were no derivation, there would be no circuit, and consequently no taste could exist. You then shorten the distance and get to the right damaged spot.