THE NEW TELEGRAPHY.

RECENT EXPERIMENTS IN TELEGRAPHY WITH SPARKS.

BY A. SLABY.[1]

IN the early months of 1897, when the news appeared in the papers that it had been possible to carry out practically the sending of telegraphic messages without a wire for distances of a mile or more, there were many doubters on both sides of the ocean. People thought it nothing more than the sensational imaginings of some able writer for the press, who wished to present to readers hungry for novelties in electrical matters a particularly toothsome dish. On the contrary, those who have followed with attention and understanding the science of electricity, came to quite a different conclusion; for these knew that a German scientist, Heinrich Hertz, had proved ten years ago by convincing experiments that the electrical forces spread themselves through space like the rays of light—so much so, in fact, that there exists between these two phenomena (of electricity and of light) no difference of quality, but merely one of quantity.

To be sure, these electrical forces do not emanate from electrical phenomena of every kind, but only from such as we designate as quick-pulsating or oscillating streams. From this Nikola Tesla first made the most interesting practical deductions, and performed those wonderful experiments in which the electrical rays transform themselves directly into the desired rays of light, without taking the roundabout way over heat, and without the strength-devouring agency of metal wires. Nature, that unapproachable schoolmistress, furnished him a shining example; for she had already solved the great problem thousands of years before. In the body of the glow-worm, which delights us on warm summer evenings with the magic of its greenish glow, she employs her whole strength in the selective radiance of light. Nikola Tesla followed Nature's footsteps and came upon the banks of a new river, into which the springs of Nature pour her energies of light in broad streams. It fell to the lot of the young Italian Guglielmo Marconi to bring to realization the transfer of forces through space with the help of electrical rays, and in a form within reach of practical application.

First let us consider the means and apparatus wherewith he produced an efficient working radiation of electrical waves.

An electrical phenomenon observed long ago, the springing of sparks from one loaded conductor to another, furnishes the most powerful electrical radiation.

Hitherto we saw in such a discharge a simple passage of the electricity from one body to another, and hardly considered that the phenomenon, which is accompanied by brilliant crackling sparks, is more remarkable than any other electrical phenomenon. To-day we know that this discharge is an intermittent one, in such wise that unnumbered other discharges follow the first discharge of electricity, and in changing direction and with diminishing strength. The whole phenomenon passes with such enormous swiftness that the movements to and fro of the electrical forces are concealed from sight. On the contrary, the eye is capable of receiving as a completed fact only the impression of one single spark.

As an originator of sparks Nature shows to our view bounds that lie very far apart. It is a tremendous jump from the faint crackling that we hear on cold winter days when, in a heated room, we pass a rubber comb through our hair, to the flashing of gigantic lightning-bolts; and yet both consist of the same phenomena; from both the same invisible forces emanate. Marconi uses an artificial producer of sparks, the strength of which occupies a moderate middle place between the extremes that Nature shows. He employs the well-known induction apparatus, that important instrument for the production of Roentgen rays, and connects its binding-clamp with two spheres of brass,

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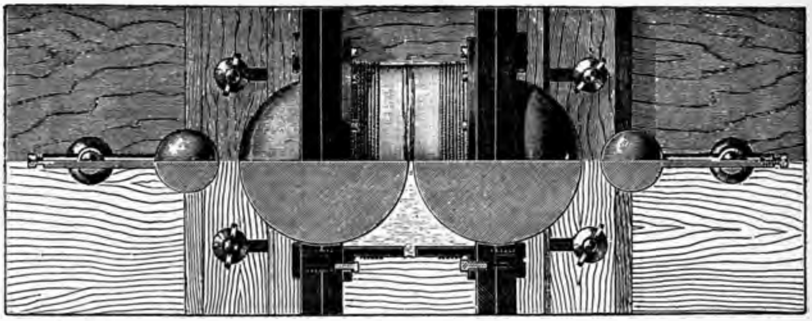

FIG. 1A. MARCONI'S SPARK-GENERATOR. FROM ABOVE.

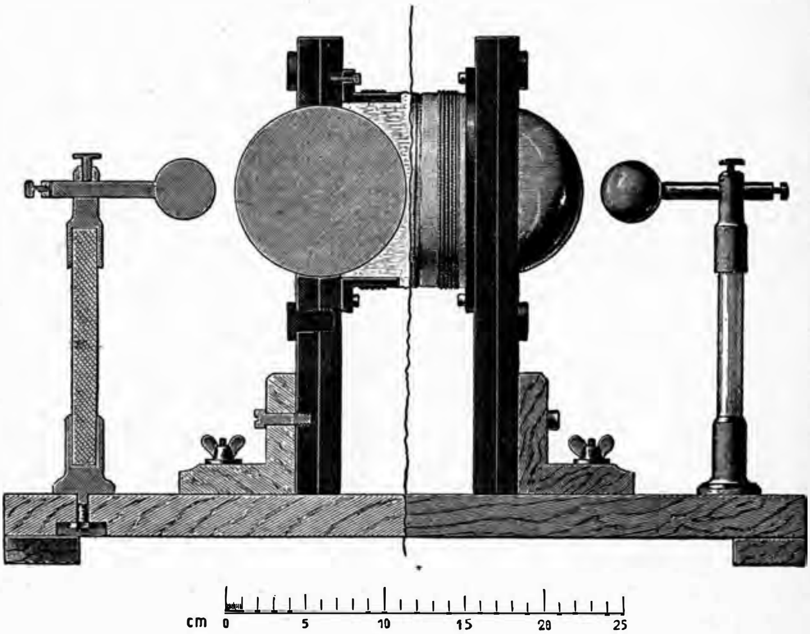

FIG. 1B. MARCONI'S SPARK-GENERATOR. CROSS SECTION, SIDE VIEW.

which are placed opposite each other at a distance of only a few millimeters (Fig. 1). When the inductorium is set in action we get an uninterrupted sequence of thick, white, shining sparks, the power of radiation of which is strengthened if the place of the sparks is filled with oil. In accordance with a process first used by Righi, he does not bind these brass spheres directly together with the binding-clamp of the induction apparatus, but charges them with the aid of smaller spheres which are placed at proper distance opposite the outer half of each of the larger spheres, which, in order to contain the oil, are surrounded with a shell of vellum.

From this apparatus for the production of sparks emanate the rays of electrical force. Heinrich Hertz was the first to make the arrangement whereby it is possible to establish their presence. For this purpose he employed the so-called resonators (Fig. 2), which are open circuits of wire the ends of which are provided with little polished balls of brass. By means of an isolated graduator, the air-space between the balls can be exactly fixed to very small fractions of a millimeter. When such a resonator is placed in the path of electric waves an electrical sympathetic ringing is roused therein, which shows itself in the passage of sparks at the point of non-contact or interruption in somewhat the same way that a tuning-fork is brought to sympathetic sounding by waves of sound. To be sure, the sparks are so minute that they can be seen only in a darkened room.

With the simple resource of this resonator Heinrich Hertz examined into the laws which the electric forces follow in their radiation.

The most remarkable among his experiments showed that the electric waves were reflected from a metal surface exactly in the same way that light is thrown back from a mirror. Moreover, by means of ingenious arrangements he discovered that the velocity with which the electric forces spread themselves through space is the same as the velocity of light—namely, three hundred thousand kilometers in a second.

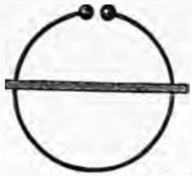

FIG. 2. HERTZ RESONATOR.

So far as it has in any case been possible, these and further experiments have brought us the certainty that light and electric rays are phenomena of the same kind, which differ from each other only in relations of size.

The retina of the eye is the sensitive instrument which permits us to become aware of the presence of rays of light; in the same way we may hereafter call the apparatus which shows us the electric rays an electrical eye. The resonator of Hertz is an eye which is still incomplete. It is weak and short-sighted. We can perceive with it only the most dazzling effects of the electric rays, and can, if I may so express myself, calculate only approximately the degree of their illuminating power.

The electrical eye which Marconi uses is essentially more sensitive; we may call it a clever improvement on the resonator of Hertz. The chief characteristic of the latter was the interruption of a metallic circuit by an air-space of uncommonly short width. The working of an electric ray impact showed itself in the appearance of visible sparks. But we can bring other means of assistance to bear in order to recognize the presence of infinitely small sparks which the human eye fails to see. The most sensitive means are always electrical; therefore we choose a continuous electrical current, the slightest traces of which can be detected by the galvanometer.

Let us imagine that the metal knobs of a resonator of Hertz have been so closely brought together that the air-space between them can be no longer detected even with the most delicate optical means; nevertheless, it is not necessary that a complete metallic contact has yet taken place. If we introduce into the wire circuit of the resonator a little galvanic battery (Fig. 3), say, in the nature of a desiccator, and a very sensitive galvanometer, then, as long as the electric stream is obstructed at the knobs, the needle of the galvanometer will remain at rest. But if the impact of an electrical discharge falls upon the circuit, electric effects tremble through it which are not barred by the air-space between the knobs, very much as a wave of water may spurt its way over an obstacle when it is turned into millions of little spray-drops. In this fashion is it that fine sparks spurt across; and though they are hidden from the keenest methods of optical reinforcement, yet for an instant they are there, and every spark of them fills the air-space with metallic steam. These guide the continuous current, and close the circuit. The result is a perceptible movement of the needle of the galvanometer. Either the needle swings back after the impact is finished,—then the isolating air-space has reëstablished itself as it was, and the electrical eye is ready to react to another impact,—or (and this is most commonly the case) fine scattered particles of metal, which have been consolidated again after evaporation, fill the air-space and build a metal bridge, whereupon the movement of the galvanometer's needle is permanent. But the slightest shock is sufficient to bring this bridge to a fall, and thus to break the metallic contact.

In the same way, as Branly first discovered, works a tube of glass when filled with iron or copper filings. Such a tube presents an insuperable resistance to the passage of an electrical stream, so that we can clamp it to the pole of a galvanic battery with metal fasteners without receiving a charge. But if this tube receives the impact of electric rays, then it conducts the main circuit, and the needle of the galvanometer moves. After the electrical radiation upon the tube is finished, a light shock given to the tube reëstablishes once more the complete resistance to the main circuit.

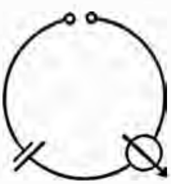

FIG. 3. RESONATOR WITH GALVANOMETER ATTACHED.

Fig. 4 shows an apparatus of this kind, in which the metal filings are replaced with iron nails loosely piled up one upon another. There are countless points of contact present having insulating surfaces. The radiation of electric waves excites among them an electric vibration, and countless invisible sparks at the points of interruption cause metallic contact.

Lodge of Liverpool appears to have been the first to use such tubes as electrical eyes for the study of the Hertz rays. In his ab-

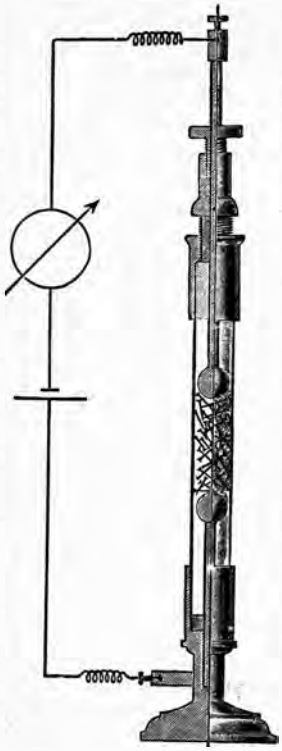

FIG. 4. THE LODGE COHERER AND BRANLY'S TUBE WITH METAL FILINGS TO REGISTER IMPACT OF AËRIAL ELECTRICITY.

sorbing book, «The Work of Hertz and Some of his Successors,» he describes various arrangements of this and of other kinds, which he had been using as early as 1889. From him came the term «coherer,» which he chose because a more intimate connection, as it were a cohesion, of the metal filings was produced by the electrical waves. One may also fairly consider Lodge the father of the idea of telegraphing with electric rays and such tubes; but he fixes as the farthest distance that can be reached one half an English mile (eight hundred meters), without ever having given any practical proof of the theory.

Marconi's electrical eye is pictured in Fig. 5. He uses a metallic powder, or, more correctly, a mixture of metallic powders, which consist of ninety-six per cent. nickel and four per cent. silver. This mixture is sealed up in a little glass tube between two knobs of silver, the meeting surfaces of which knobs are amalgamated by a trace of quicksilver. After it is filled, the tube is cleansed and soldered up; wires of platinum effect the passage of electricity, and are soldered on to the silver knobs; the tube is fastened with marine glue to a stick or pillar of glass, which serves as a support.

Fig. 6 shows the arrangement of Marconi's receiver. The main circuit, strongly drawn out, contains a desiccator (*A*), a sensitive relay (*B*), and the coherer (*C*). It is well known that a transferrer commonly used in telegraphy is called a relay. It reacts to very slender streams of electricity, and moves at the same time a tongue which conducts a second circuit with stronger batteries. When the coherer is cut off, the circuit is broken, and the tongue of the circuitless relay points to contact of rest. After the impact of the waves, cohesion in *C* permits the establishment of a current which turns the tongue of the relay on the working contact. Therewith the circuit of the battery (*a*) is closed, and the Morse indicator (*b*), which has been inserted therein, as well as the ticker (*c*), are set to work. At the first stroke of the ticker against the coherer the particles in the latter must fall asunder; thereby the first circuit becomes at rest, and the tongue of the relay lays itself at the point of rest and cuts off the battery (*a*). At a renewed subjection to the electric waves this action repeats itself. It is evident that by subjection of the coherer to intermittent radiation one can produce the Morse alphabet.

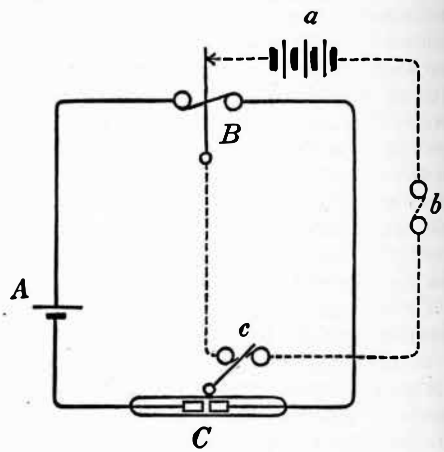

FIG. 6. MARCONI'S RECEIVER.

A—Desiccator. *a*—Battery.
B—Relay. *b*—Morse indicator.
C—Coherer. *c*—Ticker.

In January, 1897, when the news of Marconi's first successes ran through the newspapers, I myself was earnestly occupied with similar problems. I had not been able to telegraph more than one hundred meters through the air. It was at once clear to me that Marconi must have added something else—something new—to what was already known, whereby he had been able to attain to lengths measured by kilometers. Quickly making up my mind, I traveled to England, where the Bureau of Telegraphs was under-

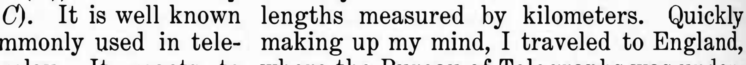

FIG. 5. MARCONI'S «ELECTRICAL EYE.»

taking experiments on a large scale. Mr. Preece, the celebrated engineer-in-chief of the General Post-Office, in the most courteous and hospitable way, permitted me to take part in these; and in truth what I there saw was something quite new. Marconi had made a discovery. He was working with means the entire meaning of which no one before him had recognized. Only in that way can we explain the secret of his success. In the English professional journals an attempt has been made to deny novelty to the method of Marconi. It was urged that the production of Hertz rays, their radiation through space, the construction of his electrical eye—all this was known before. True; all this had been known to me also, and yet I never was able to exceed one hundred meters.

In the first place, Marconi has worked out a clever arrangement for the apparatus which by the use of the simplest means produces a sure technical result. Then he has shown that such telegraphy (writing from afar) was to be made possible only through, on the one hand, earth connection between the apparatus and, on the other, the use of long extended upright wires. By this simple but extraordinarily effective method he raised the power of radiation in the electric forces a hundredfold. The upright extended wires work like the pierced tube of a watering-cart; the rays of electric force spurt, as it were, in every direction upright to the wire; they cause a great part of space to be drawn into sympathy.[1]

Now, since these wires are the essence of Marconi's discovery, the term «telegraphy without wires» is really erroneous; more correctly should it be called telegraphy by sparks, in opposition to the term used hitherto, «telegraphy by circuit» (*Stromtelegraphie*).

The experiments in England were carried out in the Bristol Channel. A mast thirty meters high was erected on the cliff near Lavernock Point—a cliff twenty meters high, one hour from the pleasant little bathing village of Penarth. Over the top of the mast was a cylindrical hood of zinc, two meters high and one meter in diameter. An insulated copper wire passed from the zinc cylinder to the foot of the mast to meet one pole of the receiver. The other pole was connected with the ocean by a long wire which ran down the face of the cliff. In the midst of Bristol Channel, five kilometers distant from Lavernock Point, lies the little island called Flatholm. There was the place for transmission. The apparatus to engender the sparks was in a little wooden cabin. Its knobs were connected, one with a zinc hood on a mast of the same height as that on Lavernock Point, the other with the sea.

After a few preliminary experiments, the sending of messages was perfectly successful. It will always be an unforgettable recollection how, on the morning of May 13, 1897, our party of five, cowering together in a big wooden case, because of the heavy wind, our ears and eyes bent with the most anxious care upon the receiving apparatus, suddenly, after the raising of the signal-flag agreed upon, perceived the first tickings, the first clear Morse letters on the tape! Silently and invisibly the message had been borne across the space from the rocky coast, ferried across by that mysterious medium, the ether.

After my departure the experiments were continued. It was possible to make clear telegraphic communications between Lavernock Point and Brean Down, straight across the entire breadth of Bristol Channel, fourteen and a half kilometers.

Having returned to my home, I went to work at once to repeat the experiments with my own instruments, with the use of Marconi's wires. Success was instant. I set up telegraphic communication between my laboratory and a factory about two kilometers away, where a water-tower was placed at my disposal for the placing of the wire of transmission. I resolved, however, to discontinue the connection, because there came a query from the office of the telephone company, whether in that district any local meteorological storm existed, since all the telephone-lines there were out of order.

Meantime the attention of the German Emperor had been drawn to the new form of telegraphy. It is known with what a lively interest and with what a depth of technical knowledge the Emperor follows the progress of applied science. Hardly a tract of this great field is foreign to him, and it is not un-

[1] The reader will find in THE CENTURY for April, 1895, in an article on Mr. Tesla's inventions, a quotation from his lecture, delivered at Philadelphia in February, 1893, and at St. Louis in March, 1893, in which he expressed confidence in the practicability of telegraphy without wires. In the same lecture will be found a description of the scheme, the connections, and the arrangement of transmitting- and receiving-instruments used later in Signor Marconi's experiments. (See «Inventions, Researches, and Writings of Nikola Tesla,» by Thomas Commerford Martin; New York, «The Electrical Engineer,» 1894, pp. 346–349.) A number of scientific men have already called attention to this fact. This does not detract from the distinct merit of Signor Marconi in having effected the transmission to a five- or sixfold distance by an application of devices which were thought capable only of a transmission of a mile or two.—THE EDITOR.

frequently the case that the reading of technical reports, foreign and German, is, as it were, a rest for him from the wearisome exertions of state affairs.

For carrying out extensive experiments, the waters of the Havel River near Potsdam were put at my disposal, as well as the surrounding royal parks—an actual laboratory of nature under a laughing sky, in surroundings of paradise! The imperial family delight to sail and row on the lakes formed by the Havel; therefore a detachment of sailors is stationed there during the summer, and I was permitted to employ the crews as helpers.

I placed the receiving apparatus in the sailors' barracks. The flagstaff there was considerably heightened, so that the highest point of the clear receiving wire was twenty-six meters above the level of the ground. For my first transmitting-station I chose a church lying on the other shore of the Havel, which was built by Frederick William IV, called the Saviour's Church at Sacrow, distant one and six tenth kilometers in an air-line. Fig. 7 shows the edifice. On one side of the basilica stands the clock-tower, which has a platform immediately below its roof. There a mast was placed, and from its highest point, twenty-three meters above the ground, a copper wire was suspended by means of a porcelain insulator. I had chosen the nave of the church as the place for my spark-generator, in order to be protected during rainy weather. The telegrams transmitted from Sacrow reached the sailors' barracks with unimpeachable clearness and exactness. To be sure, I was on one occasion in a state of lively dismay because of the indistinctness of the marks on the tape. It was the very day on which the Emperor desired to inspect the arrangements. It was only a short time before the doors closed that I was able to discover the origin of the interference and to suppress it. I had withdrawn the transmitting or spark-generating apparatus farther than was my wont within the entrance of the church, and thus it had got too near the stone flooring. By pulling the wires tighter the trouble was overcome. The sending of messages was very successful. The Emperor himself sent a telegram, and on his return to the sailors' station could convince himself of its safe arrival there.

Further experiments at the Sacrow church gave an important result. When I carried the transmitter wire perpendicularly down the clock-tower to the entrance of the church and to the spark-generator placed there, the signs entirely failed to appear at the receiving-station. After a good deal of experimenting the obstacle was discovered. In the immediate neighborhood of the clock-tower are clumps of trees (see Fig. 7) which almost entirely concealed the vertical wire, so that from the sailors' station with the telescope one could only make out the upper section of the wire. The rays emanating from the wire were swallowed up by the group of trees as rays of light might be, or else led off toward the ground. The chief condition for success with telegraphy by sparks is that all obstacles which are found in front of the transmitter wire must be cleared away.

This fact was particularly felt when I wished to open telegraphic communication between the sailors' station and Peacock Island, three kilometers apart. The air-line between the two stations is crossed by a hilly, wooded tongue of land in the Glienicke Park, which is covered with houses. The electrical rays had to pass through these houses. It was successful, truly, but only after I had increased the length of the wire at both stations to sixty-five meters. It is remarkable that connection could also be had with Peacock Island when I substituted for the vertical wire and earth connection wires about one hundred meters in length, which I stretched parallel to each other, about two meters above the level of the ground.

The experiments in Potsdam had for their object the discovery of the basal conditions on which to predi-

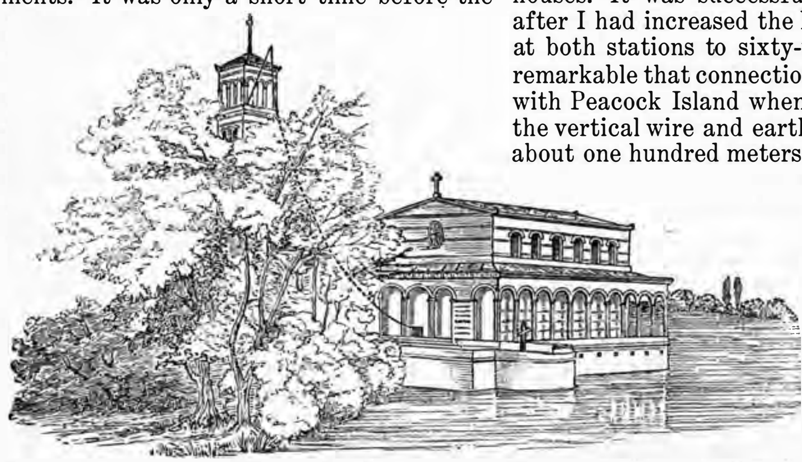

FIG. 7. FIRST TRANSMITTING-STATION, SACROW CHURCH, NEAR POTSDAM.

cate success in spark telegraphy. In order to overcome greater distances, more auspicious places and methods had been considered.

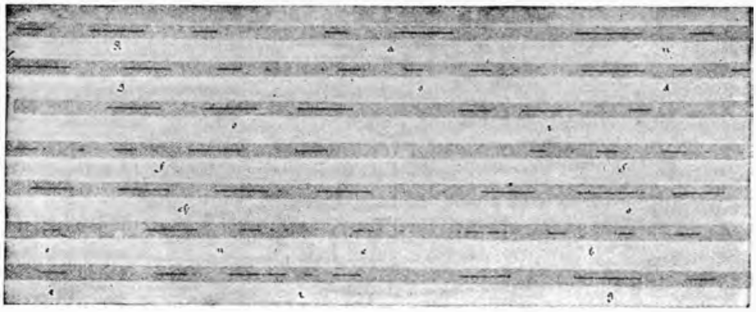

FIG. 8. FIRST TELEGRAM THROUGH THE AIR BETWEEN BALLOONS—«RANGSDORF, SCHOENEBERG.»

In the meantime Marconi, while conducting experiments at Spezia which he carried out with the support of the Italian navy, had succeeded in telegraphing from a moving battle-ship, the *San Martino*, sixteen and three tenth kilometers to the arsenal of San Bartolommeo, and at a distance of eighteen kilometers in deciphering a few signals.

I resolved to attempt still greater distances.

The Emperor had ordered the balloon department of the army to assist in these experiments. The practice-ground of the military balloonists lies in Schöneberg, near Berlin, and a military railway runs thence directly south. At a distance of twenty-one kilometers in an air-line lies the village of Rangsdorf, on the railway itself. The sending apparatus was arranged there, and the necessary guard and balloon material were sent down.

After a few experiments, we succeeded on the 7th of October in establishing communication between the two posts. There was a cold, raw northwest wind, so that both the balloons, anchored at the two places, were driven about. At both stations thin copper wire was fastened to the baskets of the balloons, reaching two hundred and fifty meters to the apparatus. Connection with the earth was made by means of swords stuck in the ground.

The first telegram received under these conditions is reproduced by the autotype process in Fig. 8. The clearness of the Morse characters seems all the more noticeable because the electrical condition of the atmosphere on that day was as unfavorable as one could imagine. The electricity of the air was so strong that one could not touch the wires hanging down from the balloons without getting the severest electrical shocks. When one of the wires broke loose from the apparatus by reason of the strong wind, a lively jumping about took place among the soldiers standing near, for fear that they might be hit by the wires whipping to and fro. Nevertheless, the effect of those electrical interferences in the air are to be seen on the Morse tape only in a few points which did not mar the legibility of the Morse characters, consisting of short and long lines.

I have often been asked in what directions and in what field the use of spark telegraphy might be employed. Our knowledge of the phenomenon in question is, so far, a very modest thing; we are really in the very opening chapters. Who would care to say to-day how far, and whither, the path will lead us? I do not purpose to paint pictures of the future, but I believe I can state with emphasis that for certain purposes the new telegraphy is ripe to-day, and well worthy of consideration. The most important appear to me to lie in the military field. Besieged fortresses, and advancing armies which have the enemy between them, could make use of spark telegraphy to-day as a method of communication. The system works just as surely on a bright day as by night and in fog, though, to be sure, only in cases where balloons can be employed, since the distances reached when towers, masts, and high trees were used would hardly suffice in cases of this kind.

Quite as important is the usefulness of the discovery for the navy. Experiments of last summer have made perfectly certain the possibility of using captive balloons on the high sea. In place of balloons, without doubt, one might use the modern kites, brought to such a pitch of perfection in America, as those of Hargrave and others. I owe it to the kindness of an acquaintance in New York that I know something of these excellent kites, and a few experiments have already shown me that they are perfectly adapted to the carrying of thin wires.

There is a future for the use of spark telegraphy for lighthouses and light-ships. The receiving apparatus can easily be made in a handy form, not bulkier than a chronometer. On the approach to a lighthouse it would not only give signs, but would tick out the name of the lighthouse; it appears even possible to provide the receiving apparatus with a regulator, to be adjusted at will according to whether a greater or smaller sensitiveness is desired, whereby the distance of the lighthouse can be read off.

An undeniable weakness of spark telegraphy is this: every telegram is imparted to the whole world; every receiver can take it up. Owing to this reason, for the present its application will have to be confined to particular cases. For practical purposes, if one desires to protect one's self from having despatches read by others, there remains always the use of signs arranged beforehand. In war, to be sure, telegraphy would become impossible as soon as a hostile spark-generator should cause a permanent disturbance of the characters. A very interesting battle might occur in the waves of ether.

Notwithstanding these undeniable shortcomings, let us not allow ourselves to be deprived of joy at the discovery of the new telegraphy. We are face to face with very peculiar phenomena. Nature has opened a new door for us. It is the mission of science at present to bring light into the opened room. After that we shall not have to wait long for the necessary technical progress.

THE SUPERFLUOUS CRITIC.

BY ALINE GORREN.

THE one point upon which the best friend of America and America's worst enemy would probably agree is that we are not a critical people. As to the results to which the fact may lead, these two persons might, however, hold very different opinions. To the one, our want of the critical sense would appear to be a fatal weakness. To the other, it would reveal itself as, in many directions, the source of our greatest strength. Now it may be possible to be firmly of this second way of thinking, and yet to be able to perceive the amount of truth that belongs to the first.

It is certainly an inherent characteristic of the Anglo-Saxon to hold action as better, any day, than any amount of abstract theorizing; and where this characteristic exists as emphatically as it does in America it would be unreasonable to expect a very free play of that deeper and more comprehensive class of criticism, as applied either to art and letters or to the esthetic side of the daily conduct of life, which trenches upon the ground of philosophical reflection and speculation, and which alone can truly be called criticism. Every thoughtful student of American institutions feels that they are triumphant because of the wise elasticity which is part of their essence, and which adjusts political ideals to the facts of life and the inconsequentialness of human nature, being willing to forego something of the logical perfection of a theory if thereby it can be made more effectively a working one; and he recognizes how profoundly in this practicality the whole genius of the people is expressed. In our social life the same order of observations may be made. It is still a largely disorganized social life. Certainly it is not organized as is social life among the Latin peoples. With them a perpetual process of analysis decomposes into their remote elements, day in and day out, every social force of any moment, and many forces which superficially seem of no moment; all the actions of man in society, and their subtle influence upon his fellows, are weighed minutely. The place of every individual is made for him, and the limits within which he may expand are prescribed. Hence the superior smoothness and amenity of the machinery of life in a country like France; hence the really larger individual liberty, since, where all know their bounds, there must be, for each, fewer chances of rough encounters with the environment. But a good American, whose ideas in respect to all the moral aspects of conduct are apt to be rigid and sharply defined, holds with regard to the infinite complexities of social relations a very different attitude. He may acknowledge, if pushed to it, that the only efficacious way which has yet been devised of making people live together agreeably is to reduce the conditions of living to a science. Nevertheless, the critical alertness necessary to the elaborating of such a science is, in some subtle way, repugnant to him. It seems too much like the alertness of the meddler—