Bell's Telephone

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The form of telephone as invented by Professor Bell is one of the most ingenious applications of magneto-electric currents, the results of which have been as useful as they were unexpected. We say unexpected, and no electrician indeed did expect that it would be possible for electric currents, induced in a coil surrounding a magnetized steel bar, to adopt such an almost infinite number of modifications as correspond to the different intonations, inflections, articulations, etc., incident to human speech; and then, what is the most wonderful of all, after transmitting these currents over an insulated telegraph wire to a distance of several miles, that the very same instrument will transform this multitude of electric waves back again into aerial sound waves, audible to the ear, so that all kinds of sounds are transmitted by the intervention of electric currents, in which they are temporarily, as it were, metamorphosed, in order to be transmitted to distances far beyond the limits which otherwise can possibly be reached by sounds.

Another unexpected fact is that this form of telephone does not require any electric battery; while the telephone of Reuss, first exhibited in this country and improved by the editor of this journal, (see page 85 of our April number for 1877), required a sufficiently strong battery in order to produce the currents, of which the nature was regulated by the sound. In Bell's telephone, however, the vibration of the air (the sound itself) generates the currents by the application of the law first discovered by Faraday, almost fifty years ago, prevailing when permanent magnets act on coils, and vice versa.

In order to explain properly the construction of Bell's telephone, we must go back to the first principles on which it is founded; when these are understood, the theory of the apparatus becomes just as simple as is the apparatus itself.

The first point to be understood is the reverse of an electromagnet. An electromagnet is (as now almost everybody knows) a straight or curved bar of soft iron, surrounded by an isolated coil of copper wire; when an electric current is passed through the wire the bar becomes a magnet as long as the current lasts, that means, it will attract iron, nickel, manganese, and cobalt, possesses polarity, so as to repel poles of the same kind and attract those of the opposite kind in other magnets, either natural, artificially magnetized steel bars, or other electromagnets; and, in short, behave to all intents and purposes like any magnet, only it acts generally stronger.

The reverse arrangement is a steel bar, permanently magnetized as strongly as practicable, and surrounded by a coil of isolated copper wire. The first experimenters in this direction imagined that in this way a constant electric current might be obtained, because if a battery current makes a bar of iron around which it is wound as a coil, magnetic, inversely, a magnetic bar must induce an electric current in the coil surrounding it. This experiment failed, however, with all who tried it, and we remember in our boyhood that we witnessed the experiments of General Krayenhoff, who exhausted all his ingenuity in trying to make this experiment succeed, but all in vain.

It was reserved for Faraday to discover, nearly fifty years ago, the law prevailing in these reverse electromagnets. He found:

1. That when a coil is passed over the poles of a magnetized steel bar, or the steel bar inserted in the coil, an electric current is developed, but lasting only as long as the relative movement of the coil or bar, when the coil or bar is moved in an opposite direction so as to separate them, a temporary current in an opposite direction is developed.
2. The next step was to surround a bar of iron with an isolated coil, and then to touch it with the two poles of a permanent magnet, so as to give it polarity by magnetic induction; also in this case a temporary current was developed, running in one direction when the iron bar was magnetized, and in the opposite direction when the magnetism was destroyed by the removal of the inducing permanent magnet.
3. The next experiment was to surround an iron bar, or bundle of iron wires, with two isolated coils; one of heavy wire, to pass the current of a voltaic battery, and one of thinner wire, to receive the induced temporary currents; and it was found that also here in the latter coil two temporary currents were developed, of which one was induced at the moment the voltaic current was closed and the iron bar magnetized, and the other in the opposite direction when the magnetism was destroyed by the interruption of the voltaic current.
4. Another step was to leave the iron bar out and to use two separate isolated coils, spirals or helices, placed close together; at the moment that the electric current in one was established, a temporary current was observed in the other, and when the current was interrupted, another temporary current in the opposite direction took place.
5. The poles of a permanent magnet were surrounded by isolated coils, and it was observed that when the poles of the magnet were touched by a piece of iron so as to divert its action and cause a fluctuation of its magnetism, temporary currents were produced, which always ran in one direction when the iron came near, and diminished the magnetism, and in an opposite direction when removed, and the magnetism was fully restored.
6. Finally, it was found that when a coil is so attached to a permanent magnet that it may be moved to and from the magnet, or slid along its length, or, inversely, a magnetic bar passed through a coil, the least motion of either, even without changing their distance, will induce a current, of which the direction depends on the direction of this motion, which may be so slight as to be even imperceptible, when an induced current will testify to its existence.

We may here remind the reader that these induced currents, when very weak, may be observed by means of the compass-needle galvanometer, the principle of which we have explained on a former occasion.

A great many varieties of apparatus have been constructed, based on the principles here explained. Pixis took two horseshoe shaped iron electromagnets, of which one could revolve with its poles before the other; the stationary one was charged by passing a voltaic battery current through its coil, while the other was revolved in front of it; the intermitting polarity of the revolving electromagnet induced a series of rapidly succeeding currents running in alternate directions through its coil.

Clark took a permanent horseshoe-shaped steel magnet, and revolved an electromagnet in front of its poles, thus evolving alternate currents in the coils of the latter, and obtaining currents without the help of a battery. His machine was described on page 36 of our February number for 1873, and has been largely imitated on a small scale for the administration of such currents for medical purposes.

The principle of two coils, in one of which the current is developed by the voltaic current passed through the other, has also been largely employed for the same purpose, while when applied on a large scale it has culminated in the Ruhmkorf coil, (described on page 228 of our October number for 1875.)

In 1862, when the editor of this journal occupied the Chair of Physics in the Cooper Institute of this city, he had made for him by Mr. Chas. T. Chester, a telegraph manufacturer in New York, a little experimental machine of this class, in which a coil was wound around the poles of an artificial steel magnet, in exactly the same way as is done in Bell's telephone, while the currents were induced by the motion of an iron plate placed in front of the poles, also like Bell's telephone; but the motion of this iron plate was produced by hand; if it had been conceived then to have them produced by sonorous vibrations, this form of telephone would have been invented then.

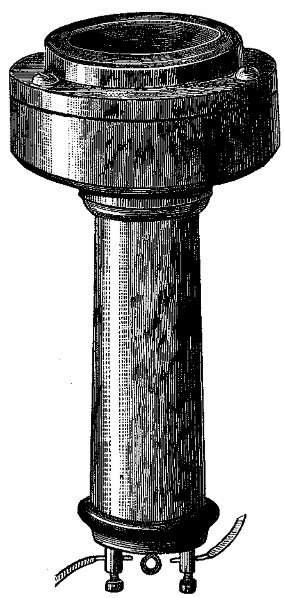

Fig. 1. - Exterior View of Bell's Telephone

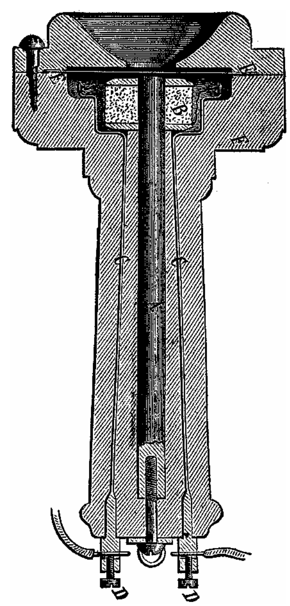

Fig. 2. - Longitudinal Sectional View

We represent in Fig. 1 the exterior appearance of Bell's telephone, while Fig. 2 represents the longitudinal section. The mouth or ear piece (because the same instrument serves both for the transmission and reception of speech) is seen on the top; under the lower opening of the funnel is an iron plate, which is put in vibration by the voice, and acts on the steel magnet under it, which can be brought very close to it by means of a set-screw, seen at the lower end. Around the upper poles of the magnet an isolated coil is wound, in which currents are induced by every fluctuation of the magnetism caused by the motions of the iron plate. These currents are transmitted over the telegraph wire and received by another entirely similar instrument, passing through its coil, inducing changes in the magnetism of the steel magnet surrounded by it, which changes in their turn cause motions in the iron plate, which are communicated to the air as sonorous sounds, and as such perceived by the ear.