A. G. BELL.

Electric Speaking Telephones.

No. 213,090. Patented Mar. 11, 1879.

Fig. 1.

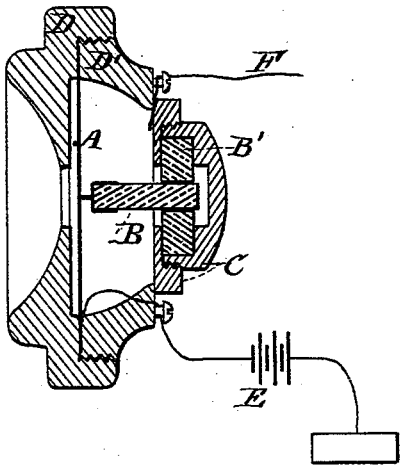
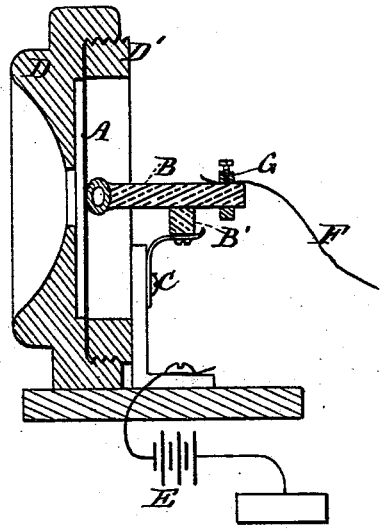


Fig. 2.



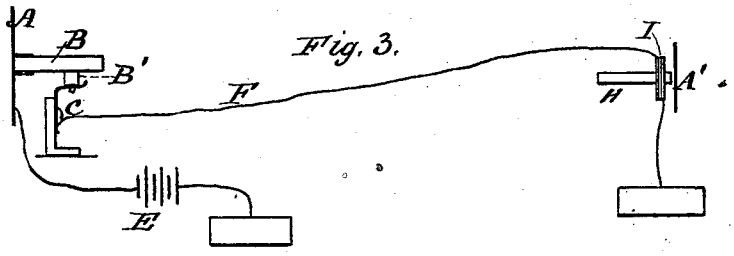


Fig. 3.

Fig. 4.

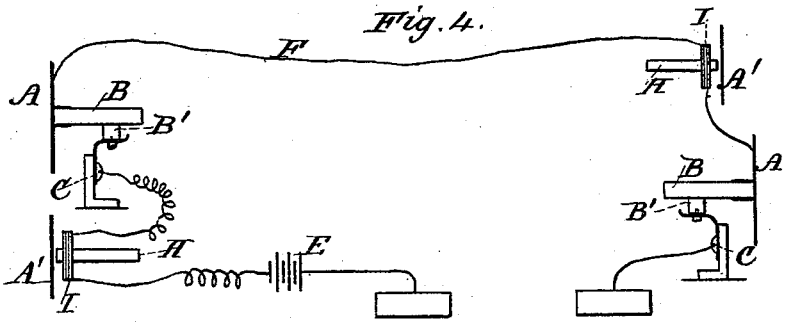
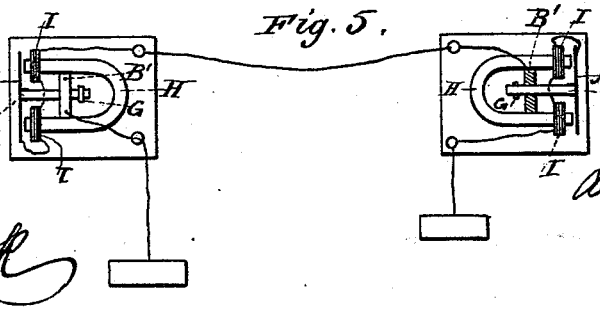


Fig. 5.



Witnesses

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UNITED STATES PATENT OFFICE.

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IMPROVEMENT IN ELECTRIC SPEAKING-TELEPHONES.

Specification forming part of Letters Patent No. **213,090**, dated March 11, 1879; application filed January 16, 1879.

To all whom it may concern:

Be it known that I, ALEXANDER GRAHAM BELL, of Washington city, in the county of Washington and District of Columbia, have invented a new and useful Improvement in Electric Speaking-Telephones, which improvement is fully set forth in the following specification.

In Letters Patent granted to me on the 7th day of March, 1876, and on the 30th day of January, 1877, numbered, respectively, 174,465 and 186,787, I have shown and described a system of electric telephony, consisting of transmitting-telephones operated by the human voice, and adapted to produce variations in the intensity of an electrical current proportional to the variations in the movements of the air produced by the voice, and of receiving-telephones adapted to be thrown into vibration by the action of the electrical current, so as to produce movements of the air at the receiving-station corresponding to the variations in the intensity of the electrical current—*i. e.*, to the movements of the air produced by the voice of the speaker at the transmitting-station—the whole being arranged for operation upon an electrical circuit, so that the sounds of articulate speech uttered in one place can be reproduced in another, and persons separated by great distances carry on conversation by word of mouth.

In my patent aforesaid, No. 174,465, I have shown and described two distinct methods of causing electrical undulations analogous to the aerial vibrations of sound—viz., first, by causing variations in the electro-motive force employed, and, second, by causing variations in the resistance of the circuit; and I have shown that such variations can be produced in the one case by vibrating a body capable of inductive action in the neighborhood of an electro-magnet in the manner in which the air is moved by the voice of a speaker, and in the other by vibrating in a similar manner a conductor forming part of a voltaic circuit in a liquid included in the circuit.

I have also shown and described a practical method of vibrating bodies of considerable weight in the way required—viz., by attaching such bodies to a membrane or diaphragm which can be actuated by the voice of a speaker.

My present invention consists of an improvement in the method of varying the resistance of a circuit, so as to produce an undulatory current for the purposes of electric telephony, and of means for producing this effect, the said means constituting a transmitting speaking-telephone.

I have discovered that when two conductors of electricity are placed in contact with each other, the electrical resistance of the parts in contact is affected when one of the conductors is caused to slide over the surface of the other, and that the resistance is affected proportionally to the velocity of the sliding motion. If this motion is produced by a sound, the resistance of the parts in contact is affected proportionally to the motion of the air during the utterance of that sound, and the friction of the conductors can thus be made to affect the intensity of an electrical current, so as to cause the reproduction of the sound from any suitable receiving-telephone placed in circuit with the two conductors.

In order that the nature of my invention and its mode of operation may be more fully understood, I shall show and describe, in illustration of my said invention, one or more forms of apparatus for producing the effect.

Figures 1 and 2 give views, in central section, of frictional telephones made in accordance with my invention, operating in connection with a battery. Figs. 3 and 4 represent diagrams of telephone-lines, with frictional transmitting-instruments and receiving-telephones of ordinary construction, operating in connection with a battery. Fig. 5 represents a form of apparatus combining the transmitter and receiver in one instrument.

The same letters always refer to like parts.

A represents an elastic plate or diaphragm. B B′ represent the conductors in frictional contact, one of which is connected with the diaphragm A, and the other is held by a suitable support, C.

The diaphragm A is secured in a suitable frame, which is here shown as a mouth-piece, D, and a ring, D′, in the same manner as in the telephones made in accordance with my aforesaid Letters Patent, and now in actual use.

The current from the battery E is repre-

sented as passing through the metallic diaphragm A, the conductors B B′, and the line-wire F, to the ground.

H represents a magnet, having coils I upon one or more of its poles, arranged in front of an elastic inductive plate, diaphragm, or armature, the said coils forming part of the telephone-circuit, in the manner substantially as set forth in my aforesaid Letters Patent. The elastic inductive plate is represented by A′ in Figs. 3 and 4.

In Fig. 5 the diaphragm A affects the movement of the one conductor on the other, and also acts as the inductive plate or armature.

In operation the vibrations of the diaphragm caused by spoken words or other sounds are communicated to the conductor B. The resistance of the parts of the conductors B B′ in contact is affected proportionally to the velocity of the vibratory movement, and the electrical current is thrown into undulatory vibrations, corresponding to the vibrations of the atmosphere due to the spoken word or other sound. These atmospheric vibrations are reproduced at the other end of the line by means of the receiving-instrument, composed of the magnet H, its coil or coils I, and armature-plate A′. The effect is due to the frictional contact, there being no variations in pressure. It is, in fact, deemed important to use means for insuring perfect contact, uniformity and constancy of pressure, and unvarying area of frictional surface.

The apparatus for carrying into effect the method of producing undulatory currents by frictional contact may be varied almost indefinitely, some of which variations are indicated in the drawings.

In Fig. 1 the conductor B is free to move in an aperture in the conductor B′, and is centrally secured to the diaphragm by a flexible connection, so that its own weight maintains the contact. The end of the rod fits in a socket, to which the flexible connection is attached. In this construction the conductor B, or "vibrating conductor," as it may be called, is preferably cylindrical in shape, and the conductor B′, or "fixed conductor," as it may be designated, is a centrally-perforated disk, secured in position by clamping it between a stationary support and a screw-cap.

It is evident, however, that instead of making the perforated disk the fixed conductor, it may be secured to the diaphragm, which may also be perforated, and the cylindrical rod may be attached to a stationary support, so that the variations in the currents are caused by the movement of the disk upon the rod.

It is not necessary that either of the conductors have the precise form shown. The rod could be triangular, square, or polygonal in cross-section, and the aperture in the disk may be made to correspond. The outside shape of the disk might be varied, also. The faces of the perforated conductor need not be flat, but may be rounded or curved, or shaped in any desired way. Other means than a screw-cap might be used to secure the fixed conductor in place, as well as means for adjusting the same nearer to or farther from the diaphragm.

I contemplate the employment of means for adjusting the conductors to compensate for wear.

The rod may be rigidly connected with the diaphragm, and means applied to the perforated conductor for maintaining the proper contact with the rod.

In Fig. 2 one of the conductors is attached to the plate by means of a vulcanized india-rubber ring, which I have found to constitute a perfect connection, so far as flexibility is concerned, without interfering with the transmission of the vibratory movement of the plate.

The material of which the conductors are preferably made is carbon; but metallic conductors alone or in connection with carbon may be used.

Instead of making what I have designated as the "rod" solid or of one piece, it may be formed by winding a thin sheet of metal (such as platinum, for example) upon a rod, the latter preferably being in the center of the sheet. When the conductor thus made is placed in the perforated conductor, the metallic sheet, being elastic, tends to unroll, and thus maintains proper frictional contact notwithstanding wear and tear.

In Fig. 2 the conductors are represented as rods arranged at right angles to each other. The shape of these rods may be varied, as above indicated in reference to the rod used in the form of apparatus shown in Fig. 1; but they are preferably square in cross-section. The rod may be provided with a sliding weight, G.

It is evident that this device, or a substantially equivalent one, might be used upon the rod-conductor in Fig. 1.

I have represented in Figs. 3 and 4 the vibratory conductors as rigidly secured to the plate, and contact is secured by supporting the fixed conductor upon metallic springs.

The various modifications and adjustments described with reference to the device as illustrated in Fig. 1 may be used with other forms, except in so far as from the nature of the construction itself they may be inapplicable.

In Fig. 3 a line is represented with a frictional telephone or transmitter at one end, and a receiving-telephone of the character shown in my aforesaid Letters Patent at the other end.

In Fig. 4 the apparatus are duplicated, a receiver and a frictional transmitter being shown at both ends.

In Fig. 5 is shown a line having at each end an apparatus which serves both as transmitter and receiver.

The fixed conductor is secured between the arms of the magnet, and the vibratory conductor is attached to the inductive plate or

armature, located in front of the poles of the magnet.

By using in all the forms of apparatus two or more vibratory conductors and a suitable number of fixed conductors with electric connections, so that the current passes through two or more points of contact, the effect is very much increased—that is, the amplitude of the electric undulations is increased, and the reproduced sounds become louder. The conductors in frictional contact may be united in series or in multiple arc.

It is evident that the construction of the conductors in Fig. 5 and their relative arrangement may be varied, in the manner indicated in the description of the instruments, separate from the receiving magnet and coils, and also that the conductors in frictional contact may be combined with a bar-magnet having a single coil about one pole, instead of with a horse-shoe-magnet, as shown in Fig. 5.

I have shown and described certain forms of apparatus, and have also indicated ways in which modifications may be made therein; but I do not profess to have described or indicated all the modifications and variations in construction and arrangement of details of which my invention is susceptible, as many others might be made without departing from the spirit of my invention.

Although I prefer that one of the conductors shall be perfectly stationary and the other vibratory, no ill effects are produced from a slight movement of the conductor which I have called "fixed" in contradistinction to the vibratory conductor, which is attached to and responds to the movement of the diaphragm.

The fixed or stationary conductor may be a cylinder supported at the ends in delicate bearings, and have a rotating motion imparted to it by the vibrations of the other conductor in contact with it. This produces a kind of friction denominated in mechanics as "rolling friction," and from which very good effects are obtained.

In the arrangement shown in Fig. 5 no battery is employed, and the current passed through the conductors in frictional contact is generated by the motion of the plate itself.

It is evident, of course, that a battery may be included in the circuit with good effect. The apparatus shown in Fig. 5 is designed to occasion a simultaneous variation in the electro-motive force employed, and in the resistance of the circuit; and the instrument can be so constructed that the resistance of the circuit diminishes while the induced current is increasing in intensity, and vice versa, in which case the amplitude of the electrical undulations is increased, and the resulting sound produced from the receiving-telephone becomes louder.

Any of the methods known to electricians for varying the resistance of an electric circuit proportionally to the motion of a plate or diaphragm vibrated by the human voice may be used in connection with a magneto-electric telephone to vary the resistance of the circuit through which the magneto-electric current is passed, so as to co-operate with the magneto-electric undulations, and produce from the receiving-telephone in the circuit louder sounds than could otherwise be produced if the circuit were to have an unvarying resistance.

The electro-motive force and the resistance through which it is passed may be varied in other ways so as to produce electrical undulations of great amplitude. For instance, a speaking-telephone similar to the instruments described above may be constructed in which the conductors in frictional contact are unlike metals, such as bismuth and antimony, far apart from one another in the electro-motive series.

Neither batteries nor permanent magnets need be used in connection with a transmitting-telephone of this construction, as the friction of the unlike substances will itself produce an undulatory current of electricity.

I have already constructed an apparatus similar to the instruments shown in this specification, excepting that the conductors in frictional contact were replaced by rubbers of glass and silk, so that frictional electricity was produced by the human voice. An instrument of this kind may be made to transmit articulate speech by means of frictional electricity generated by the voice itself.

Having thus described my invention, and the manner in which the same is or may be carried into effect, what I claim, and desire to secure by Letters Patent, is—

1. The method of producing currents of varying intensity in a circuit, the same consisting in altering the electric resistance of said circuit by the movement in frictional contact of electric conductors, substantially as described.

2. The method of transmitting speech, the same consisting in throwing upon a line electric undulations by increasing and diminishing the resistance of the circuit by the movement in frictional contact of electric conductors in accordance with the vibrations of a diaphragm responding to atmospheric vibrations, substantially as described.

3. The combination, with an elastic vibratory diaphragm, of a vibrating conductor attached thereto, and a conductor in frictional contact with said vibrating conductor, substantially as described.

4. The combination, with two or more conductors in frictional contact with each other, of an elastic vibratory plate or diaphragm, arranged to cause a movement past each other of said conductors in accordance with the vibrations of the diaphragm, substantially as described.

5. The combination, with an electric circuit, of two or more conductors resting in contact and forming part of said circuit, so that the current passes through the point or points of

contact of a vibratory plate or plates, for effecting a movement past each other of said conductors, substantially as described.

6. The combination, with an electric circuit, a source of electricity, and a receiving-instrument for reproducing sounds from the currents passing through said receiving-instrument, of a transmitting-instrument composed of an elastic vibratory plate or diaphragm and two or more conductors resting in frictional or sliding contact with each other and forming part of aforesaid circuit, one or more of said conductors being attached to and vibrating with said diaphragm, substantially as described.

7. A telephone or instrument to be used in the electric transmission of speech or sounds, the same consisting of a magnet, one or more coils surrounding its pole or poles, an elastic inductive plate or diaphragm located in front of said poles, a vibrating conductor attached to said plate, and a separate conductor in contact with said vibratory conductor, substantially as described.

8. The combination, in an electric circuit in which a receiving-instrument of ordinary or suitable construction is placed, of a magnet and associated coils, an elastic inductive plate or diaphragm in front of said poles, a vibrating conductor attached to said diaphragm, a conductor fixed with reference to said vibratory conductor and in contact therewith, and electrical connections for forming an electric circuit through said coils, and through said conductors from one to the other through their point of contact, substantially as described.

9. A transmitting-instrument or telephone composed of an elastic vibratory diaphragm secured in a frame, a perforated conductor fixed to said frame, a conductor attached to said diaphragm and free to move in the aperture in said perforated conductor, and devices or means for connecting the said instrument with an electric circuit, so as to form a part thereof, substantially as described.

10. The method of producing undulatory currents of electricity by the friction of conductors placed in an electric circuit, substantially as herein shown and described.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

ALEXANDER GRAHAM BELL.

Witnesses:
EWELL A. DICK,
A. POLLOK.