L. W. SOUTHGATE.

TELEPHONE RELAY OR REPEATER.

APPLICATION FILED MAR. 3, 1902.

961,815.

Patented June 21, 1910.

2 SHEETS—SHEET 1.

Fig. 1.

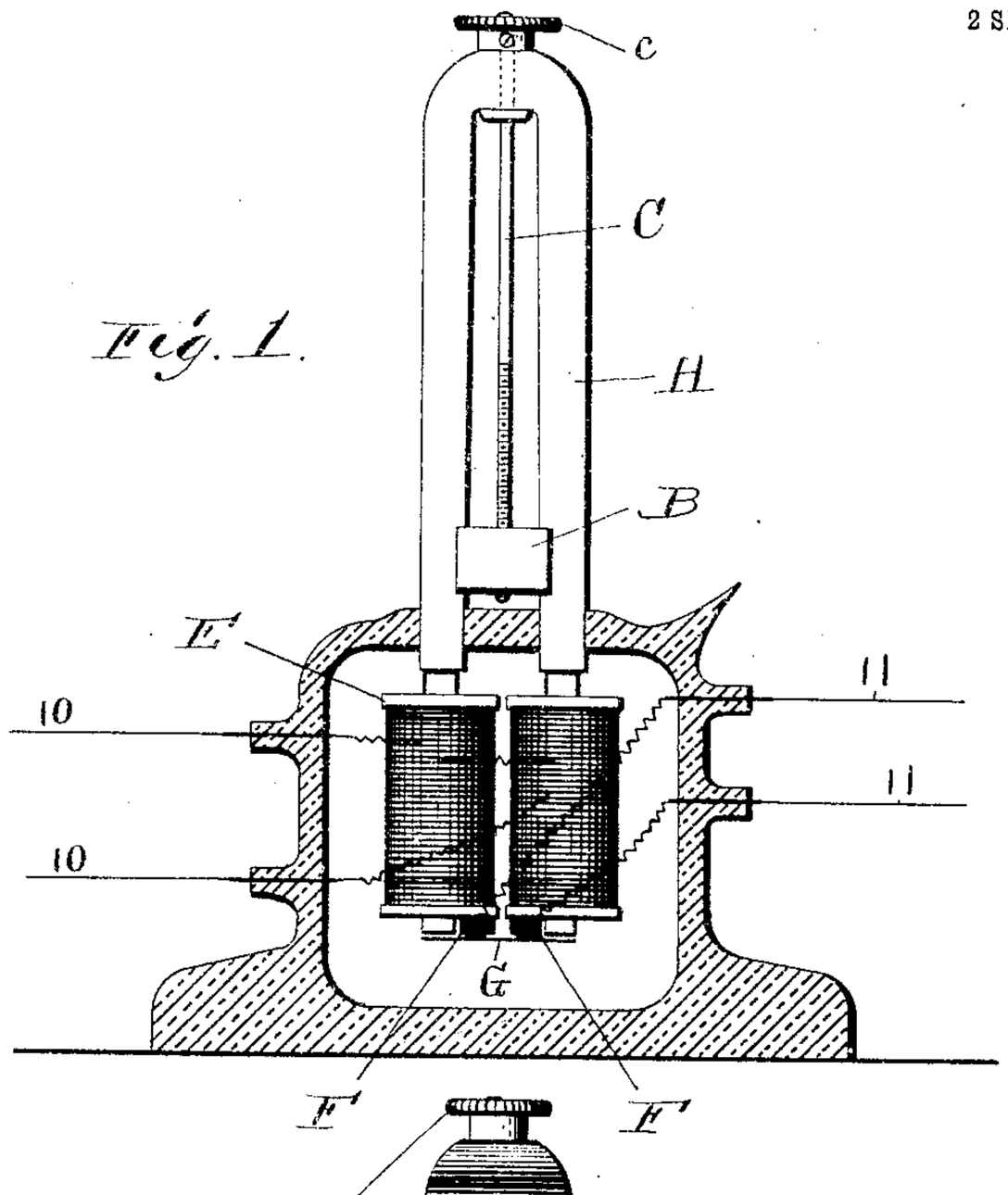


Fig. 3.

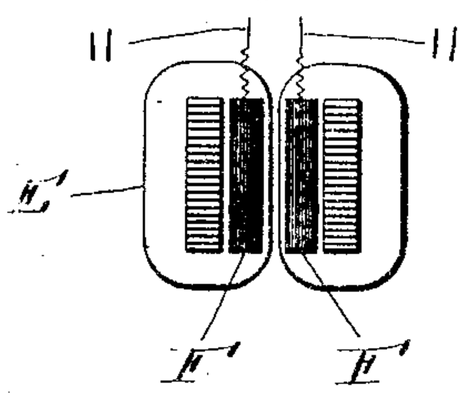


Fig. 2.

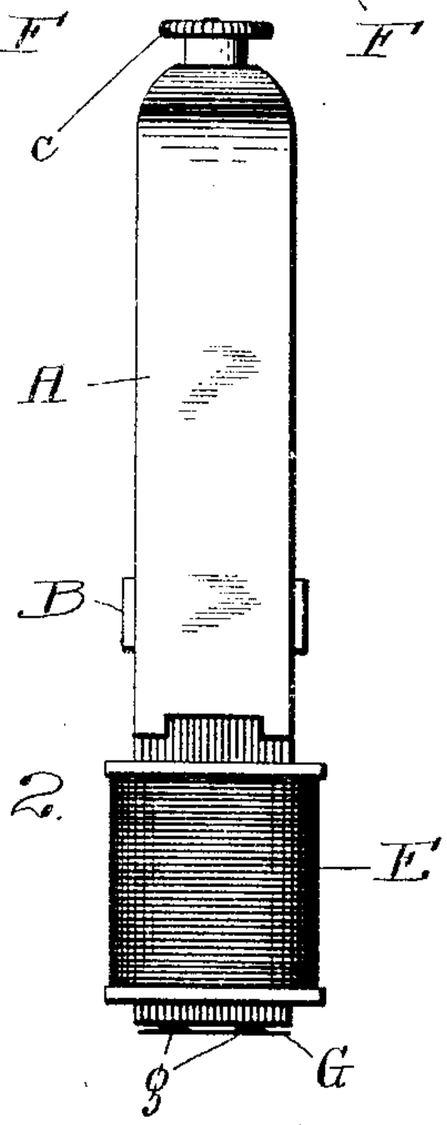


Fig. 4.

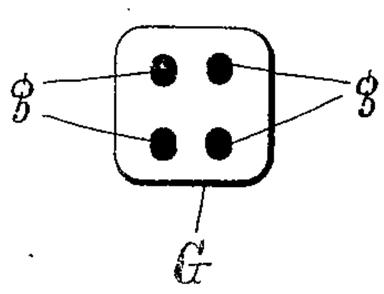
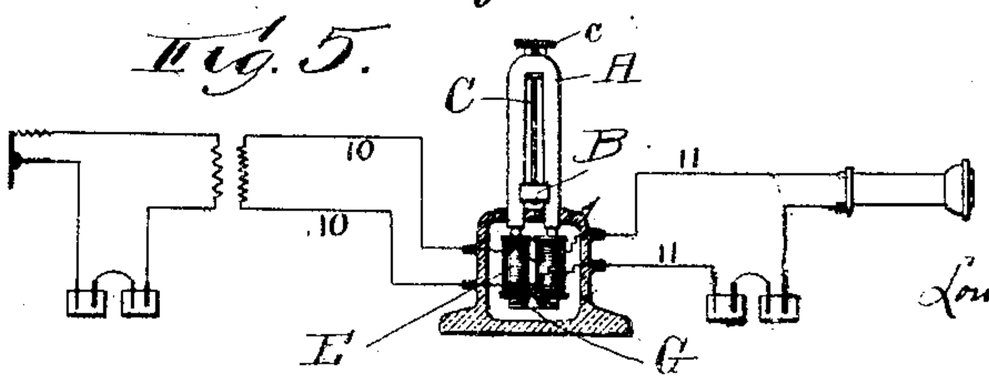


Fig. 5.



Witnesses:
W. E. Regan.
H. E. Forde.

Inventor:
Louis W. Southgate

L. W. SOUTHGATE.

TELEPHONE RELAY OR REPEATER.

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2 SHEETS—SHEET 2.

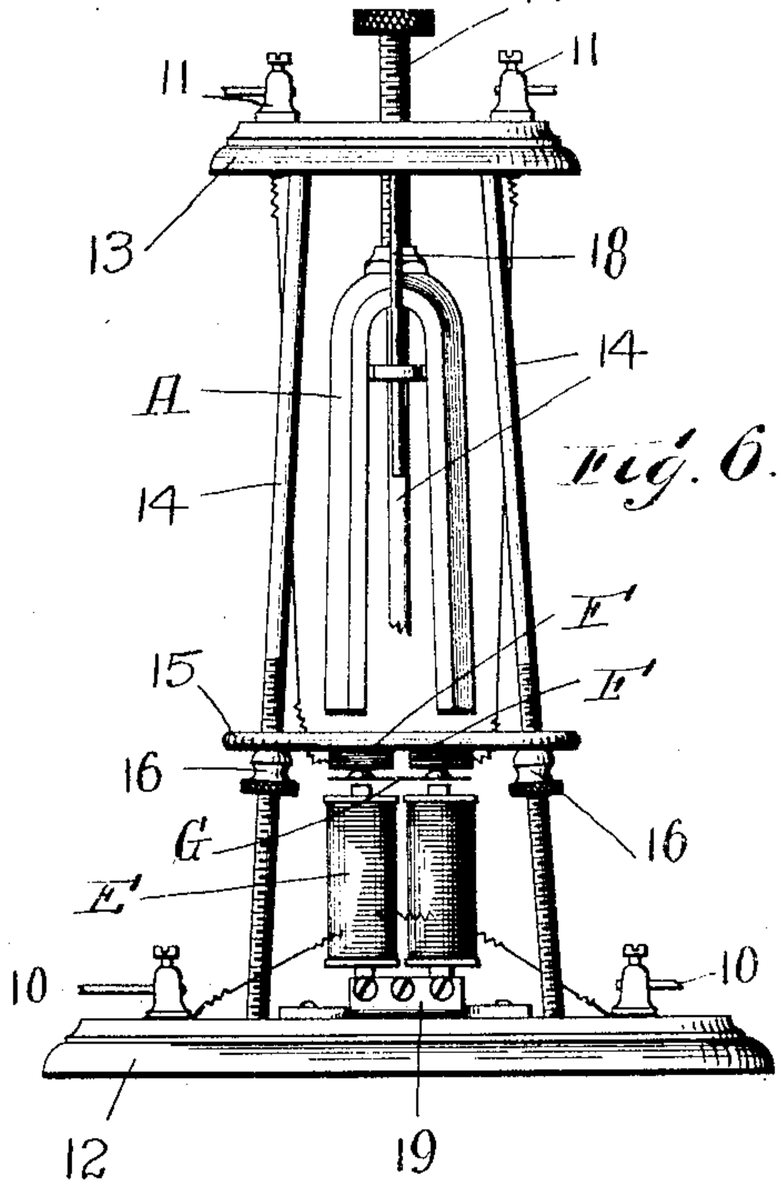

Fig. 6.

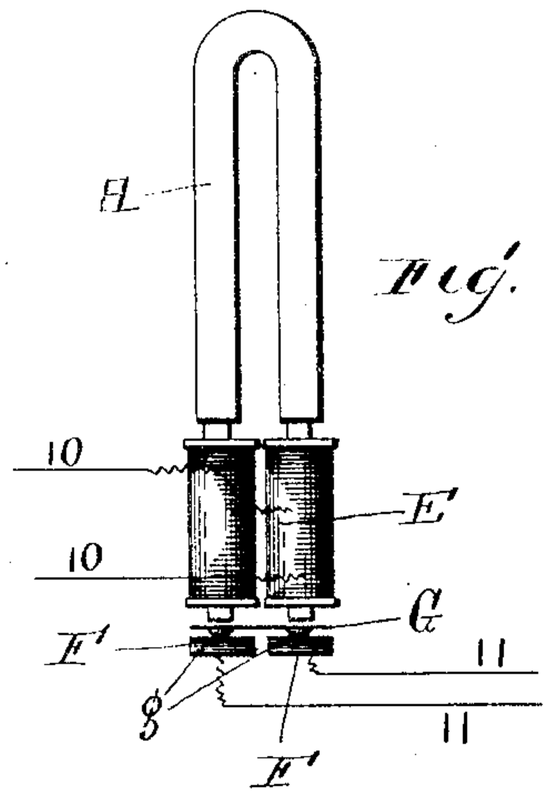

Fig. 8.

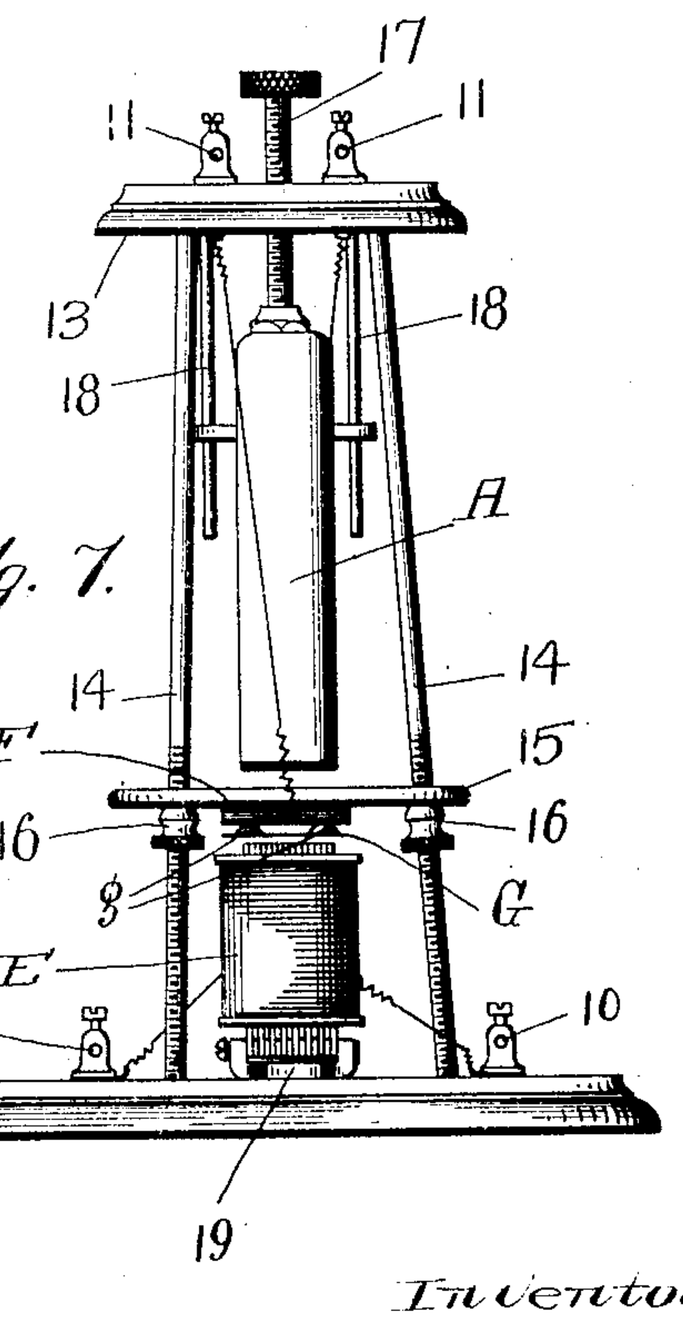

Fig. 7.

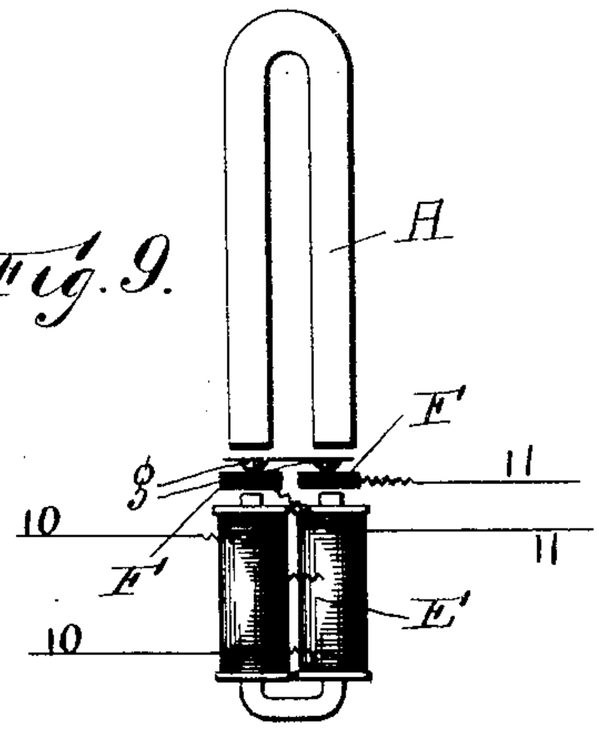

Fig. 9.

Witnesses:
M. E. Regan.
M. E. Forde

Inventor:
Louis W. Southgate

UNITED STATES PATENT OFFICE.

LOUIS W. SOUTHGATE, OF WORCESTER, MASSACHUSETTS.

TELEPHONE RELAY OR REPEATER.

961,815. Specification of Letters Patent. Patented June 21, 1910.

Application filed March 3, 1902. Serial No. 96,425.

To all whom it may concern:

Be it known that I, LOUIS W. SOUTHGATE, a citizen of the United States, residing at Worcester, in the county of Worcester and State of Massachusetts, have invented a new and useful Telephone Relay or Repeater, of which the following is a specification.

It has been proposed by numerous inventors since 1880 to make a telephone relay or repeater by using an electro-magnet or coil in a first circuit, and a variable resistance device or microphone in a second circuit, including a new source of electricity, said microphone being connected to an iron or steel diaphragm or armature mounted in close relation to the magnet, so that the microphone will be actuated thereby. While it is possible to make a telephone relay or repeater of this character, which will amplify, so far as I am informed and believe, no telephone relay or repeater has yet been brought to such practical point as to be capable of commercial use. The reason of this is that the sound vibrations of the human voice are made up of a complex series of fundamentals upon which are superadded in a complex manner a great variety of overtones or harmonics. These overtones or harmonics give the timbre which makes up the characteristic voice vibrations. These harmonics or overtones are very rapid, complex, and varied. In the ordinary telephone, when the voice vibrations are translated into electrical undulations or waves, a loss of character occurs, and similarly when the electric undulations or waves are translated into vibrations of the receiving diaphragm, another loss of character occurs. But these losses of character in the ordinary telephone are such that the resulting vibrations sufficiently represent the initial voice vibrations to convey intelligence. If, however, a telephone relay or repeater in which the percentage of loss of character is large be introduced into the telephone circuit, such further loss of character is encountered as to make the resulting vibrations of the receiver of such poor character as to outweigh the advantage of amplification obtained by the relay or repeater. For this reason, the transmission of speech through repeating or relaying mechanisms is not at present commercially attempted, as it would not be as good as it would be over the same length of line without a repeater or repeaters. On the other hand, if a relay or repeater could be devised in which the percentage of loss of character was small, the amplification of the current attained thereby would greatly extend and facilitate telephone service, as enough of the character of the voice vibrations would be retained for practical purposes.

The aim of the present invention is, therefore, to provide a telephone relay or repeater in which the loss or character of the incoming electric undulations or waves shall be very small.

In the heretofore proposed telephone relays or repeaters operating on the principle above described, several difficulties have been encountered. The first is the magnetic lag of the receiving electro-magnet or coil. This is not a very material loss, and can be practically neglected. I render this difficulty as small as possible by making the core of the electro-magnet out of laminated soft iron, as hereinafter described, so that the translation of the incoming electric undulations into magnetic variations will be prompt. The second and principal difficulty heretofore encountered, I believe, is the mechanical lag or inertia of the microphone, which forms part of the relay or repeater. The force exerted by the receiving electro-magnet of the relay is, of course, very minute and only a fraction of the force of the sound-waves originally impacting on the original transmitter. The inertia of the moving part or parts of the microphone in the relay thus becomes such retarding factor that the small magnetic variations caused by the original overtones will not actuate the microphone, and, hence, loss of character occurs. Moreover, in most forms of relays which have been heretofore proposed, a diaphragm or spring arm is interposed between the electro-magnet and the movable electrode of the microphone, so that not only the inertia of the movable electrode, but also the relatively heavy tension of the spring or resistance of the diaphragm to flexure must be overcome to operate the microphone. Because of this difficulty, a further fault is encountered, as, when the movable part of the microphone is arranged in connection with a spring arm or diaphragm, the same obviously will be much more responsive to a tone which is the same or harmonically the same as the inherent rate of vibration of the spring arm or diaphragm. Hence, not only will the microphone be more responsive to this note

but a persistent dominant note (which I believe is caused by this capability of the microphone to respond more readily to some particular rate or rates of vibration) is soon struck, and a steady, loud tone proceeds from the microphone, preventing the transmission of speech. This second difficulty, I believe, is the point which has prevented the development and introduction of a successful relay or repeater. While it is impossible to make a relay or repeater which changes the forms of energy work exactly in phase or step with the original vibrations, if the loss of character can be reduced to a small percentage, a relay or repeater can be advantageously employed. To overcome this mechanical difficulty, I have devised the following relay or repeater: The microphone of my improved relay or repeater contains, as its principal novel feature, an armature which is unattached and which is held in position simply by magnetic supension so as to form practically a floating armature, held in position only by magnetic pull. The way this is preferably done is to use two separated carbon electrodes side by side, and to use an extremely light, delicate, reed-like armature to bridge the space between the same, this armature thus forming with said electrodes a simultaneous double-acting microphone in which the armature is a third movable electrode. This armature is held in critical contact with said electrodes by a permanent magnet, the pull of which may be adjusted. The receiving electro-magnet is placed in immediate proximity to said armature. The armature is preferably held up against the two electrodes by the pull of the permanent magnet. By this construction, the armature is most delicately suspended and is capable of motion by a very slight magnetic change. Further, as the said armature, by this construction, is made of extremely light weight, its inertia will be very small. Furthermore, as the armature is unattached, that is as there is no diaphragm or spring arm in the device, one large factor in producing the dominant tone is eliminated. By these novel features, a relay or repeater is produced in which the loss of character is small.

In the accompanying two sheets of drawings forming part of this application, I have shown what I now believe to be the best way for practicing the invention, and several modifications thereof.

Referring to said drawings, and in detail, Figure 1 is a cross-sectional view of a telephone relay or repeater constructed to embody my invention; Fig. 2 is a side view of the operative parts thereof; Fig. 3 is a plan view showing the construction of the microphone; Fig. 4 is a plan or face view of the floating armature; Fig. 5 is a diagrammatic view illustrating one way the relay can be used; Fig. 6 is a front elevation, and Fig. 7, a side elevation of a modified form of relay constructed to embody my invention; and Figs. 8 and 9 are diagrammatic views illustrating different arrangements of the parts as modifications.

Referring to the drawings, and in detail, A designates a permanent magnet of the horse-shoe type. A soft iron piece B is fitted to the legs thereof so as to be adjustable back and forth in the magnet. A brass-screw C having a thumb-wheel *c* is journaled in the apex of the magnet and is tapped into the adjustable piece B. By turning the thumb-wheel *c*, the piece B can be adjusted back and forth in the magnet, and thus more or less of the lines of force shunted therethrough so that the strength of the poles can be adjusted. Secured to the poles of the permanent magnet, is an electro-magnet E. This electro-magnet is made up of two cores, each comprising a series of thin, soft iron strips secured to each pole of the permanent magnet A. The strips of soft iron are preferably varnished or japanned so as to be electrically insulated from each other. Electric insulating material is preferably arranged between the poles of the permanent magnet and the cores of the electro-magnet, as indicated by a heavy line in Fig. 2, so as to prevent short circuiting of the microphone through the permanent magnet. The usual bobbins of insulated wire are placed on the cores to make up the electro-magnet E, and the first circuit 10—10 is electrically connected thereto. On the ends of the electro-magnet bobbins are arranged electrodes F—F, which are preferably made of carbon. These carbon electrodes are preferably plated on their backs with metal, and wires are secured thereto which are connected to the relay or repeating circuit 11—11. The carbon electrodes F—F are preferably ground off smooth with the poles of the electro-magnet. The electrodes F—F thus stand side by side with their working faces in the same plane with said poles. The two electrodes F—F are separated from each other so that there is no electric connection between them. Bridging the space between the said electrodes, is an armature G. This armature is preferably made of a shape just about to cover the poles of the electro-magnet and the carbon electrodes F—F. This armature is made out of very thin, soft iron. The same preferably has points *g*—*g*—*g*—*g* bearing on the electrodes F—F to form a double microphone. These points may be little carbon pieces or may be simply humps in the armature. When the armature is made entirely out of metal, I preferably platinum-plate the same. Four points *g*—*g*—*g*—*g* are preferably used, so that there will be two points in contact with

each electrode. The relay as thus constructed is preferably placed in a glass envelop from which the air is exhausted. This can be done in a convenient way by embedding the lower part of the permanent magnet A in a glass envelop, by embedding the leading-in wires of the two circuits 10—10 and 11—11 in said envelop, by exhausting the air from said envelop, and by sealing the same as an ordinary incandescent lamp is sealed. When the relay is constructed as thus described, the same is arranged between the two circuits in any desired manner, as, for example, as shown in Fig. 5, where the incoming undulations in a first circuit which contains a transmitter are relayed or repeated into a second circuit which contains a battery and a receiver. Of course, the relay or repeater may be connected in circuit in any other desired way. When the device is connected in circuit, the piece B is adjusted so that the armature will be brought to critical contact in the microphone. Then the incoming undulations of the first circuit will be translated into magnetic variations by the electro-magnet, which variations will be faithfully copied by the strains put on the floating armature, which thereby will actuate the microphone of the relay as said armature forms a movable electrode therein.

In Figs. 6 and 7, a modification is shown. This modification is made up of a base 12 and top 13, which are connected by screw-threaded rods 14. The rods 14 support a hard rubber platform 15 by nuts 16, which are threaded on the rods. The said platform carries the two electrodes F—F. The electro-magnet E is arranged below the microphone, and the floating armature is kept in position by the permanent magnet A, which is arranged above the microphone. The permanent magnet is adjusted by a screw 17 to adjust the pull of the same. The screw 17 is journaled in the top of the electro-magnet and screw-threaded into the top 13. The magnet A is held from turning during adjustment by rods 18—18, which project through holes in a small vulcanite or rubber piece arranged in the magnet. The laminated cores of the electro-magnet are held in place by a brass clamp 19.

While it is preferred to have the floating armature held up in contact with the two electrodes, so far as the broad scope of my invention is concerned, the floating armature can be arranged above the electrodes, as shown in Fig. 8, where the electro-magnet is shown as arranged above the same, or, as in Fig. 9, where the electro-magnet is shown as arranged below the same. The permanent magnet A may or may not be used, as desired, in these modifications. The preferred form of the device, however, is that shown in Figs. 1 and 2, or Figs. 6 and 7, wherein the floating armature is held up in magnetic suspension, the lines of force of which magnetic suspension are changed by the action of the electro-magnet.

Many other forms of devices may be constructed to embody the principal features of my invention without departing from the broad scope thereof as expressed in the claims.

Having thus fully described my invention, what I claim and desire to secure by Letters-Patent is:—

1. In a telephone relay or repeater comprising a coil or electro-magnet and a microphone, an unattached armature responsive to magnetic variation arranged in the field of said coil or electro-magnet for actuating the microphone.

2. In a telephone relay or repeater comprising a coil or electro-magnet and a microphone, a magnetically suspended armature responsive to magnetic variation for actuating the microphone.

3. In a telephone relay or repeater comprising a coil or electro-magnet and a microphone, a magnetically suspended unattached armature responsive to magnetic variation arranged in the field of said coil or electro-magnet for actuating the microphone.

4. In a telephone relay or repeater comprising a coil or electro-magnet and a microphone, an unattached armature arranged in the field of said coil or electro-magnet and forming the movable electrode of the microphone.

5. In a telephone relay or repeater comprising a coil or electro-magnet and a microphone, having a magnetically suspended electrode otherwise free to move by gravity responsive to magnetic variation arranged in the field of said coil or electro-magnet.

6. A telephone relay or repeater comprising a coil or electro-magnet; and a microphone, consisting of two electrodes, and a third unattached electrode actuated by magnetic variation arranged in the field of said coil or electro-magnet.

7. A telephone relay or repeater comprising a coil or electro-magnet; and a microphone, consisting of two electrodes and a third electrode actuated by magnetic variation held in magnetic suspension in contact with the two electrodes.

8. A telephone relay or repeater comprising a coil or electro-magnet; and a microphone having two electrodes and a third unattached electrode actuated by magnetic variation held in magnetic suspension in contact with the two electrodes.

9. A telephone relay or repeater comprising a coil or electro-magnet; and a microphone having an electrode actuated by magnetic variation arranged in the field of said electro-magnet or coil and a permanent

magnet holding this electrode magnetically suspended in proper contact.

10. A telephone relay or repeater comprising a coil or electro-magnet; and a microphone having an electrode actuated by magnetic variation arranged in the field of said electro-magnet or coil, a permanent magnet holding this electrode magnetically suspended, and means for adjusting the pull of the permanent magnet on said electrode.

11. A telephone relay or repeater comprising a coil or electro-magnet; and a microphone, having an electrode actuated by magnetic variation arranged in the field of said electro-magnet or coil, a permanent magnet for holding this electrode magnetically suspended, and an adjustable piece for adjusting the pull of the permanent magnet on the electrode.

12. A telephone relay or repeater comprising a coil or electro-magnet, two electrodes, a third electrode movable by magnetic variation arranged in the field of said coil or electro-magnet, and a permanent magnet holding the third electrode in place in contact with the two electrodes.

13. A telephone relay or repeater comprising a coil or electro-magnet, two electrodes, a third electrode movable by magnetic variation arranged in the field of said coil or electro-magnet, and a permanent magnet in line with the electro-magnet for holding the third electrode by magnetic suspension in contact with the two electrodes.

14. A telephone relay or repeater comprising a coil or electro-magnet; and a microphone having two electrodes, a third electrode responsive to magnetic variation, and a permanent magnet above the microphone for holding the third electrode in position.

15. A telephone relay or repeater comprising a microphone consisting of two electrodes, a third magnetic electrode, an electromagnet, and a permanent magnet arranged above the microphone.

16. A telephone relay or repeater comprising an electro-magnet; and a microphone comprising two electrodes arranged side by side, and a third electrode bridging the space between the same, the poles of the electro-magnet and the electrodes being arranged in the same plane.

17. A telephone relay or repeater comprising an electro-magnet; and a microphone having two electrodes and a third electrode responsive to magnetic variation, the two electrodes being arranged inside of the poles of the electro-magnet.

18. A telephone relay or repeater comprising a permanent magnet, an electro-magnet, and a microphone having a member responsive to magnetic variation, a glass envelop for the microphone, and means for adjusting the pull of the permanent magnet from the outside of said envelop.

19. A telephone repeater having a receiving circuit, a receiving magnet, a transmitting circuit containing a variable resistance transmitting medium, and an armatured electrode connecton between said magnet and said medium, said connection having unrestricted vibratory movement due solely to the pull of the magnet and the weight of the said connection to transmit current variations from said receiving circuit to said transmitting circuit.

20. A telephone relay having a receiving circuit, a receiving magnet, a transmitting circuit, a variable resistance transmitting medium in said transmitting circuit, and an armature electrode connecting said magnet and said medium, said electrode being arranged for free vibratory movement in a vertical direction and positioned wholly by the action of the magnet and the weight of the armature electrode member thereby to vary the conductivity of said medium and to transmit current variations from said receiving circuit to said transmitting circuit.

In testimony whereof I have hereunto set my hand, in the presence of two subscribing witnesses.

LOUIS W. SOUTHGATE.

Witnesses:

PHILIP W. SOUTHGATE,

MARY E. FORDE.