(No Model.) 2 Sheets—Sheet 1.

S. D. FIELD.

TELEPHONE.

No. 540,969. Patented June 11, 1895.

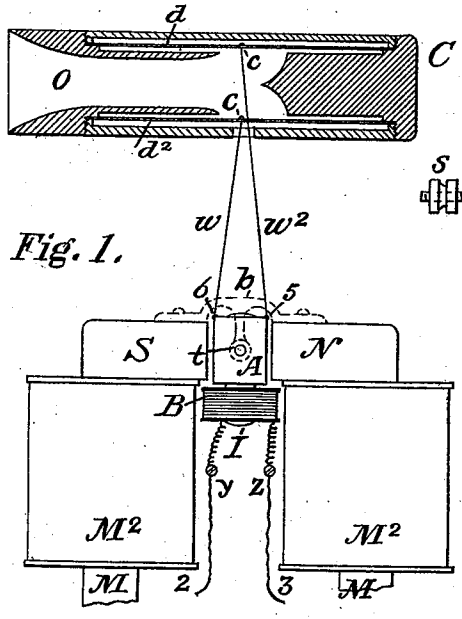


Fig. 1.

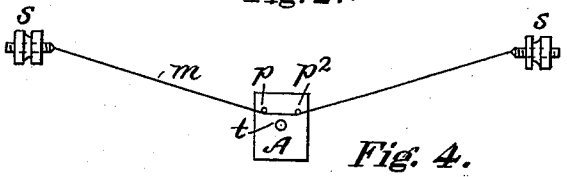


Fig. 2.

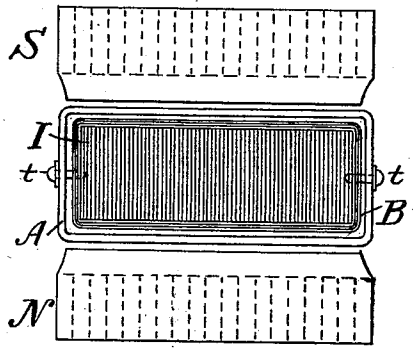


Fig. 4.

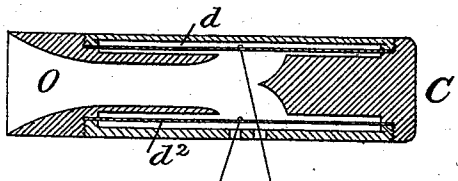
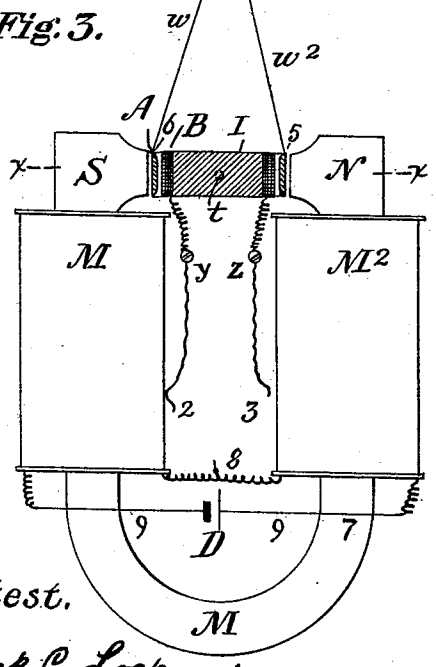


Fig. 3.



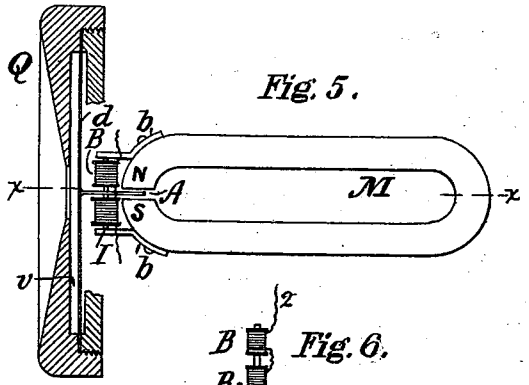


Fig. 5.

Fig. 6.

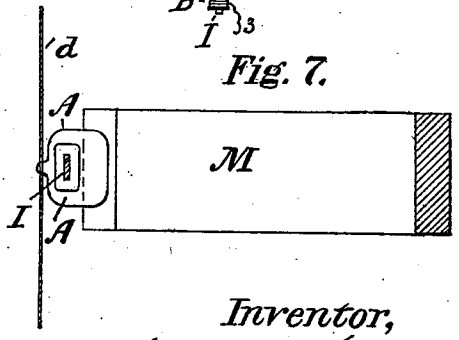


Fig. 7.

Attest.

Frank C. Lockwood.

Fromilli Pierce

Inventor,

Stephen D. Field

(No Model.) 2 Sheets—Sheet 2.

S. D. FIELD.

TELEPHONE.

No. 540,969. Patented June 11, 1895.

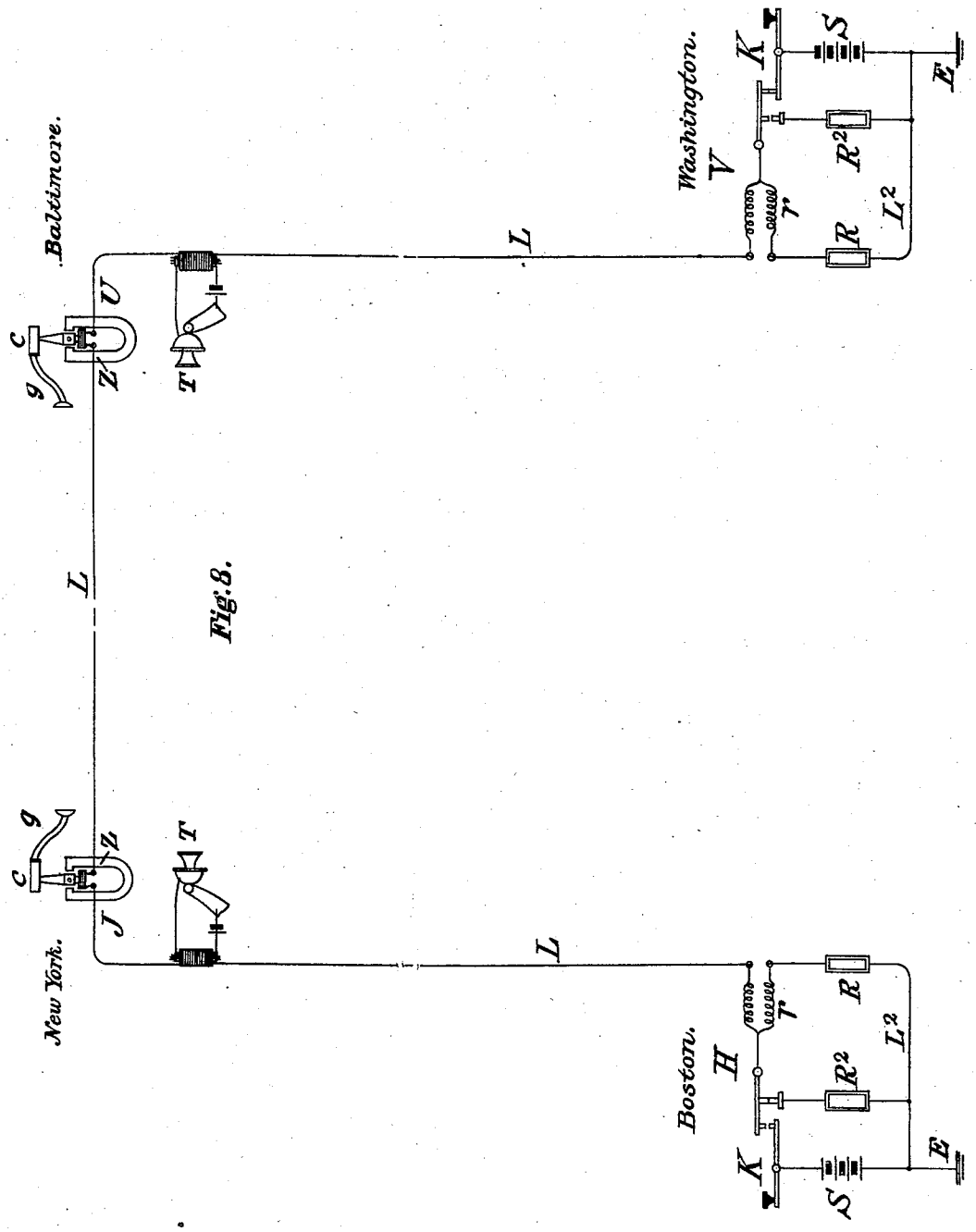


Fig. 8.

Attest,
Joseph A. Gately
Fromwille Pierce

Inventor,
Stephen D. Field.

UNITED STATES PATENT OFFICE.

STEPHEN DUDLEY FIELD, OF STOCKBRIDGE, ASSIGNOR TO THE AMERICAN BELL TELEPHONE COMPANY, OF BOSTON, MASSACHUSETTS.

TELEPHONE.

SPECIFICATION forming part of Letters Patent No. 540,969, dated June 11, 1895.

Application filed December 5, 1894. Serial No. 530,907. (No model.)

To all whom it may concern:

Be it known that I, STEPHEN DUDLEY FIELD, residing at Stockbridge, in the county of Berkshire and State of Massachusetts, have invented certain Improvements in Electric Telephones, of which the following is a specification.

My present invention relates to the telephonic transmission and reproduction of speech, and more particularly to magneto telephones.

I have invented a magneto speaking telephone capable of operating satisfactorily either as a receiving or transmitting instrument, which though particularly sensitive to electrical impulses or variations of extremely rapid frequency, and therefore of high efficiency as a receiver or reproducer of speech or sonorous vibrations—is by reason of its short magnetic moment practically responsive to such rapid rhythmical vibrations only; and is so sluggishly and inappreciably affected by relatively slow electrical changes such as those incident to the transmission of telegraphic signals, or those developed by a large proportion of such extraneous and intrusive currents as ordinarily disturb telephonic circuits, (even though these may be of much greater volume,) that with respect to them it may be considered as practically irresponsive. From the fact that this instrument is as stated substantially unaffected by extraneous disturbing currents or by telegraphic currents traversing the circuit with which it may be associated, and actually circulating through a portion of its own helices, while it responds perfectly to voice currents, and currents developed by sonorous vibrations, I term it a "discriminative telephone." It is based upon the fact that a single impulse (or even a slow succession of impulses) possessing the general character of those concerned in the transmission of speech is of itself incapable of producing any very perceptible effect upon the diaphragm of a speaking telephone, it requiring a rapid sequence of such vibrations to put the diaphragm in motion and produce sound.

In devising the discriminative telephone, I have abandoned the use of polarized electromagnets connected directly in the line circuit and acting upon or acted upon by the vibratory diaphragm, such arrangement being too slow in operation. In place thereof, I have organized an induction apparatus in mechanical association with the diaphragm comprising a main line coil, a closed short or low resistance circuit in mutual or reciprocal inductive relation thereto, and an intense polarizing medium for such induction apparatus.

The main circuit coil of my telephone is a winding of fine wire closely wound round an iron core, preferably very short, and formed of thin laminations; and round the same core in inductive relation to the fine wire coil is placed a closed circuit of extremely low resistance, such as a ring or endless ribbon of metal delicately hung or poised at its center of gravity, and so mechanically connected with a vibratory diaphragm or diaphragms, that the oscillations of the ring will produce vibrations of the diaphragm, and that *per contra*, if the diaphragm be vibrated by an external force, it will oscillate the ring. This combination is mounted in the field of a strong polarizing magnet, in such a manner that the ring can readily be oscillated across the lines of force of the said magnet.

In the drawings which illustrate this specification, Figure 1 represents a magneto-telephone involving my invention, and Fig. 2 a means of adjustment of the moving armature thereof. Fig. 3 is a modified and improved form of the instrument; and Fig. 4, an enlarged view in horizontal section on the line $x\ x$ of Fig. 3 through the pole-pieces, coils, and core. Figs. 5 and 7 are respectively plan and vertical sectional views of another modification, the latter on the line $x\ x$ of the former; and Fig. 6, a detail thereof. Fig. 8 illustrates the application of my discriminative telephone to a system of composite transmission.

The principle of my invention is clearly manifested by Fig. 1. In it are two diaphragms $d\ d^2$, suitably mounted in a case C, provided with an opening or sound channel O, serving to receive or emit sound waves; and to which if desired, a flexible or other speaking tube can be attached in a manner well understood.

M is a strong U magnet shown as an elec-

tro-magnet, adapted to be excited by the magnetizing helices M^2, although a permanent magnet will answer; and S N are pole pieces thereof, an intense magnetic field being developed between them. An iron core I is placed in this magnetic field, and a fixed coil B formed of a considerable number of convolutions of fine insulated wire is wound round it, or placed thereon. Its terminal wires connect with binding posts y z, and by means of these with the line or main circuit wires 2 and 3.

An oscillating armature A forming a closed circuit of very low resistance is delicately hung in the magnetic field surrounding a portion of the iron core I, and in close inductive relation to the fine wire helix B. This armature is preferably made of a single turn or ring of copper strip or ribbon having it ends united to form a circuit conductively closed on itself; and can conveniently be hung on trunnions, one of which is shown at t. It is mechanically connected with the diaphragms by means of two stiff but fine cords, or wires w w^2, extending from opposite points 5, 6 of the armature to the centers c of the two diaphragms respectively; steel wire being found to be well adapted for this purpose.

In using this instrument as a transmitter, the diaphragms, being mechanichally vibrated by the impact of sound waves originating near the opening O, co-operate with each other to oscillate the low resistance armature A in the magnetic field, and the currents developed in its circuit by such motion induce corresponding currents of raised potential in the fine wire coil B, which are the working currents and pass to the line and distant station, there to operate the receiver; but when the telephone is acting as a receiver, the line currents generated at the distant station and circulating in the fine wire helix, induce strong currents in the copper ribbon which in this case is the secondary circuit. Now since the coils are between the poles of the polarizing magnet, the lines of force extending between the said poles pass directly through them. Hence the secondary currents induced in the oscillatory armature, cutting as they do the lines of force of a specially strong magnetization, tend to cause the said armature to rotate and do enable it to oscillate on its trunnions, its motion being at once communicated by means of the wires w w^2, to the diaphragms, which are thus thrown into vibrations copying the original sound produced vibrations, and which therefore reproduces the original sounds.

I have found this apparatus to reproduce speech with satisfactory loudness, and with unusually clear articulation.

In connection with this instrument I have found the adjustment device illustrated in Fig. 2 to be highly convenient and useful. It serves as an adjustment enabling the armature to resume its normal and central position with great rapidity, and consists in securing a stretched cord m of india rubber, or a fine steel or brass wire at its two ends to suitable fixed points which may be provided with adjusting screws s, and attaching the same near its center to the armature A at the two points or pins p p^2, so that in the oscillations of the said armature, as a strain is imparted to the cord at one point, the tension is diminished to an equal extent at another point. The armature in turning on its pivot t, will put tension on the cord m through one of the pins p p^2, releasing an exactly equal amount of pressure through the other pin, so that the cord or fiber remains neutral while at the same time the armature is held or brought back to its center exactly.

Fig. 3 shows the working parts of an improved instrument embodying the same principles of construction and operation. In this case, the polarizing magnet M with its poles N S and its magnetizing helices M^2 are the same as in Fig. 1. The helices M^2 conduct a current produced by the source D, and conveyed to and between them by the wires 7, 8 9. The distinctive features of this modification are, that the iron core is finely laminated, is made very short, and is placed wholly in the most intense portion of the field directly between the pole pieces; that the fine wire coil B is wound so as to closely surround the whole of the said core; and that the closed low resistance armature entirely surrounds but does not touch the fine wire coil.

Fig. 4 may be regarded as a sectional view taken through the line x x of Fig. 3. It shows the laminations and preferred form of the iron core I, and indicates that the magnet M may be a compound magnet, or be itself laminated. It also illustrates with great clearness the shape and relative arrangement of the fixed fine wire coil B, the copper band constituting the closed circuit of the oscillatory armature A, and the trunnions t, on which it is pivoted. The core may be secured in a brass bracket or support b attached to the poles as indicated by broken lines, in Fig. 1, or in any way, but it is not thought necessary to more than indicate such attachments, they being mere mechanical details familiar to those skilled in the art. The terminals of the fine wire coil connect with binding screws y z, to which the line wires as in the former case may be attached. As in Fig. 1, the diaphragms d d^2 have mechanical connections w w^2, with the oscillatory armature A; and the vibrations of either may be imparted to the other.

When a prolonged line current is caused to pass through the coils of an electro-magnet as in an ordinary telephone, the inductance of the coiled wire, and the magnetic inertia of the iron core serve to prolong its effect, and it is liable to be the cause of considerable disturbance; but the laminated core of this form of my instrument is very short, by preference not more than one quarter of an inch in length; and being so short, slow pulsations

of current produce an exceedingly minute inductive effect in the induction ring, but quick pulsations and reversals produce a relatively strong and prompt response in the induction ring which is thus caused to vibrate across the lines of force of the polarizing magnet in exact unison with the primary impulses in the line coil. When single impulses of current, though of considerable volume, traverse the fine wire line coil, but a single impulse is induced in the low resistance secondary or ring circuit, and this is so short that any effect it may tend to produce upon the associated mechanism is practically imperceptible.

In this instrument therefore, the magnetic inertia of the core is reduced to a minimum, and the disturbing effect known as self-induction is nearly eliminated, the line coil being closely surrounded by a short closed metallic circuit in which currents opposed in direction to those of the line, circulate. The reciprocal reaction of the line and induced currents on each other assists the former in their passage through the instrument winding, and greatly reduces the lag due to the self induction of closely coiled wire.

In the forms which so far have been considered, two diaphragms have been shown and described; but though generally advisable, it is not always necessary to employ two, and in my improved telephone, the oscillating ring circuit, the core, and the fixed line coil can readily be associated with a single diaphragm by turning the sound opening round to a position perpendicular to the diaphragm d^2, and by attaching a single actuating wire w to any desired point 5 or 6 on the front end of the armature A. A more portable structure however, requiring but a single diaphragm but equally founded on the principles enunciated herein, can be made on the plan illustrated in Figs. 5, 6, and 7. M is the magnet, shown in this instance as a permanent magnet, and d is the vibratory diaphragm mounted in the usual cap piece Q, which is provided in the ordinary way with the sound opening O, and vocalizing chamber v. The iron core I, held in brass brackets b screwed to the magnet, supports the fixed line coil B which as shown may be in two divisions, one at each end.

The low resistance closed circuit armature A (shown in side view in Fig. 7) is secured at one point to the diaphragm, surrounds the central portion of the coil I, and extends into the magnetic field where it is adapted to vibrate between the poles and set up currents in the line coil B; or conversely, have currents induced in it by the said line coil, which cause it to move within the field and to vibrate the diaphragm.

In all forms of my telephone, the inductive circuit armature presents in its movements a sharp edge to the air and the resistance offered to it by the air is therefore very slight.

The advantages attaching to telephones constructed on the foregoing plan, are especially emphasized when such telephones are employed on "noisy circuits" so called; that is circuits which are invaded by parasitical currents, induced by or leaking from adjacent conductors, or the earth. When these currents have a frequency considerably below that involved in speech transmission, their disturbing effects on my telephone is unimportant. Therefore by its employment in association with earth completed circuits, better results can often be attained than those reached by ordinary telephones, even when associated with metallic circuits. This property of discrimination, marks my telephone, as being particularly well adapted for composite systems of telegraphic and telephonic transmission; and I have experimentally demonstrated that any two such instruments when placed in the circuit of a telegraph line, take no cognizance of the Morse signals, while vocal messages are readily exchanged between them. I have passed Morse writing through such telephones, using a current of eighty millampères, without producing disturbing sounds of a strength sufficient to interfere with the successful and satisfactory transmission of speech by an ordinary carbon transmitter. Its employment therefore in a composite system enables me to dispense with electromagnetic resistances and such similar graduating devices as have heretofore invariably been required to so modify the Morse signals that they will not be manifested in the receiving telephones. Heretofore the plan has been to modify the telegraphic currents, to the end that they shall not operate the receiver; but by my invention the telephone is so made that it will not manifest the unmodified and therefore unhampered telegraphic currents.

In Fig. 8, is illustrated a composite system of simultaneous telegraphy and telephony over a single conductor; and many modifications will readily suggest themselves to those skilled in the art. L is a line extending between two terminal stations, say Boston and Washington, where it has earth connections, and passing through two way offices, New York and Baltimore, the said stations for briefer reference being marked respectively H, J, V, and U. As shown, H and V are telegraph stations provided each with a battery S, a duplex relay r, an artificial or balancing line L^2, including an adjustable resistance R a normal resistance R^3, and a continuity preserving key K. J and U are telephone stations provided with receiving telephones Z, constructed in accord with the principles of my invention, and having flexible hearing tubes g attached to their casings c, and transmitters T of any preferred form. The telephones Z will not be disturbed by or interfere with the passage of the telegraphic currents.

Of course if ordinary keys are employed at the telegraph stations, they must be bridged by condensers, in a manner well understood.

I have now fully described my present invention, its construction and operation, and I claim—

1. A magneto telephone having two independent circuit windings in inductive relation to each other, one of the said windings being in mechanical connection with the diaphragm and forming a closed circuit complete in itself, and the other being adapted for connection in a main line circuit, substantially as described.

2. In a magneto telephone, the combination of a movable armature attached to the diaphragm and having a low resistance circuit closed on itself, and a fixed main or line circuit coil or winding in inductive relation thereto; the said movable and fixed windings being placed together in a magnetic field of force; substantially as described.

3. In a magneto telephone, the combination substantially as hereinbefore described, of an iron core; a fixed main or line circuit coil or winding of many turns surrounding the said core; and a movable armature winding attached to a vibratory diaphragm, and constituting a low resistance local circuit closed on itself, also surrounding the said core, and adapted to oscillate thereon; the said core and its windings being in reciprocal inductive relation, and placed together in a magnetic field.

4. A discriminative telephone, comprising the following elements in combination: an intense polarizing medium; an iron core polarized thereby; a main circuit winding of fine wire surrounding the said core; a movable low resistance local circuit winding, also surrounding the said core, and pivotally mounted to oscillate freely in the magnetic field; and a vibratory diaphragm mechanically connected with the said movable circuit winding, whereby vibrations produced in either are communicated to the other; substantially as specified.

5. In a discriminative telephone, a strong polarizing magnet; an iron core mounted between its poles; a fixed main circuit coil or helix surrounding the core; and a vibratory diaphragm; combined with an oscillatory armature, consisting of a single turn of metal ribbon or strip closed on itself to form a local circuit in mutual inductive relation to the fixed helix: the said armature being hung on trunnions over the core in the magnetic field, mechanically connected with the diaphragm, and provided with sharp edges, whereby the resistance offered by the air to its oscillations is minimized, substantially as specified.

6. A discriminative magneto telephone comprising a polarizing magnet establishing a strong magnetic field; an iron core mounted in the said field; a main circuit coil of fine wire wound over the said core; and a low resistance armature winding closed on itself to constitute a complete local circuit surrounding the said fine wire coil and hung on trunnions to oscillate within the magnetic field and about the fine wire coil and core; and a vibratory diaphragm having a mechanical connection with the said oscillatory armature, whereby the initial vibrations of either are imparted to the other, as described.

7. A discriminative telephone, consisting of a polarizing magnet establishing an intense field of force between its poles; and a suitably mounted vibratory diaphragm; combined with an inductive apparatus comprising a short iron core, a fixed main circuit coil placed round the said core, and an oscillatory armature of copper ribbon forming a closed local circuit hung on trunnions round the said core, over the said main circuit coil, the said armature being mechanically associated with the diaphragm as described, so that the oscillations of the one will produce vibrations of the other, or vice versa, and the entire induction apparatus being placed directly within the field of force, constituted by the polarizing magnet, substantially as described.

8. A discriminative telephone, consisting of an intense polarizing medium; an induction apparatus placed as a whole within the field of said polarizing medium, and comprising an iron core surrounded by main and local circuit windings having reciprocal inductive relations, one being fixed, and the other hung on trunnions and forming an armature adapted to oscillate across the lines of force of said field; and a plurality of diaphragms mechanically connected with opposite points respectively, of the said armature, substantially as and for the purposes specified.

9. In a magneto telephone, the combination with a vibratory diaphragm; a strong polarizing magnet; a short iron core mounted between the poles and concentrating the lines of force thereof; and a fine wire main circuit coil wound or placed round the said core, the said core and coil, both having a horizontal cross-section generally of oblong form, combined with an oscillatory armature formed of an endless copper ribbon, also of oblong horizontal cross-section, and constituting a closed short circuit, the said armature being hung on trunnions surrounding the said core and line coil, between the poles of said magnet, and having mechanical connections with the said diaphragm, whereby it is made responsive alike to the mechanical vibrations of the diaphragm, and to the electrical vibrations of the line coil substantially as described.

10. The combination in a magneto telephone substantially as hereinbefore described, of a polarizing magnet; a vibratory diaphragm; short, highly laminated iron core, supported between the poles of said magnet; a fine wire main circuit coil wound longitudinally over the said core, and fitted with main line terminals; a movable armature consisting of an endless copper ribbon forming a complete local circuit of low resistance surrounding the said core and coil, and placed between the latter and the magnet poles, the said armature being hung on trunnions and adapted thereby for oscillation across the lines of force

of said poles; and rigid steel wires or equivalent mechanical connections between the said vibratory diaphragm and oscillatory armature.

11. In a magneto telephone, the combination of a strong horse shoe polarizing magnet; a main or line circuit coil, winding or helix rigidly mounted between the poles thereof; a plurality of vibratory diaphragms mounted in a suitable case in front of the poles of the said magnet; and an oscillatory armature forming a closed local circuit, also placed between the magnet poles, and pivotally mounted to oscillate in the space between the said poles and the said coil, the said armature being in electro-inductive connection with the said main circuit coil, and in mechanical connection with the said diaphragms; whereby the said armature may be actuated inductively by electrical vibrations in the circuit of the coil, or directly by mechanical vibrations of the said diaphragm; substantially as described.

12. In a magneto telephone, a movable armature or winding mounted to oscillate in the field of force of a polarizing magnet, combined with an adjusting device comprising two pins, one on each side of one of the armature pivots, and an elastic cord stretched between two external fixed points placed at equal distances on each side of the armature and connected with the said pins, whereby increased tension on either side exerted by the oscillations of the armature is balanced by an equivalent decrease of tension on the opposite side, as set forth.

13. An electrical circuit in which telephonic currents and telegraphic currents or others having a similar relatively low rate of change are circulating; combined with a discriminative receiving telephone included therein, the said telephone having its diaphragm mechanically controlled by a closed local circuit winding surrounding a short iron core being mounted to oscillate in a strong polarizing field and having inductive relations only with the main line, whereby while remaining perfectly responsive to the said telephonic currents it is enabled to disregard and is made irresponsive to the said slowly recurring currents circulating in said main line substantially as described.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 16th day of November, 1894.

STEPHEN DUDLEY FIELD.

Witnesses:

GEO. WILLIS PIERCE,

H. R. LEISK.