No. 778,409. PATENTED DEC. 27, 1904.

O. M. FRYKMAN.

TELEPHONE APPARATUS.

APPLICATION FILED APR. 20, 1903.

Fig. 2.

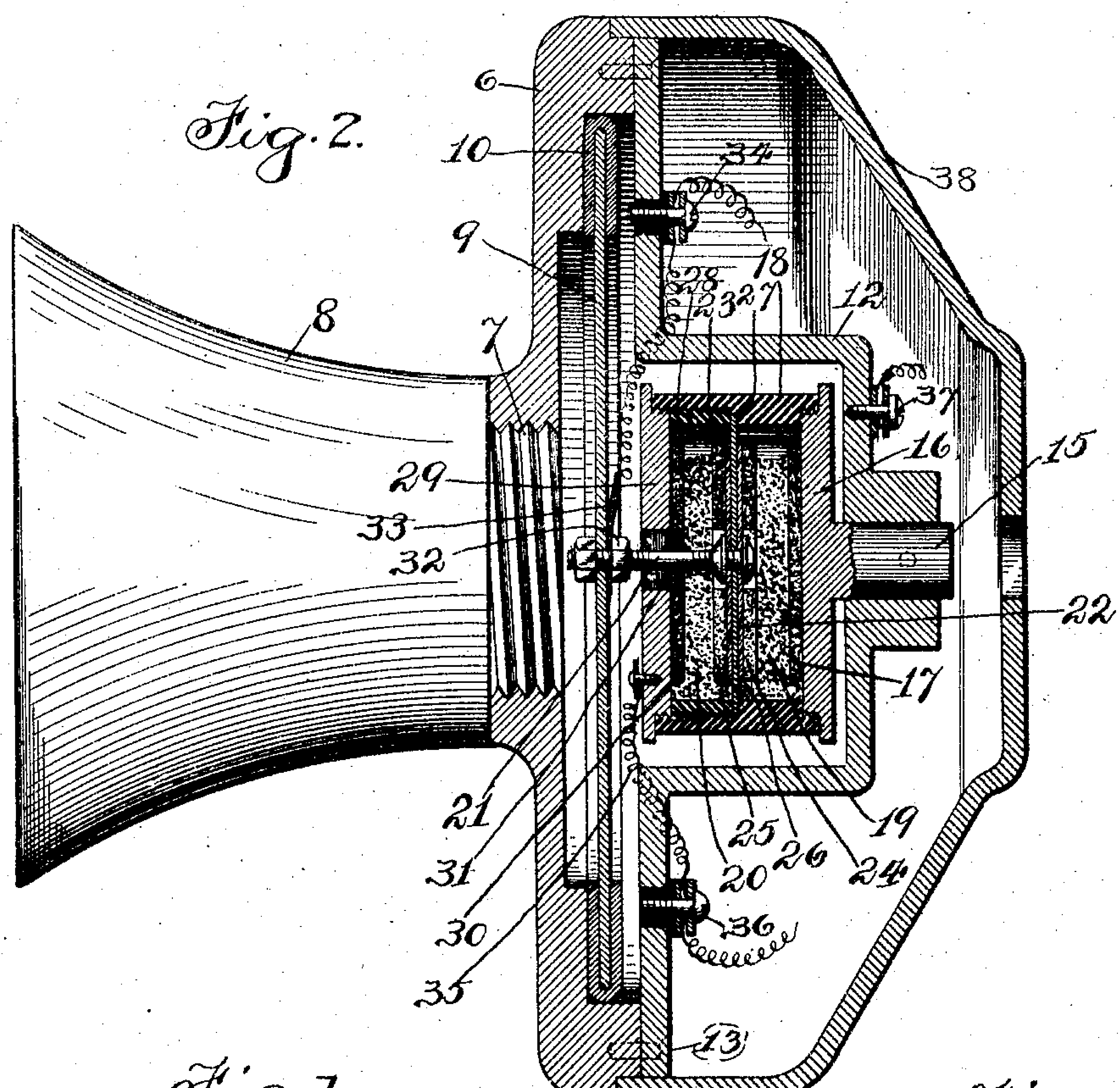



Fig. 1.

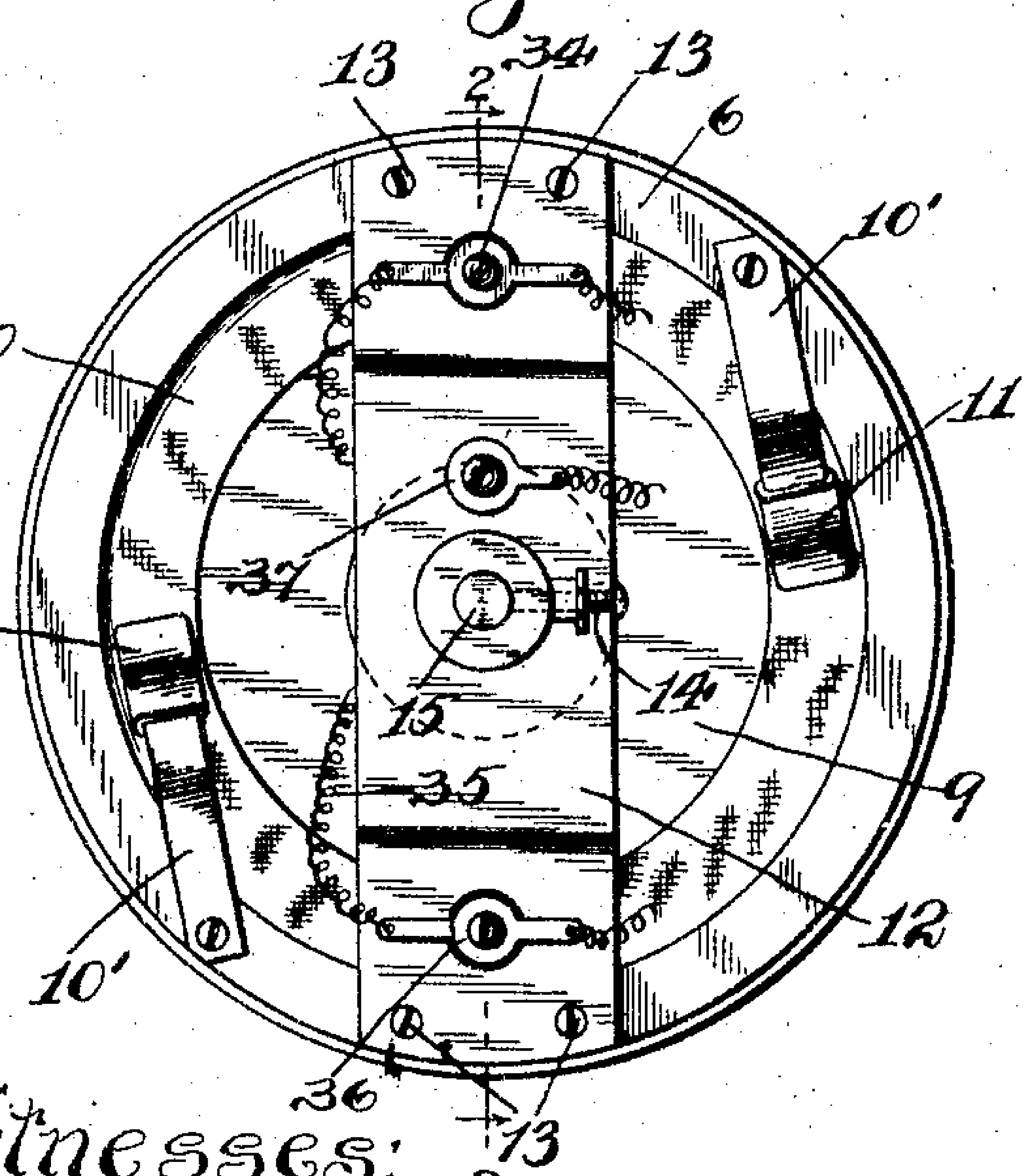
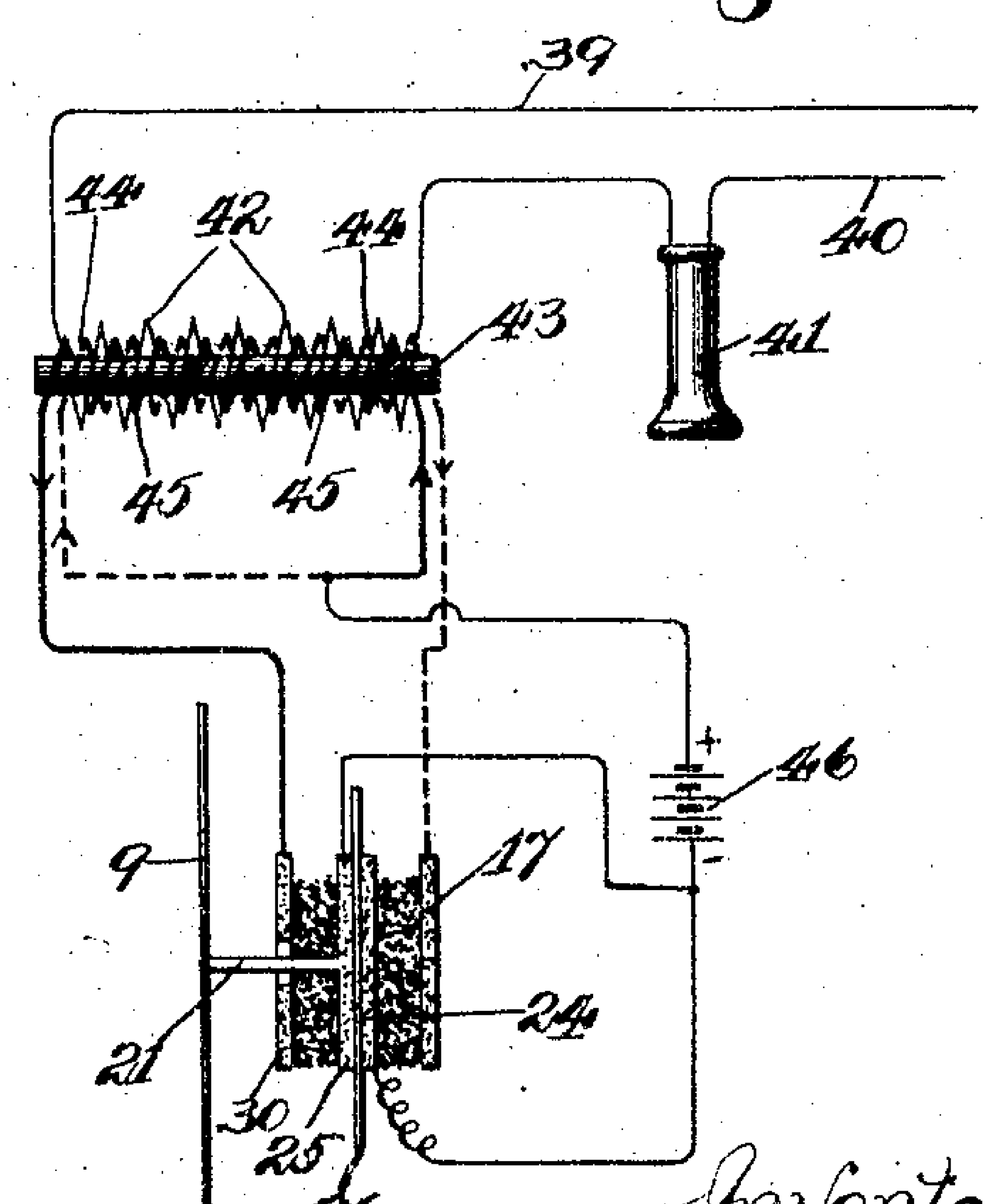



Fig. 3.

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No. 778,409. Patented December 27, 1904.

# UNITED STATES PATENT OFFICE.

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## TELEPHONE APPARATUS.

SPECIFICATION forming part of Letters Patent No. 778,409, dated December 27, 1904.

Application filed April 20, 1903. Serial No. 153,350.

*To all whom it may concern:*

Be it known that I, OSCAR M FRYKMAN, a citizen of the United States, residing at St. Paul, in the county of Ramsey and State of Minnesota, have invented a certain new and useful Improvement in Telephone Apparatus, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to telephone apparatus, and more particularly to means employed for transforming sound-vibrations into variations of an electrical current adapted to be impressed through the interposition of suitable conductors upon receiving instruments placed at a distance. It is now the common practice in the telephonic art to employ an induction-coil one winding of which is connected with the transmission-line over which voice-currents are to be transmitted and the other winding of which is connected through a source of current with a microphone-transmitter. The vibrations of the diaphragm of the microphone-transmitter in conformity with the sound-vibrations impressed thereupon cause variations in the resistances of the microphone of the transmitter, thereby causing undulations in the strength of the current flowing through the primary of the induction-coil. These variations in the strength of the current in the primary winding induce rapidly-alternating currents in the secondary winding, which currents are frequently known as "telephonic voice-currents." The iron core of the induction-coil is magnetized to a considerable extent by the continuous passage of current through the primary winding, this current continuing of greater or less strength at all times during which the transmitter is connected in circuit in a manner adaptable for the purpose of transforming sound-waves. As is well known by those skilled in the art, it requires a greater expenditure of electrical energy to produce a given change in the number of lines of force threading the iron core when the said core is saturated or partially saturated with lines of force than when the said core is in a neutral condition, in which no lines of force are threading it. The strength of the currents induced in the secondary winding of an induction-coil depends directly upon the rate of change in the number of lines of force threading the secondary coil. It is therefore desirable that a given expenditure of electrical energy, or in telephone practice that a given amount of energy in a sound-vibration, shall cause the greatest possible variation in the number of lines of force threading the secondary of the induction-coil employed. As the frequency of the sound-vibrations cannot be varied or controlled at will, this in practice amounts to the same thing as saying that it is desirable that the rate of change in the number of lines of force threading the induction-coil be as great as possible. The greatest possible rate of change in the number of lines of force threading an induction-coil core occurs when the direction of the lines of force changes—that is, when the polarity of the core changes.

It is the principal object of my invention to provide means for impressing voice-currents upon a transmission-line wherein the core of the induction-coil employed is normally in a substantially neutral condition magnetically and whereby the operation of suitable microphones corresponding with sound-vibrations of a transmitter-diaphragm may cause variations in the number of lines of force threading the induction-coil core on either side of zero. It has heretofore been attempted to use induction-coils for telephonic purposes in which the number of lines of force threading the induction-coil core was made to vary on either side of zero; but the transmitters with which it has been attempted to attain this result have not been suitable for the purpose. It has been attempted to use carbon button-transmitters in which the transmitter resistance was varied by a variation in the pressure between two carbon button-electrodes. Since it has been practically impossible to regulate and adjust the normal pressure and resistance between these pairs of button-electrodes, it has been practically impossible to properly control the currents flowing through the induction-coil windings. The variation in the magnetization of the core at or near its neutral condition, in which it is most susceptible to magnetic influence, and the rapidly-changing direction of the lines of force through the core cause the greatest possible inductive effect upon the secondary winding of the coil. In this manner the amount of electrical energy and the amplitude of the variations of the voice-currents impressed upon the transmission-line are very greatly enhanced.

My invention will be better understood by reference to the accompanying drawings, in which—

Figure 1 is a rear elevation of an improved transmitter adapted to be used in connection with my invention, the inclosing casing being removed. Fig. 2 is a cross-sectional view of the transmitter, taken on line 2 2 of Fig. 1; and Fig. 3 is a diagrammatic view representing a transmitter, a source of current, an induction-coil, and a transmission-line embodying the features of my invention.

I have illustrated a transmitter having a front plate 6, into a suitable opening 7 in the front of which the hard-rubber mouthpiece 8 is screw-threaded. A main diaphragm 9, provided with a suitable soft-rubber cushion 10, is held in position against the front plate 6 by means of the spring-clips 10′ 10′, each provided with a rubber sole 11. To the rear of the front plate 6 a bridge 12 is secured by the machine-screws 13 13. An adjusting-screw 14 adjustably secures the stem 15 to the bridge 12, the stem 15 carrying at its forward end an electrode-plate 16, to the front side of which the carbon electrode 17 is secured. Screw-threaded upon the electrode-plate 16 is a hard-rubber tube 18, forming with the electrodes chambers 19 and 20, each containing granular carbon, as shown. A stem 21 rigidly connects the diaphragm 9 with a pair of electrode-plates 22 and 23, to which the carbon electrodes 24 and 25, respectively, are fastened. Between the electrode-plates 22 and 23 is clamped a thin flexible auxiliary diaphragm 26, preferably of insulating material, such as mica. This mica diaphragm is desirably secured to the walls of the electrode-chamber, between a shoulder 27 of the tube 18 and a clamping-ring 28, screw-threaded into the forward end of the tube 18. The front electrode-plate 29 is screw-threaded into the forward end of the tube 18 and is provided upon its rear face with a carbon electrode 30. A bushing 31, of felt or similar material, surrounds the stem 21 and prevents the escape of carbon granules from the electrode-chamber. Clamped between the nut 32 and the diaphragm 9 is a connecting-clip 33, from which a conducting-wire leads to an insulated terminal screw 34. A conducting-wire 35 electrically connects the front electrode 30 with an insulated terminal 36. An electrical connection with the rear electrode 17 is made by means of the terminal screw 37. An inclosing casing 38 is provided through an opening at the rear of which suitable conducting-wires may be led to the terminal points within. It will be seen that the front and rear electrodes and the intermediate electrode are electrically insulated one from the other, except for the presence of the intervening granular carbon, through which current may pass from one to the other. It will be seen that this construction provides two microphones, one comprising the rear electrode 17 and the intermeniate electrode 24, with the intervening carbon, and the other comprising the front electrode 30, the intermediate electrode 25, and the granular carbon in the chamber 20. The vibration of the main diaphragm 9 causes identical vibrations of the intermediate electrode comprising the electrodes 24 and 25, the flexible mica diaphragm permitting the movement of the intermediate electrode relatively to the stationary electrodes 17 and 30. It will be seen that a movement of the main diaphragm toward the rear will cause a compression and a corresponding decrease in the electrical resistance of the granular carbon in chamber 19, while a forward movement or the main diaphragm causes a compression and consequent decrease in the resistance of the carbon granules in the chamber 20, intervening between the electrodes 25 and 30. It will of course be apparent that the compression of the granules in either of the chambers 19 or 20 is accompanied by corresponding decrease in the compression of the granules in the other chamber. Thus while the electrical resistance between the electrodes 25 and 30 is decreased the electrical resistance between the electrodes 17 and 24 is correspondingly increased, and vice versa.

The manner of electrically connecting my improved transmitter will be apparent from an inspection of Fig. 3. In Fig. 3 the transmitter-electrodes are diagrammatically illustrated at 17, 24, 25, and 30. In Fig. 3 I have diagrammatically illustrated a transmission-line between whose limbs 39 and 40 there are connected a receiver 41 and the secondary winding 42 of an induction-coil whose iron core 43 is also wound with two primary windings, as shown. In order to distinguish the two primary windings, one of them (the winding 44) is illustrated by a dotted line. The primary windings 44 and 45 are connected, through a common source of current 46, with the transmitter-electrodes, as shown. Tracing the current from the positive pole of the battery 46, it will be seen to divide, part flowing in the direction indicated by the arrow-heads, through the winding 44 of the induction-coil, to the electrode 17, thence through the intervening carbon granules to the electrode 24, and thence to the negative pole of the battery 46, and part flowing in the direction indicated by the arrow-heads, through the winding 45, to the electrode 30, thence through the carbon granules and the intermediate electrode 25 to the negative pole of the battery 46.

It is desirable that the number of ampere-turns in the primary windings be substantially equal. Thus if the primary windings, as is desirable, are each of the same number of turns it is desirable that the resistance of each of the transmitter-microphones be the same. The resistances of the transmitter-microphones may be made substantially equal by providing substantially equal distances between the intermediate electrodes and the front and rear electrodes, respectively. The carbon button-transmitters of the prior art which it has been attempted to use in the manner herein described have not proved satisfactory for the purpose. One of the principal difficulties encountered is that it is extremely difficult to properly regulate and adjust the normal resistance between the electrodes of a carbon-transmitter in which the variations in the resistance are caused by variations in pressure between the carbon electrodes. It will be seen from the direction of the arrow-heads placed on the windings 44 and 45 that the currents traversing these windings are in opposite directions and if, as is desirable, under normal conditions, when no sound-wave is being impressed upon the transmitter-diaphragm, the resistances in the two paths through the transmitter are substantially the same there will be no net energization of the induction-coil core 43. A sound-wave impressed upon the diaphragm 9, causing a movement of the intermediate electrode toward the rear, will compress the granules in the chamber 19 and cause an expansion between the granules in the chamber 20. This will decrease the resistance through the circuit including the winding 44 and cause an increase in the flow of current therethrough. At the same time the resistance in the circuit including the winding 45 will be increased, causing a corresponding decrease in the current flowing therethrough. The effects of these current changes in the windings 44 and 45 are addative so far as the magnetic energization of the core 43 is concerned. Thus the total change in the number of lines of force threading the induction-coil core is twice as great as would under otherwise similar conditions be produced by but one transmitter-microphone, as is now commonly employed in practice. The inductive effect upon the secondary winding 42 is, furthermore, greatly increased, due to the fact that the saturation or magnetization of the induction-coil core is very low, whereby a slight change in the strength of the energizing-current causes a large change in the number of lines of force threading the core. Furthermore, the currents induced in the secondary winding are dependent in strength upon the rate of change in the number of lines of force threading the core 43. Thus upon the reverse or forward movement of the diaphragm 9 and the intermediate electrodes 24 and 25 the current through the primary winding 44 is decreased, while at the same time the current through the primary winding 45 is increased. This causes a rapid change in the polarity of the magnetization of the core 43. A change in the magnetization of the core from a flux in one direction to a flux in the reverse direction causes the greatest possible rate of change that can be attained. It is obvious that the rapid change in the number and the direction of the lines of force threading the core 43 will produce very great inductive effects upon the secondary winding 42. The increased electrical energy and the increased amplitude of the variations of the telephonic voice-currents in the secondary winding provide means whereby an improved voice transmission of very great power may be secured.

For purposes of mechanical construction I have found it desirable to use two separate disks of carbon to form the intermediate electrodes; but as these two electrodes are conductively connected together by the electrode-plates and the stem to which they are riveted they may be considered from an electrical standpoint as one single intermediate electrode. In the following claims, therefore, I shall refer to the intermediate conductive whole, which makes contact with the granular carbon in both of the chambers 19 and 20, as a single intermediate electrode.

While I have herein shown and described one preferred embodiment of my invention, it will be apparent to those skilled in the art that many modifications may be employed without departing from the spirit thereof. I do not, therefore, wish to limit myself to the precise disclosure herein set forth; but,

Having described my invention, I claim as new and desire to secure by Letters Patent—

1. In a telephone-transmitter, the combination with a diaphragm thereof, of two relatively stationary electrodes, an intermediate electrode, a mechanical connection extending between said diaphragm and said intermediate electrode, a tube of insulating material surrounding said intermediate electrode and connecting said relatively stationary electrodes to form therewith an electrode-chamber, a flexible mica diaphragm upon which said intermediate electrode is supported, an annular shoulder upon the interior of said tube against which the periphery of said flexible diaphragm rests, a clamping-ring adapted for insertion from one end of said tube for clamping said flexible diaphragm against said annular shoulder, said flexible diaphragm dividing the electrode-chamber into two compartments and permitting movement of said intermediate electrode with respect to said relatively stationary electrodes, and granular carbon interposed between the electrodes in each of the compartments of said electrode-chamber.

2. In a telephone-transmitter, the combina-

tion with a diaphragm thereof, of two relatively stationary electrodes, an intermediate electrode, a mechanical connection extending between said diaphragm and said intermediate electrode, a tube of insulating material surrounding said intermediate electrode and connecting said relatively stationary electrodes to form therewith an electrode-chamber, a flexible mica diaphragm upon which said intermediate electrode is supported, an annular shoulder upon the interior of said tube against which the periphery of said flexible diaphragm rests, a clamping-ring adapted for insertion from one end of said tube for clamping said flexible diaphragm against said annular shoulder, said flexible diaphragm dividing the chamber into two compartments and permitting movement of said intermediate electrode with respect to said relatively stationary electrodes, granular carbon interposed between the electrodes in each of the compartments of said electrode-chamber, and an induction-coil having two differentially-connected primary windings, each connected in an electrical circuit including said intermediate electrode, one of said relatively stationary electrodes, the intervening granular carbon, and a source of current.

3. In a telephone-transmitter, the combination with a diaphragm thereof, of two relatively stationary electrodes, an intermediate electrode, a mechanical connection uniting said diaphragm and said intermediate electrode, a tube of insulating material surrounding said intermediate electrode and at its ends having screw-threaded engagement with said relatively stationary electrodes to form therewith an electrode-chamber, a flexible mica diaphragm for supporting said intermediate electrode, an annular shoulder upon the interior of said tube against which the periphery of said flexible diaphragm rests, a clamping-ring adapted to be screwed into the front end of said tube to clamp said flexible diaphragm against said shoulder, said flexible diaphragm dividing the chamber into two compartments and permitting movement of said intermediate electrode with respect to said relatively stationary electrodes, and granular carbon interposed between the electrodes in each of the compartments of said electrode-chamber.

4. In a telephone-transmitter, the combination with a diaphragm thereof, of two relatively stationary electrodes, an intermediate electrode, a mechanical connection uniting said diaphragm and said intermediate electrode, a tube of insulating material surrounding said intermediate electrode and at its ends having screw-threaded engagement with said relatively stationary electrodes to form therewith an electrode-chamber, a flexible mica diaphragm for supporting said intermediate electrode, an annular shoulder upon the interior of said tube against which the periphery of said flexible diaphragm rests, a clamping-ring adapted to be screwed into the front end to clamp said flexible diaphragm against said shoulder, said flexible diaphragm dividing the electrode-chamber into two compartments and permitting movement of said intermediate electrode with respect to said relatively stationary electrodes, granular carbon interposed between the electrodes in each of the compartments of said electrode-chamber, and an induction-coil having two differentially-connected primary windings, each connected in an electrical circuit including said intermediate electrode, one of said relatively stationary electrodes, the intervening granular carbon, and a source of current.

In witness whereof I hereunto subscribe my name this 14th day of April, A. D. 1903.

OSCAR M. FRYKMAN.

Witnesses:

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J. O. VIGER.