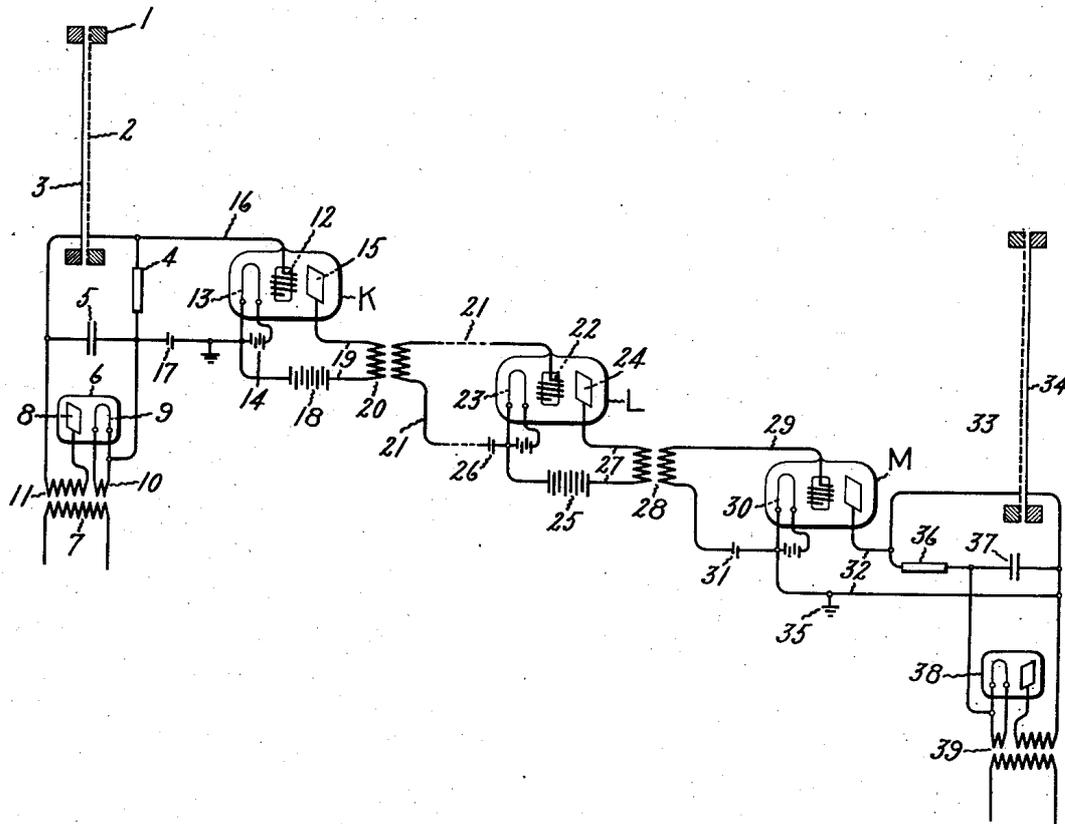


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ELECTROSTATIC TELEPHONE SYSTEM.
APPLICATION FILED JULY 15, 1914. RENEWED SEPT. 7, 1916.

1,223,496.

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UNITED STATES PATENT OFFICE.

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ELECTROSTATIC TELEPHONE SYSTEM.

1,223,496.

Specification of Letters Patent.

Patented Apr. 24, 1917.

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To all whom it may concern:

Be it known that I, IRVING LANGMUIR, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Electrostatic Telephone Systems, of which the following is a specification.

The present invention relates to the art of telephony.

It has been suggested to utilize the variations of capacity of a vibrating condenser plate creating undulatory currents suitable for reproducing sound. Although attempts to render the condenser telephone a practical instrument extend over many years it has been found impossible heretofore to make this type of telephone anything more than a scientific toy.

20 In accordance with my present invention, I have provided an electrostatic telephone system in which the undulatory variation of charge of the condenser receiver is impressed upon the control member of an electron discharge device, which control member receives only a charging current and consumes practically no energy, but by the character of its static charge controls an exchange of energy between independent electrodes whereby an amplified independent undulatory current of relatively high voltage is obtained. This current at the receiving end of the system varies the potential of the control member of an electron discharge device furnishing a varying high potential charge which is impressed upon a receiving condenser and thereby reproduces the sound.

35 Similarly an undulatory current may be produced which is utilized in an ordinary electromagnetic receiver.

The accompanying drawing illustrates diagrammatically both the transmitting and receiving ends of a telephone system operating in accordance with my invention.

45 The telephone transmitter 1 which is of the usual type comprises two or more parallel conducting plates constituting opposite poles of a condenser. As diagrammatically indicated one pole 2 consists of a perforated metal plate and the other pole 3 consists of a vibratory diaphragm of some light, strong material, such for example, as gold-beaters' skin coated with a conducting film of light weight, as gold leaf. The plate

2 is grounded by means of a high resistance 4 which has a value of at least ten megohms. For example, a so-called Bronson resistance may be used comprising a receptacle containing metal plates separated by an air space and coated with radio-active salts, or a resistance consisting of xylol and absolute alcohol. The condenser member 3 is maintained at a definite potential, preferably several hundred volts, from any convenient source of direct current of substantially steady voltage. For example, this source may be constituted by the condenser 5 having a capacity sufficient to maintain a substantially constant potential, conveniently of about one microfarad, which is maintained charged by an incandescent cathode rectifier 6, in turn fed by transformer 7, or other convenient source of alternating current of proper potential. A high voltage battery may be used for the same purpose. The rectifier 6 preferably operates with a pure electron discharge as described fully by me in a co-pending application, Serial No. 795,610, filed October 16, 1913, although other suitable high voltage rectifying devices could be used. The space within the envelop is evacuated to a pressure below about $\frac{1}{10}$ of a micron of mercury and an anode 8 and other metal parts are so completely freed from ionizable gas so that when the cathode 9 is heated to incandescence, for example, by means of a transformer section 10, and potential is impressed on cathode and anode, as by a transformer section 11, a pure electron discharge will pass when the polarity of the impressed current is such as to make the electrode 9 negative and the electrode 8 positive. Thereby impulses of unidirectional current are impressed upon the condenser 5, which smooths out the undulations because of its relatively high capacity so that one electrode of the transmitter 1 is maintained at substantially constant potential. The purpose of high resistance element 4 is to prevent the irregular accumulation of potential on the condenser. Because of the very high resistance of the element 4, the leakage is so small that very little current is taken from the condenser 5 so that it is maintained substantially continuously fully charged.

The electrode 2 of the condenser receiver is connected to the grid 12 of a discharge

controlling device K having a cathode 13 maintained incandescent by a battery 14 and having a cooperating gas-free anode 15.

A pure electron discharge device already described above in a peculiar way cooperates with the electrostatic transmitter to produce a current transmissible over a telephone circuit, namely,—the means for producing variations in a current of relatively high voltage by means of the varying charge of a control member of low capacity, itself taking substantially no current. Considering the transfer of charge along the conductor 16 as a minute current of high voltage having the frequency of sound waves, the device K may be considered as a means of enormously amplifying this current. Amplifications of much more than a thousand-fold may be obtained. The capacity of the grid 12 and also the grid circuit 16 preferably should be chosen to be less than the capacity of the condenser receiver, so as to be sensitive to variations of static charge of the receiver. The grid 12 is preferably maintained at a definite potential by means of a battery 17, or other source of constant potential. As already explained the electron discharge device K is evacuated to such a high degree and its electrodes freed from ionizable gas to such an extent that the exchange of energy between cathode 13 and anode 15 when connected to terminals of a battery 18, or other source of direct current, takes place by pure electron emission without the ionization of residual gas. Under these conditions the grid 12 when negatively charged varies a flow of energy between the cathode and anode in proportion to its charge, so that variations of potential on the condenser telephone transmitter 1 produced by the vibrations of its plates by the sound are faithfully reproduced as undulatory current in the electrode circuit 19. This current is conducted to the primary of a transformer 20. The secondary of the transformer 20 is connected to a telephone transmission line 21. If desired the variations in the current may properly be used to produce variations of charge on the grid of another electron discharge device to still further increase the amount of energy. A second amplifying device has not been illustrated in the transmitting end of the system as the principle of operation is sufficiently illustrated at the receiving end of the system.

At the receiving end the transmission line is connected respectively to the grid 22 and the cathode 23 of an electron discharge device L which also has a local circuit connected between the cathode and an anode 24 and containing a battery 25. The variations of potential of the grid 22 produced by the line potential superimposed on the potential of the battery 26 cause an undulatory current to flow in the circuit 27, in a manner

already explained. This current may be transformed to higher voltage by a transformer 28, the secondary of which is connected to the grid circuit 29 and the cathode 30 of another electron discharge device M, the electrode circuit of which contains a battery 31. The number of discharge devices thus used depend upon the character and length of the telephone system.

The electrode circuit 32 of the last electrical discharge device of the system is connected to a suitable telephone receiver, which in the drawing is shown as an electrostatic receiver having a perforated plate 33 and a vibratory conducting diaphragm 34, or if desired, the terminals of the lines 32 may be connected to an ordinary magnetic receiver. When an electrostatic receiver is used a number of condenser members may be connected in series or in parallel to increase the area of the vibrating surface and thus increase the loudness of the sound.

The flexible conducting membrane 34 of the receiver is grounded at 35 and is thus maintained at a definite potential. The opposite pole 33 is connected to one terminal of a high resistance 36, similar to the resistance 4. The other terminal of this resistance is connected to one pole of a condenser 37, both the resistance and the condenser being in the electrode circuit 32 of the discharge device M. The condenser is maintained charged by an incandescent rectifier 38, fed by a transformer 39 similarly to the rectifier 6. Variations of conductivity in the electron discharge device M produced by variations of charge on the grid produce a current in the circuit 32 and thereby a varying potential across the resistance 36. The variable charge of relatively high voltage when impressed upon the electrode or electrodes of the receiver strongly and positively vibrates the membrane so as to reproduce the sound even when the leakage is considerable as during damp weather.

The advantages of an electrostatic telephone system embodying my invention are faithful reproduction of the overtones of sound, without the production of undesired harmonics due to the small mass of the vibrating members and also the possibility of amplifying the electrical current to be transmitted without distortion. As large surfaces may be used at the receiving end of the line, sounds may be reproduced loud enough to be heard considerable distances, as in a large hall. In this manner music may be reproduced without loss of quality.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. In a telephone system, the combination of a condenser the capacity of which is variable in response to sound vibrations, means for maintaining one of the electrodes of said condenser at a definite potential with

respect to earth, a source of energy, and an electrical discharge apparatus having electrodes connected to said source of energy and also a charge-controlled member connected to said condenser for varying the conductivity between said electrodes, said member taking substantially no current.

2. In a telephone system, a transmitting device comprising the combination of a device varying in electrical capacity in response to sound waves, means for maintaining one of the electrodes of said device at a fixed potential, an energy transmitting apparatus operating by pure electron discharge in a vacuum too high to permit positive ionization, having main electrodes and a static charge responsive member for controlling an exchange of energy between said electrodes, electrical connections between said sound responsive device and said member and a source of energy connected to said electrodes.

3. In a telephone system, the combination of a condenser, at least one electrode of which is free to vibrate, means for maintaining one of the electrodes of said condenser at a definite potential, a current con-

trolling device comprising main electrodes and a member controlling the conductivity of said device, being responsive to variations of static charge and having a capacity less than the capacity of said condenser, circuit connections between said condenser and the control member of said relay, a source of energy connected to the electrodes of said relay and sound producing means actuated by a variable current from said relay device.

4. In a signaling system, the combination of a condenser telephone transmitter, means for maintaining at least one electrode thereof at a definite potential, an electron discharge device having a grid circuit the capacity of which is less than the capacity of said transmitter, a local source of energy of substantially invariable voltage in the electrode circuit of said discharge device, and a telephone receiver in operative relation to said electrode circuit.

In witness whereof, I have hereunto set my hand this 14th day of July, 1914.

IRVING LANGMUIR.

Witnesses:

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