C. A. RANDALL.
Telephone System.

2 Sheets—Sheet 1.

No. 227,300. Patented May 4, 1880.

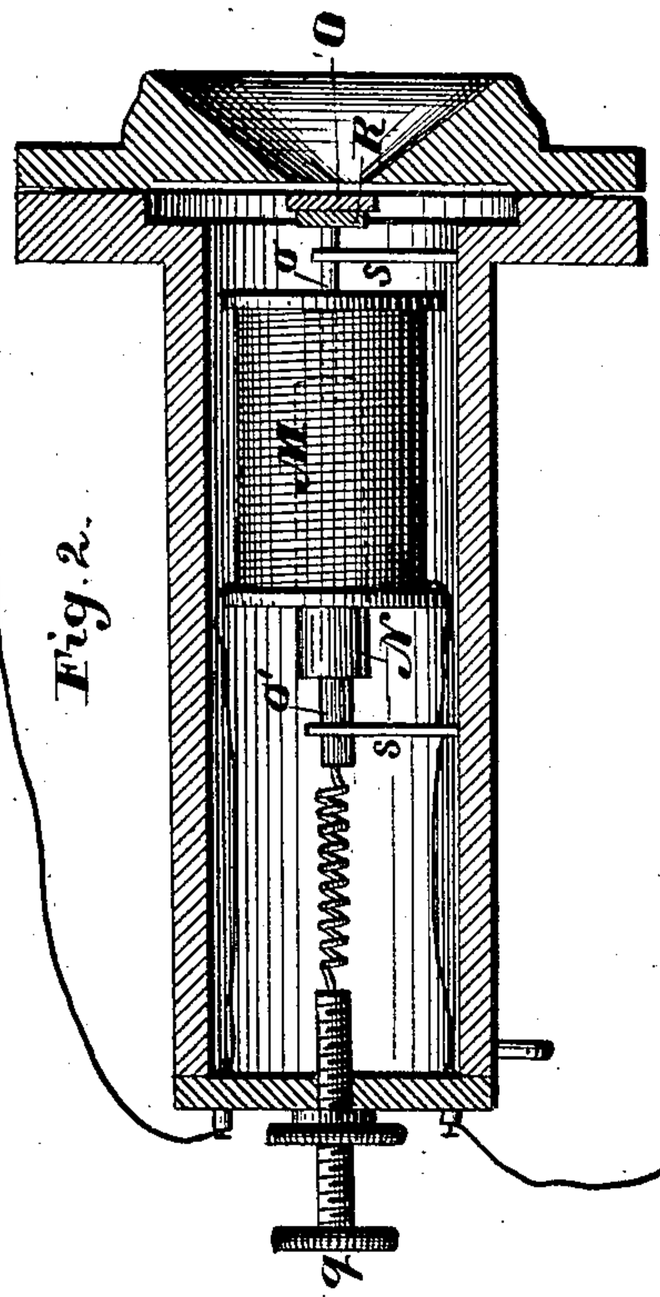

Fig. 2.

Fig. 1.

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2 Sheets—Sheet 2.

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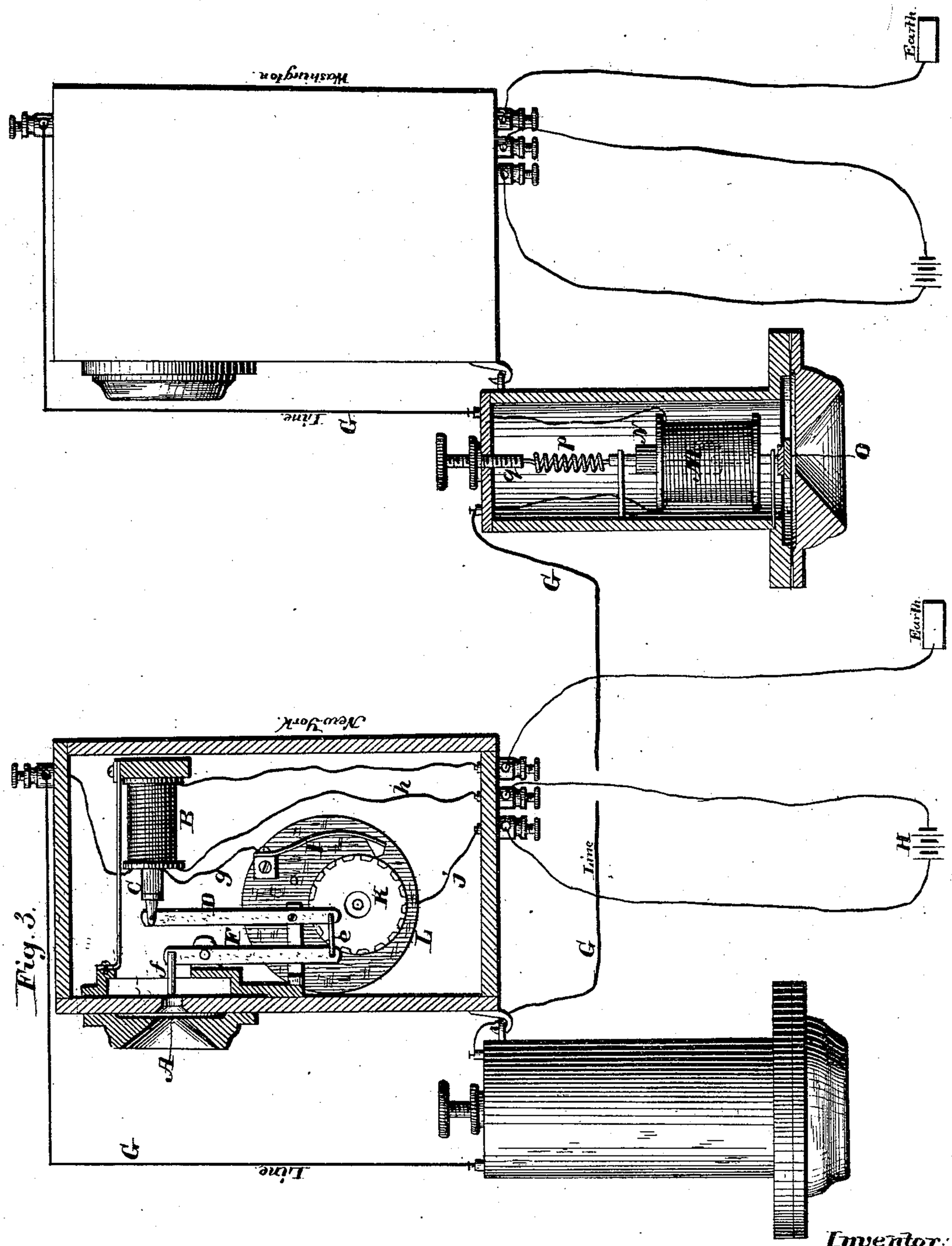

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UNITED STATES PATENT OFFICE.

CHARLES A. RANDALL, OF NEW YORK, N. Y.

TELEPHONE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 227,300, dated May 4, 1880.

Application filed December 27, 1879.

To all whom it may concern:

Be it known that I, CHARLES A. RANDALL, of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Telephone Systems, of which the following is a specification.

This invention relates to an improved method and apparatus for the transmission of electrical pulsations corresponding to the air-vibrations of vocal or other tones, but especially for the transmission of and reconversion into sound of electrical impulses caused by the air-vibrations of articulate speech. Its object is to enable communication by articulate speech over long electrical circuits, to prevent interference with the electrical impulses of the circuit by induction, and to increase the loudness of tones produced by the receiver.

My invention consists, mainly, in employing upon a telephone-circuit a rapidly intermittent instead of an undulatory or vibratory current, and in causing the tension of said intermittent current to be varied by devices actuated by vibrations of the transmitter-diaphragm. An intermittent current is produced when there is a succession of actual "makes" and "breaks" of the circuit over which the current flows, or when there are instantaneous changes from slight to great resistance, which are virtual makes and breaks, whereas an undulatory or vibratory current results from gradual changes of intensity of current on a constantly-closed circuit.

The invention consists, secondarily, in an improved transmitter provided with apparatus for producing the intermittent current; and it consists, also, in the combination, with the transmitter so constructed, of an improved receiver, all of which will be hereinafter particularly described and explained.

The distinction between an intermittent and an undulatory current will be understood by considering that intermittent currents are the result of a rapid make and break of a battery-circuit, or by sudden or instantaneous changes of intensity, and that undulatory currents result from gradual changes of intensity in a constantly-closed circuit.

In the telephone systems now in use the articulate sounds are transmitted and received by means of the undulatory current in contradistinction to intermittent currents.

As all sounds are but air in vibration, it only becomes necessary to ascertain the number of vibrations there are to sounds of ordinary conversation to enable the electric transmission of the same. It is a matter of record that the gravest tones have about sixty-five vibrations per second, a very high tenor voice about five hundred and fifty at C-sharp, and a soprano voice about fifteen hundred vibrations per second. It has been proven that there is scarcely a limit to the number of vibrations over a wire or circuit capable of transmitting the highest number of the vibrations of a series of vibrations—*i. e.*, if we have from two or more transmitting-instruments several series of vibrations (low and loud tones) to be transmitted simultaneously, the highest tone, we will say, having about fifteen hundred vibrations, if the conductor or circuit is in a proper electric condition to permit of the transmission and receiving of that number of electrical vibrations or impulses without breaking the circuit, all other tones having a less number of vibrations may also be transmitted readily, definitely, distinctly, and independent of each other simultaneously over or upon said circuit.

Instead, however, of keeping the circuit constantly closed, I send into, upon, or over the circuit rapid intermittent currents, the rapidity of the intermittent currents depending upon the work to be done over or upon such circuit in transmission of tones, those of a high rate of vibration requiring a higher rate of transmission of intermittent impulses.

There are various ways of transmitting intermittent currents into, upon, or over a line-circuit; but I have preferably employed and illustrate in the accompanying drawings an induction-coil having its primary and secondary coils constructed in the usual manner, (and using or not a condenser therewith,) the iron core of the coil easily movable therein, a battery and a train of wheels or gearing for driving a circuit-breaker in such a manner as to rapidly and automatically make and break the battery-current over the primary coil and circuit, thereby, as is well understood, inducing a current of greater or less force in the sec-

ondary circuit, accordingly as the core is inserted in full or in part into the coil, and according, generally speaking, to the size of coils, core, battery, &c., so that by properly constructing the same, currents of great electro-motive force may be obtained and circuits of great length may be worked.

By employing currents of great electro-motive force upon the line-wire the receiver is more strongly and positively affected, and the tones produced by it more loud and distinct; and, also, by having a transmitting current of great electro-motive force, there is less interference from induction from other wires, as the apparatus may be adjusted over or above the action of the extraneous currents, the receiving apparatus responding only to the stronger transmitted current.

In Letters Patent granted to me November 4, 1879, No. 221,355, I have described a telephonic transmitter in which I employ an induction-coil having a movable iron core in connection with a "tension-changer" in the primary circuit, for the purpose of obtaining in a more marked degree a variation in the intensity of the current in the secondary coil and the circuit of which it is a part.

In my present invention, however, I have dispensed with the tension-changer in the primary circuit, as I may employ in the primary circuit a constant or unvarying battery-current of an electro-motive force that I may deem best, and as the induction or induced current in the secondary coil or circuit, whether constant and uniform or of varying intensity, will depend upon the position of the iron core in the helix, I depend for the variation in the intensity of the current in the secondary coil and the circuit of which it is a part upon the amplitude of the movement of the iron core or the force of the sound that operates it, and upon the rate of movement of core or the variation of intensity of the line-current by the pitch of the sound.

I do not confine myself to the movable iron core, as there are other methods of varying the electro-motive force of the current in the secondary circuit, either by moving the coil or having an iron shield over the coil that may be vibrated, and other ways, without departing from the principle shown.

While I have stated that I dispense with the tension-changer in the primary circuit, I do not confine myself thereto, as I may use a tension-changer in the primary circuit; and I may arrange a series of circuit-breakers in independent electric contact with independent batteries of one or more cells to carry currents of electricity from said batteries (one or more) over, upon, or through the primary coil by means of suitable contact-makers operated directly or indirectly by a vibrating diaphragm, or its equivalent, and thereby vary the force of the current over the primary coil, and consequently the electro-motive force of the current in the secondary coil and its circuit, and that while the core is remaining in its normal position.

At the receiving-station I may employ an induction-coil the primary coil of which shall be in the main-line circuit and the secondary coil connected to the receiving electro magnet or magnets; or the receiving magnet or magnets may be placed directly in the main circuit.

The apparatus that I would employ consists of an ordinary electro-magnet coil having an iron core delicately suspended in or vertically through the center of the helix and easily movable therein, and held in normal position by the action of the current over the helix and by a suitable spring. One end of the core may be connected directly or indirectly to a diaphragm suitably constructed and arranged in connection with an ear-trumpet or other device for giving up the vibration of the core in tones. The action of the magnet is upon the well-known principle that if a current be sent through a coil of wire having an opening through the center and a rod of soft iron be brought near the opening, it is at once drawn into the helix. In action, therefore, the iron core is held in normal position by the tension of the current flowing over the helix and the spring, and is made to vibrate or oscillate as the current varies in force over the helix, it being drawn farther in upon the increase of the force of current over the helix and drawn out by the spring when the current weakens, and this movement or vibration is as the variation of the electro-motive force of the current over the helix, and corresponding, therefore, to the electrical vibrations upon the main circuit.

While I am aware it is generally considered that electro-motive force is only the excitant that sets up tension, and that it is located at the point where energy takes the form of electricity, and that tension is the strain upon the circuit equal to the electro-motive force at the source and falling according to the resistance of the circuit, still I use the terms as meaning virtually the same, as there cannot be tension without electro-motive force.

In lieu of the spring another helix of similar construction may be employed having a constant current over the same, and so connected that the helix in the line and the helix in the local circuit will each have the tendency to draw the core into itself, the one having the greater electro-motive force predominating. One or both of such helices should be adjustable to or from each other.

Having set forth the general principles and features of my invention, the same may be more fully understood by the following description, reference being had to the accompanying drawings, in which—

Figure 1 is a side elevation of my apparatus for telephonic transmission by my improved method, the inclosing-case and diaphragm being shown in section. Fig. 2 is a similar view of the receiver. Fig. 3, Sheet 2, shows a com-

plete telephone-circuit having at each end of the line-wire a transmitter and receiver constructed according to my invention.

The letter A, Fig. 1, indicates the diaphragm of the transmitter, and B an induction-coil having a movable core, C, the outer end of which is pivoted to the long arm of a lever, D, having its short arm connected by a pivoted link, *e*, with the long arm of a lever, F, fulcrumed behind the diaphragm, and having its short arm bent at an angle, as at *f*, and with its tip resting against the center of the diaphragm. By means of these multiplying-levers the vibratory movement of the diaphragm will be so amplified in transmission to the core C that said core will have a range of movement in the coil far greater than if said core were attached directly to the diaphragm, and the secondary current passing through said coil may have a great range of intensity.

One terminal of the secondary circuit of the induction-coil is connected to the main line G, and the other terminal is connected with the earth.

One terminal, *h*, of the primary circuit of said coil connects with one pole of a battery, H, and the other terminal, *g*, of said circuit connects with metallic spring-arm I, the free end of which bears upon the periphery of a break-wheel, K, constructed, in the ordinary manner, with breaks at very short intervals, the metallic portion of the wheel being connected by a wire, *j*, with the pole of the battery H opposite to that with which wire *h* is connected.

The break-wheel K is mounted upon the projecting end of one of the arbors of a train of a spring-motor, L, which may be constructed in any ordinary manner, the arbor upon which the break-wheel is mounted being one of the fastest-moving arbors of the train.

In the receiver, Fig. 2, M designates a coil similar to that of an ordinary electro-magnet, and having a soft-iron core, N, delicately suspended in and partially through its hollow center and readily movable longitudinally therein. This core has connected centrally to its outer end, through a rod, *o*, a diaphragm, O, and said diaphragm and the core are held in a normal position by a spiral spring attached to a central stud, *o'*, of the core, and having its other end connected by a suitable spiral spring with an adjusting-screw, *q*.

The rod *o* and stud *o'* slide in bearings formed in standards *s*, projecting from the casing, and support the core.

Between the end of rod *o* and the diaphragm may be interposed soft-rubber cushions R.

One terminal of the coil M is connected with the main line G and the other with the earth.

In this receiver, as will be observed, the amplitude of the vibrations of the diaphragm is controlled by the movement of the core of the magnet, and to give this core any great degree of movement there is required a current of much greater electro-motive force than is found produced by any transmitter hitherto constructed; but with my improved transmitter a strength of current and a range of intensity are secured by which the core of the receiver-magnet causes vibrations of great amplitude in the diaphragm, producing tones quite loud.

I have now described the principle and the essential mechanical devices for telephonic transmission and reception according to my invention.

Each station in a telephonic circuit should be provided with both a transmitter and receiver, and connection should be made separately between the main line and both.

When it is desired to communicate from one station to another, the signal may be made with any of the known signal apparatus, and the stations being in electrical communication the spring-motor at the sending-station is wound up and allowed to run, rotating the break-wheel, and thus causing a very rapid succession of electrical impulses, or, in other words, a quick intermittent current, to pass over the line; and if, now, by speaking in front of the diaphragm, it is caused to vibrate, these sound-vibrations of varying pitch and loudness cause vibrations of corresponding rapidity and amplitude in the diaphragm, the motion of which is communicated through the levers D and F to the core C of the induction-coil, and the varying movement of this core, both in respect to rapidity and amplitude, correspondingly qualify the character of the intermittent current passing over the main line, which current, in traversing the coil M of the receiver at the receiving-station, causes a movement of the core N precisely similar to that of the core C at the sending-station, and consequently a motion similar to that of the diaphragm A of the transmitter is transmitted to diaphragm O, and a vibration of the air in front of the latter diaphragm is produced similar to those air or sound vibrations at the other end of the line which put the diaphragm A in motion. These vibrations are communicated to the ear as sounds having the same character, pitch, and loudness as those produced in front of the transmitter.

In Fig. 3 is shown a main line having at each end both a transmitter and receiver, and said main-line wire connects with both, as with the receiving and transmitting telephones now in use.

Though I have shown the break-wheel K as having a non-conducting substance inlaid in its periphery to make the breaks, any other form of rapid circuit-breaker may be used—as, for instance, a metal wheel having triangular teeth, the spring-arm resting upon the tips of these teeth.

The apparatus may be provided, as is obvious, with the advancing adjusting devices when found necessary.

While in Fig. 3 I have shown both the transmitter and receiver at each station as included in the main-line circuit, it will be well understood that either may be switched out, if desired, when the other is being used, by the use of an ordinary two-button switch or other suitable shunting device.

What I claim is—

1. The method of telephonic transmission herein described, the same consisting in causing an intermittent electrical current to pass over a main line to a receiver, and qualifying the character of said intermittent current by means of a device operated by sound-vibrations, that varies the electro-motive force of the intermittent currents, substantially as described.

2. The combination, in a telephonic transmitter, of a diaphragm adapted to be operated by sound-vibrations, a main-line wire and apparatus for producing an intermittent electrical current thereon, and a device adapted to be operated or controlled by the diaphragm for regulating or varying the tension or electro-motive force of the current upon the main line, substantially as and for the purpose set forth.

3. The combination, in a telephone system, of a transmitter provided with a diaphragm adapted to be operated by sound-vibrations, and with apparatus for producing an intermittent electrical current upon the line-wire, and also with a device adapted to be operated or controlled by the diaphragm for regulating or varying the tension or electro-motive force of the current upon the main line, with the receiver, consisting of the hollow coil and the movable core attached to a suitably-supported diaphragm, substantially as described.

4. The combination of the diaphragm A, a battery, and the induction-coil having one of its terminals connected with the earth and the other with a main line, and provided with a movable core connected with said diaphragm, the battery being connected through a circuit-breaker with the primary circuit of said induction-coil, substantially as described.

5. The combination of the diaphragm A, the multiplying-levers D F, the core C of the induction-coil, having its primary circuit forming a portion of a battery-circuit, including an automatic circuit-breaker, and a main line connected with the earth, and including the secondary coil of said induction-coil, substantially as described.

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

CHARLES A. RANDALL.

Witnesses:
THOMAS B. BRADY,
PHILIP G. RANDALL.