(No Model.) 2 Sheets—Sheet 1.

J. C. LUDWIG.

APPARATUS FOR INTENSIFYING ELECTRICAL UNDULATIONS.

No. 448,153. Patented Mar. 10, 1891.

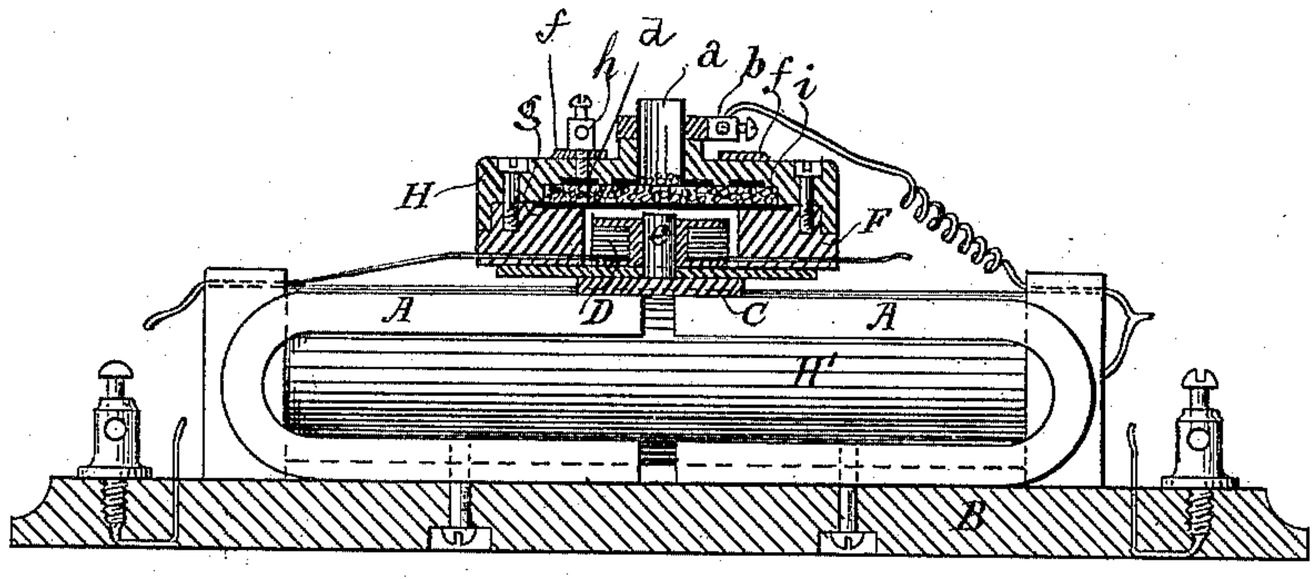


FIG 1.

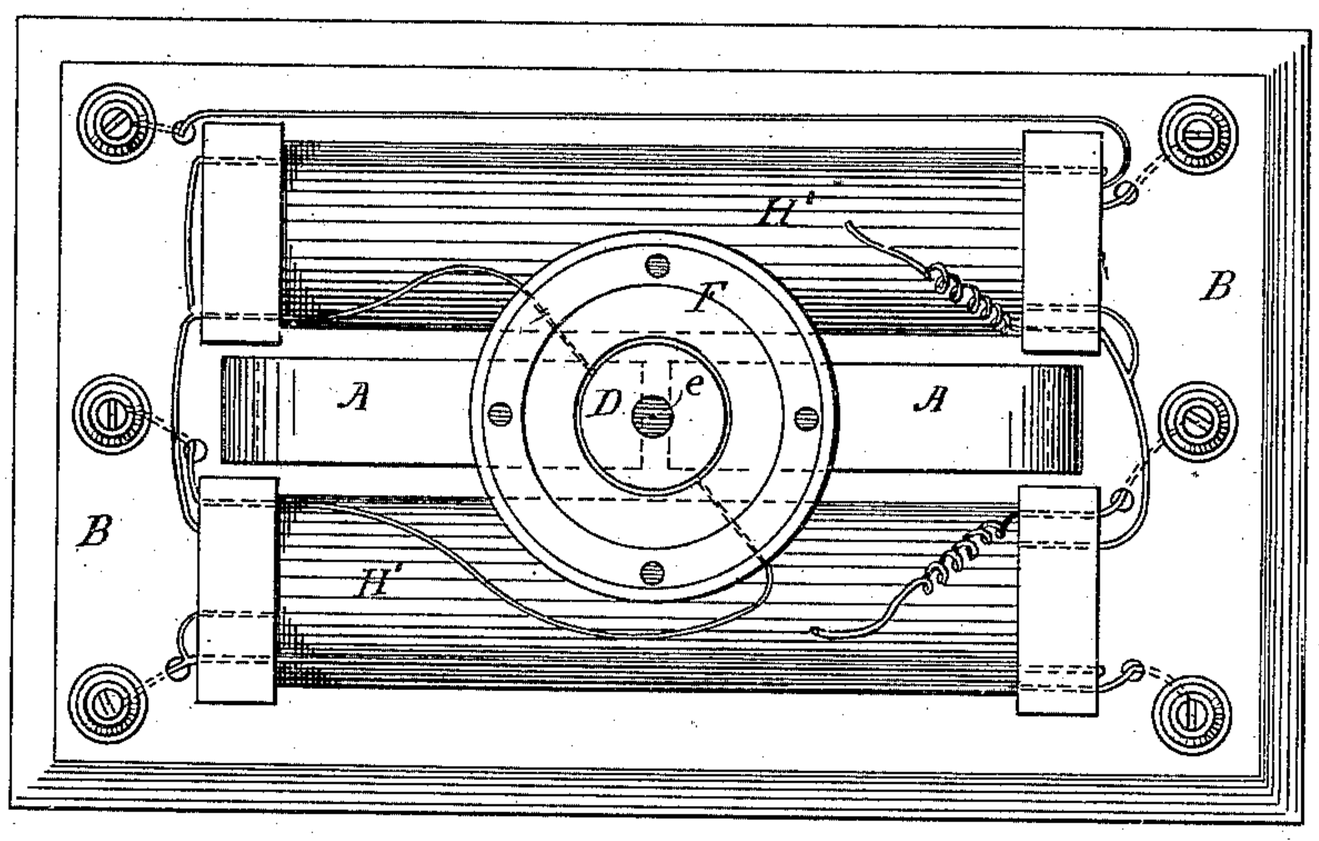
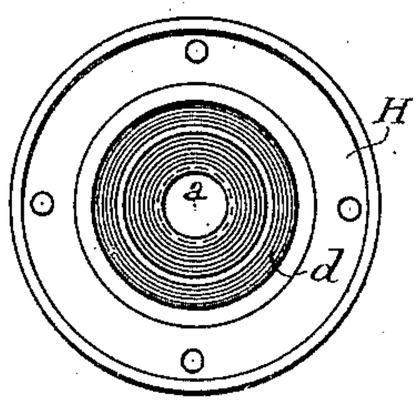


FIG 2.

FIG 3.



WITNESSES.

M. A. Wacker

M. G. Loefler.

INVENTOR

John C. Ludwig

By John L. Boone

(No Model.) 2 Sheets—Sheet 2.

J. C. LUDWIG.

APPARATUS FOR INTENSIFYING ELECTRICAL UNDULATIONS.

No. 448,153. Patented Mar. 10, 1891.

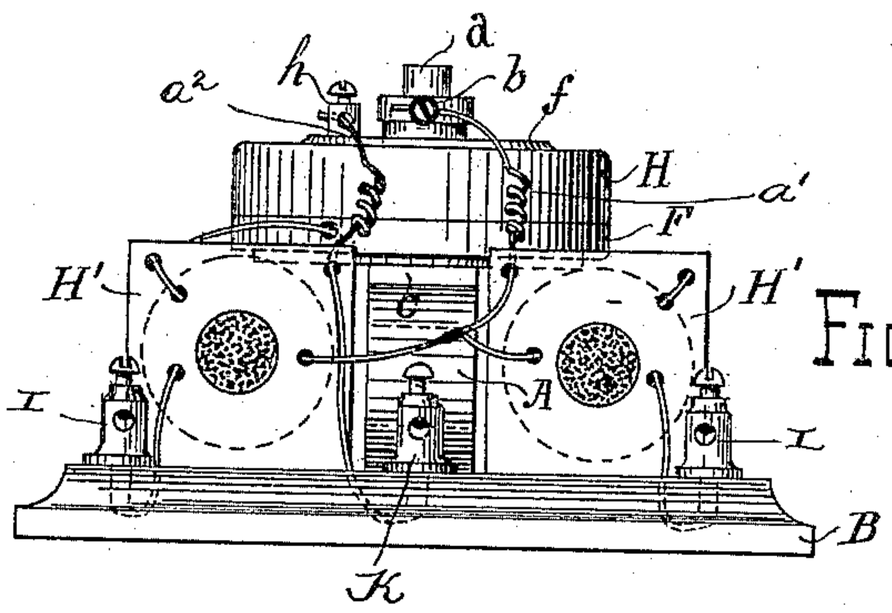


FIG 4.

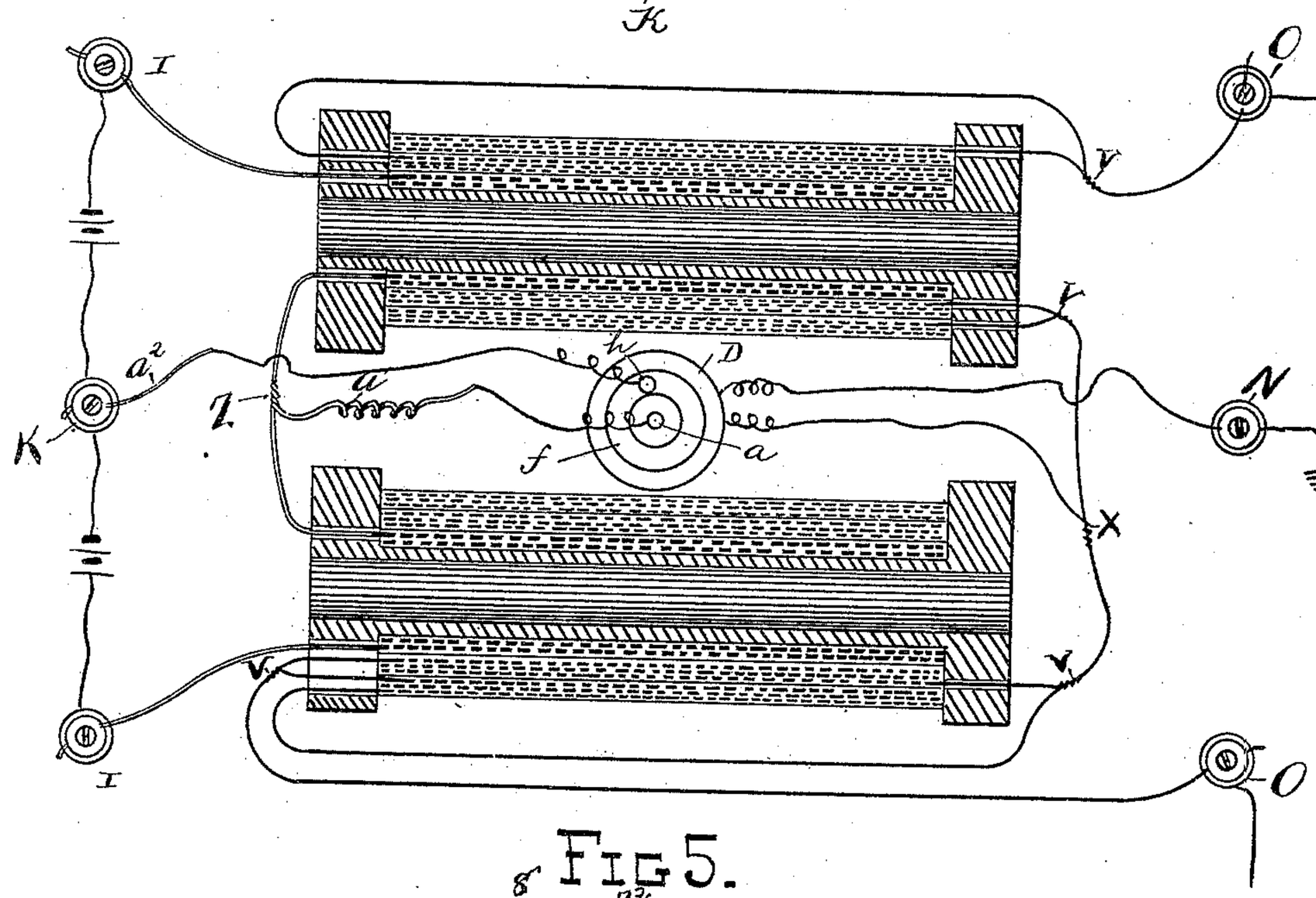


FIG 5.

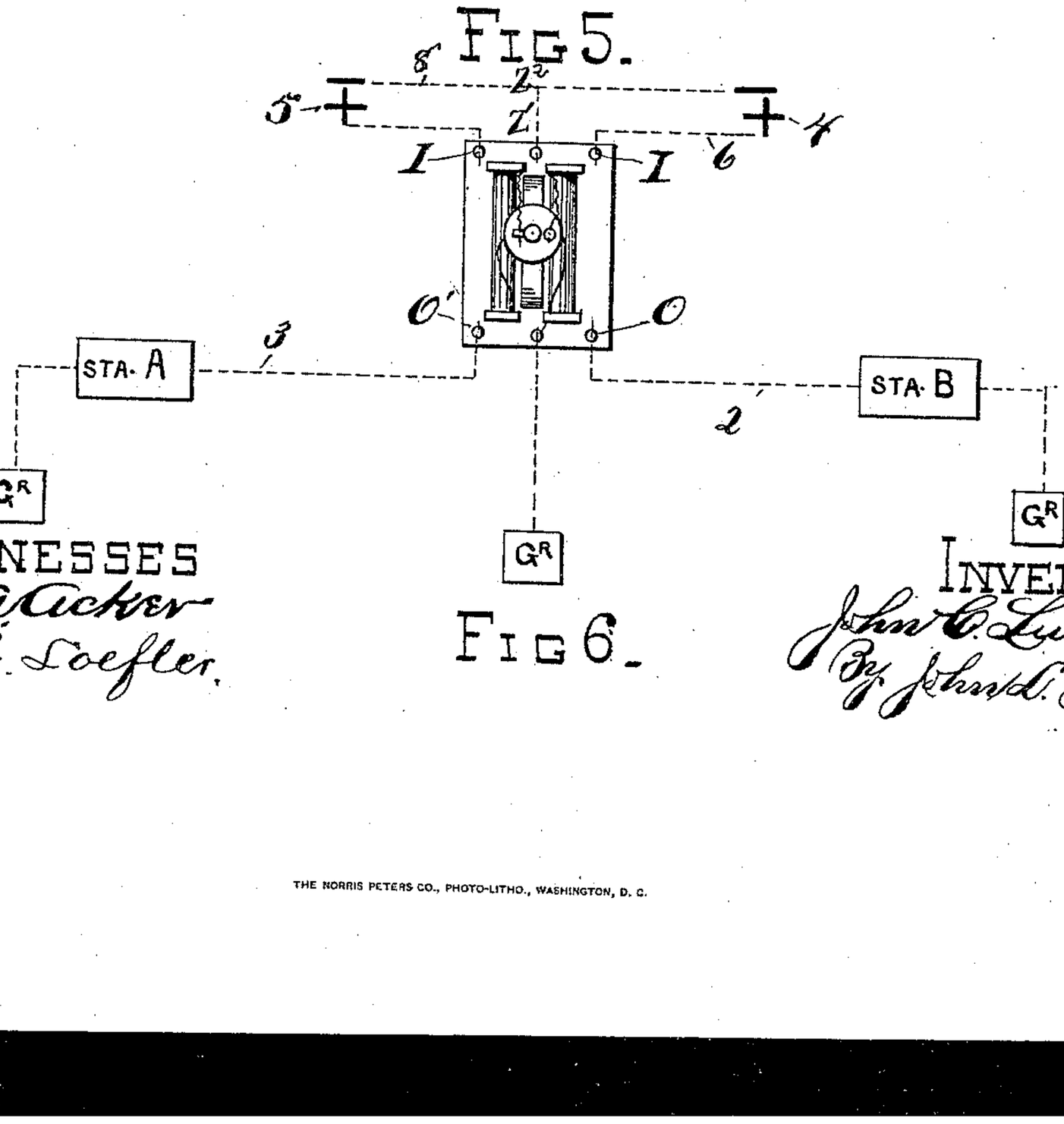


FIG 6.

WITNESSES
R. A. Acker
M. G. Loefler.

INVENTOR
John C. Ludwig
By John C. Boone

UNITED STATES PATENT OFFICE.

JOHN C. LUDWIG, OF SAN FRANCISCO, CALIFORNIA, ASSIGNOR OF SEVEN-EIGHTHS TO HENRY T. COMPTON, LOUIS F. MONTEAGLE, TIMOTHY PAIGE, AND GEORGE H. ROE, OF SAME PLACE, ALLEN T. AYRES AND WILLIAM C. MASON, OF OAKLAND, CALIFORNIA, AND HIRAM J. AYRES, OF AKRON, OHIO.

APPARATUS FOR INTENSIFYING ELECTRICAL UNDULATIONS.

SPECIFICATION forming part of Letters Patent No. 448,153, dated March 10, 1891.

Application filed September 10, 1889. Serial No. 323,525. (No model.)

To all whom it may concern:

Be it known that I, JOHN C. LUDWIG, a citizen of the United States, residing at the city and county of San Francisco, and State of California, have invented certain new and useful Improvements in Apparatus for Intensifying Electrical Undulations; and I do hereby declare the following to be a full, clear, and exact description of said invention, such as will enable others skilled in the art to which it most nearly appertains to make, use, and practice the same.

My invention relates to a novel apparatus, which I call a "telephone-repeater," to be applied in the length of a telephone-wire in the manner of applying an ordinary relay in the length of a telegraph-wire, and for much the same purpose, only my apparatus or relay is so constructed, arranged, and connected that the electrical undulations which are transmitted over the line are renewed and intensified and rendered more distinct by passing through my apparatus or repeater. For instance, if the sound-vibrations which are transmitted between two points over a telephone-wire are weak or indistinct, by introducing my relay or repeater in the length of the line it accomplishes the purpose of increasing the sounds; or, if the distance between two telephone-stations is so great that the battery-power is insufficient to reproduce the sounds from one station to the other the difficulty can be remedied by introducing one of my repeaters at some point in its length where it will be acted upon by the transmitted electrical undulations. It follows, therefore, that my repeating-instrument can be used at stated distances apart and thereby make it possible to send telephonic messages over long distances.

It consists of a combined receiving and transmitting instrument mounted between two induction-coils, each of which contains a primary and a secondary circuit. Each primary circuit is connected with a local battery, and the two primary circuits are connected with a single wire, which leads the current above the diaphragm of the receiving and transmitting instrument. The line-wire connects with the secondary circuit on each side and passes through the bobbin of the receiving and transmitting instrument below the diaphragm and thence to the ground. Suitable means are provided for causing the electrical undulations of the diaphragm to act upon the primary current and cause it to vary its resistance according to the vibrations of the diaphragm, whereby the secondary circuit is correspondingly affected by the induced current and its energy supplemented or renewed, all as hereinafter more fully described.

Referring to the accompanying drawings, forming a part of this specification, Figure 1 is a longitudinal section showing the location of diaphragm between the two circuits and the carbon granules resting upon and completing the primary circuit. Fig. 2 is a plan view showing the cover removed. Fig. 3 is an under side view of the cover. Fig. 4 is an end view showing the primary-circuit connections; Fig. 5, a longitudinal sectional view of the two induction-coils, showing the circuit-connections; and Fig. 6 is a plan view showing my improved relay interposed in the length of a line between two stations and the local-battery connection.

The letters A A, Figs. 1 and 2, represent two permanent magnets, which are secured in line with each other upon a base B with their poles slightly separated, as shown at Fig. 1. A metallic plate C is secured to the upper side of these two magnets, so as to extend across the space between them and form a bridge, upon which the bobbin or spool D is placed. A core *e*, which constitutes one of the poles of the magnet, projects upward from the plate or bridge C through the hollow center of the spool or bobbin and terminates at or slightly above the upper face of the spool. A circular case F, which is made of vulcanized rubber or other non-magnetic substance, is secured around the bobbin, and this case has a horizontal upper face, the level of which is slightly above the upper end of the pole *e*, upon which a thin metallic diaphragm

g is placed horizontally. It will readily be understood by electricians that these features constitute a telephonic receiving and transmitting apparatus, which can be varied in its construction and arrangement according to circumstances. For instance, a single permanent magnet can be used, and it may be placed vertically or horizontally, and various other well-known adaptations can be used without departing from the spirit and scope of my invention. My object in the above arrangement, however, is to so adjust the diaphragm to the pole of the magnet and bobbin that its upper face can be covered or partially covered with particles or granules of carbon, for the purpose hereinafter described.

The letter H indicates the cover for the case F, which is also made of some non-magnetic substance, and is so constructed as to fit down upon and clamp the outer edge of the diaphragm *g*. A slight chamber *i* is formed on the under side of this cover above the central part of the diaphragm, for the purpose hereinafter specified, and a metallic center post *a* (which in the present instance is represented as tubular) passes up through the center of the cover and has a binding-screw *b* connected with it above the cover. The metallic end of this center post is exposed on the under side of the cover and is flush with the top of chamber *i*. An annular metallic plate *d* is also secured in the top of the chamber *i*, surrounding the lower end of the center post *a* and on a level with it, and this plate is metallically connected with a similar metallic plate *f* on the outside of the cover. A binding-post *h* is secured to this metallic plate *f*. The center post *a* and its exposed face on the under side of the cover are insulated from the plates *d* and *f* and their metallic connections.

On each side of the magnet A is an induction-coil H′. Each coil contains three separate circuits, as indicated at Fig. 5, Sheet 2. The inner or center circuit immediately surrounding the soft inner core in each coil is the primary circuit, and this circuit is connected at one end with a local battery through binding-screws I, as hereinafter described, while the opposite ends of the two primary circuits of the two coils are brought together and connected at *z*, and thence a wire *a′* leads to the binding-screw *b* of the center post *a* above the cover H. Another wire a^2 connects the binding-screw *h* with the local battery through the binding-screw K, thus forming a complete circuit from the local battery through the primary coils and then back again to the batteries, except the break in the cover H, immediately above the diaphragm, which is closed, as hereinafter specified.

The two outer circuits on each of the induction-coils are secondary circuits, which are connected at one end with the line-wire through the binding-screw O, while their opposite ends are united at *v* and then connected with the helix of the bobbin underneath the diaphragm *g* and then led to the earth through the binding-post N. The two secondary circuits on each coil are insulated from each other and also from the primary circuit, and their ends are connected together, as shown at *v v*, Fig. 5, so that they practically form a single secondary current, the effect being to reduce the resistance in the secondary circuit. I have discovered that if a single secondary circuit composed of wire of the same size as that used on the bobbin below the diaphragm is employed in the induction-coils, the resistance between the helix of the bobbin and the secondary circuit is so nearly equal that no appreciable increased effect is transmitted to the diaphragm; but by employing a double or compound secondary circuit in each coil induced currents of greater quantity are generated, the effect of which is to cause the coil to act with greater vigor on the bobbin-wire and diaphragm. This effect might be produced by a single circuit if the wire used were sufficiently large, or the number of coils might even be increased; but I have produced excellent results with the two coils.

Upon the horizontal diaphragm *g*, I place loosely a quantity of carbon granules or particles, so that they will not impede the vibrations of the diaphragm, but will contact with the electrodes *a* and *d* on the under side of the cover H, and being themselves in contact with each other they serve to complete the primary circuit and thus place the diaphragm between two circuits.

Referring now to Fig. 6, in which I have shown the line-connections with my telephone-repeater, the numeral 2 indicates one of the line-wires and 3 the other line-wire. The wire 2 connects with the secondary circuit on one side of the receiving and transmitting instrument through the binding-post O while wire 3 connects with the secondary circuit on the opposite side of the receiving and transmitting instrument through binding-screw O′. The numerals 4 and 5 represent the two local batteries from which the primary current is derived. The positive pole of each battery is connected with the primary circuit of one of the induction-coils by wire 6 through the binding-screws I I at the end of the induction-coils opposite the line-wires. The negative poles of the two batteries are connected together at Z^2 by the wire 8, and thence are connected by the wire Z′ with the binding-screw *b*. When a message comes over one of the wires 2 or 3, the diaphragm *g* is caused to vibrate by the electrical undulations. The movement of the diaphragm causes the carbon particles which rest upon it and form a connection between the electrodes *a b* in the cover H to alternately press together and against the electrodes and make a closer contact or separate and press more lightly, according to the direction of the vibration of the diaphragm, thus disturbing the primary current in the coils that

causes the induced current to act simultaneously through the secondary circuit upon the diaphragm, thus giving to the diaphragm a new impulse that sends the message along the wire 3 with renewed force and energy. It will now be seen that the diaphragm *g* is placed between two circuits. The secondary circuit transmits to it the electrical undulations while the primary circuit receives from its undulations a disturbed impression which causes the induced current to vary its intensity and simultaneously react through the secondary circuit upon the diaphragm with the same effect as if the sound-vibrations were again repeated.

Having thus fully described my invention, what I claim as new, and desire to secure protection in by Letters Patent of the United States, is—

1. In a telephone repeating-instrument, a telephone-receiver, a local-battery circuit having its poles terminating adjacent to the diaphragm, loose granular particles of carbon or other conducting substance placed on the diaphragm to complete the local-battery circuit, and one or more secondary circuits interposed between the line-wire and the bobbin of the receiver.

2. In a telephone repeating-instrument, a telephone receiver and transmitter placed between two induction-coils, each of which contains a primary and a secondary circuit, the secondary circuit connecting with the bobbin-wire underneath the diaphragm of the receiver and transmitter, while the primary circuit connects above the diaphragm, and means for causing the vibrations of the diaphragm to disturb the primary circuit, substantially as set forth.

3. A telephone repeating-instrument consisting of a telephone receiver and transmitter placed between two induction-coils, the primary or battery circuit of the induction-coils connected at one end with a local battery, while the opposite ends of each connect with insulated metallic connections adjacent to the diaphragm of the transmitter, one or more secondary circuits surrounding the primary circuit on each side of the receiver and transmitter, one end of each secondary coil being connected with the wire of the line, while their opposite ends are connected with the bobbin-wire of the receiver and transmitter, and means for causing the vibrations of the diaphragm to disturb the primary and induced current, substantially as described.

4. In a telephone repeating-instrument, a telephone receiver and transmitter having a horizontally-disposed magnet, a case mounted on said magnet and having a horizontal upper face, a lid for said case having a recessed under surface, and a horizontal diaphragm supported by the horizontal face of the case, in combination with a bobbin passing vertically through the case, a core or magnetic pole extending vertically from the magnet through the bobbin, a local-battery circuit connected with electrodes terminating above the diaphragm, and means supported by said diaphragm within the recess in the cover and operating, as described, to complete the primary circuit.

5. In a telephone repeating-instrument, a magnet placed between two induction-coils, a telephone receiver and transmitter having a horizontal diaphragm placed above the magnet, a local-battery circuit connected with electrodes terminating immediately above the diaphragm, one or more secondary circuits interposed between the line-wire and the bobbin of the receiver and transmitter, and means for causing the vibration of the diaphragm to disturb the primary circuit, substantially as described.

6. In a telephone repeating-instrument, a telephone-receiver, a local-battery circuit having its poles terminating above the diaphragm, loose granular particles of carbon or other conducting substance placed upon the diaphragm to complete the primary or local-battery circuit, a case having a horizontal face to support said diaphragm, and one or more secondary circuits interposed between the line-wire and the bobbin of the receiver and transmitter, all arranged and combined substantially as shown, and for the purposes set forth.

7. In a telephone repeating-instrument, a diaphragm horizontally supported on a case above a magnet, a cover for said case having a chamber on its under side above the diaphragm, a central metallic post passing down through the cover and terminating at the roof of the chamber, and an annular metallic plate insulated from the center post and metallicly connected with a binding-post above the cover, substantially as herein shown and described.

8. In a telephone repeating-instrument, a horizontal magnet consisting of two magnets A A, placed in line with each other, a metallic plate C, arranged to bridge the space between the adjacent poles of the magnet, a case F, having an upper horizontal face, a diaphragm *g*, supported on said horizontal face above the magnets, a bobbin or spool D in the center of the case, and a magnetic-pole *e*, extending up through the center of the bobbin, substantially as herein described.

9. In a telephone repeating-instrument, a telephone-receiver, a local-battery circuit having its poles terminating adjacent to the diaphragm, said circuit being completed by the electric undulations acting on said diaphragm, and one or more secondary circuits interposed between the line-wire and the bobbin of the receiver and transmitter.

In testimony whereof I affix my signature in the presence of two witnesses.

JOHN C. LUDWIG.

Witnesses:
N. A. ACKER,
J. H. BLOOD.