E. GRISSINGER.

TELEPHONE REPEATER.

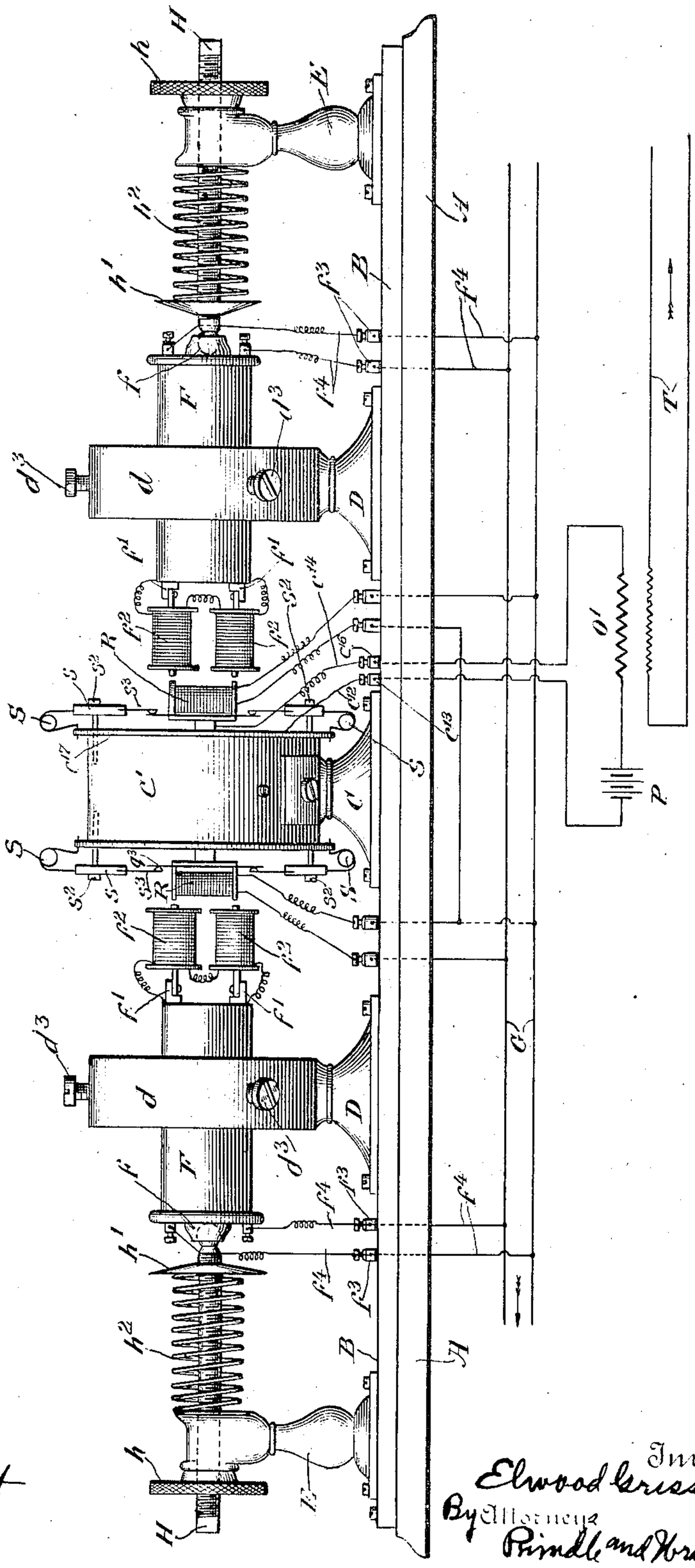
APPLICATION FILED DEC. 12, 1908.

1,198,213.

Patented Sept. 12, 1916.

3 SHEETS—SHEET 1.

Fig. 1.



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E. GRISSINGER.

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3 SHEETS—SHEET 2.

Fig: 2

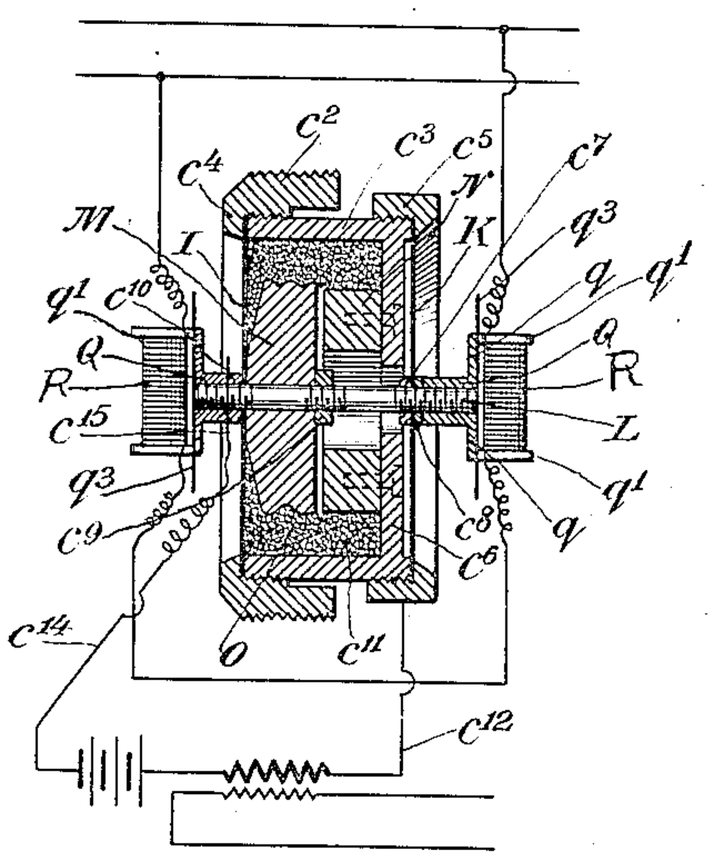


Fig: 3

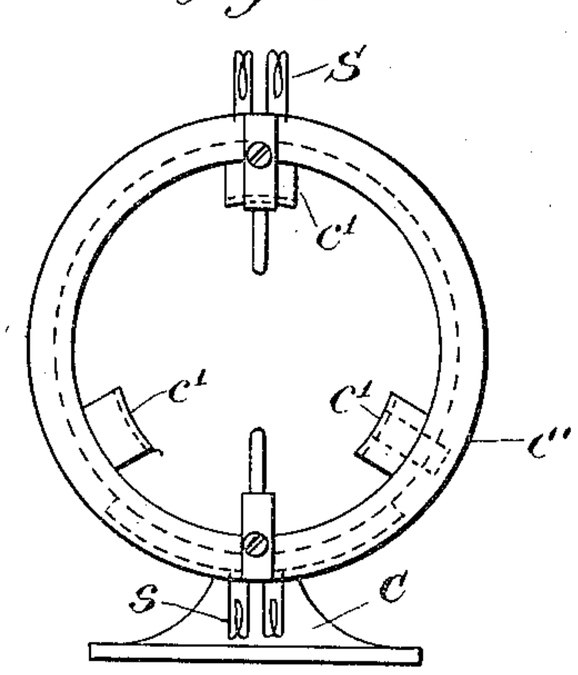


Fig: 4

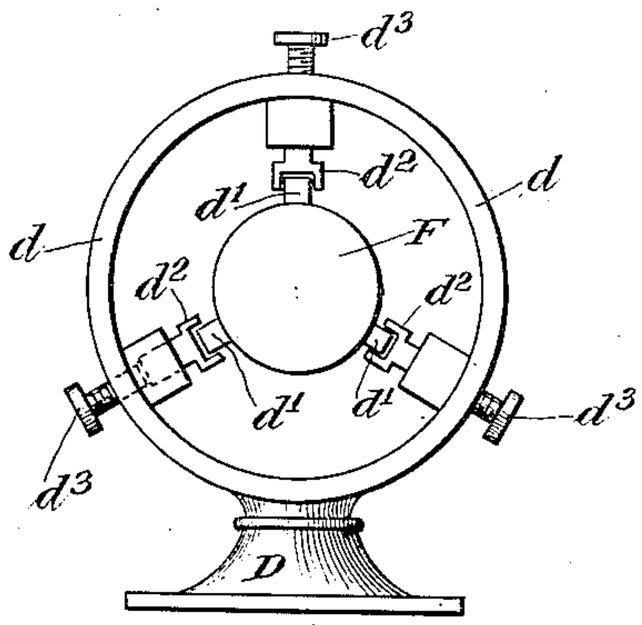


Fig: 5

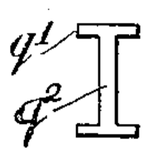


Fig: 6

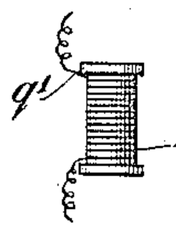


Fig: 7

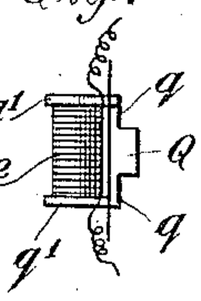


Fig: 8

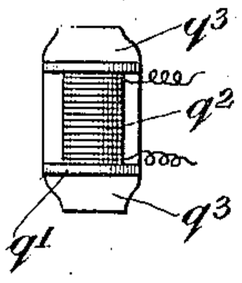


Fig: 9

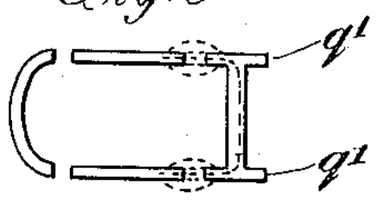
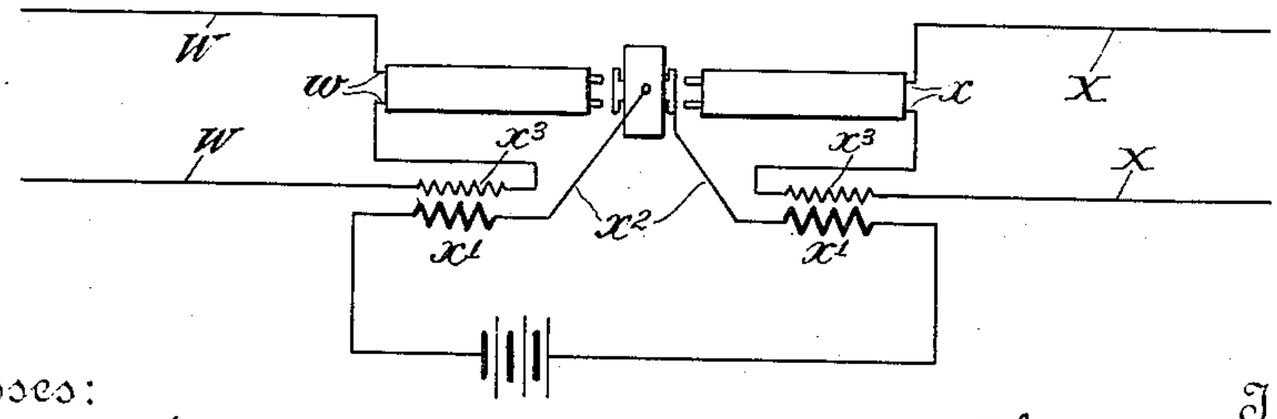


Fig: 10



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3 SHEETS—SHEET 3.

Fig: 11

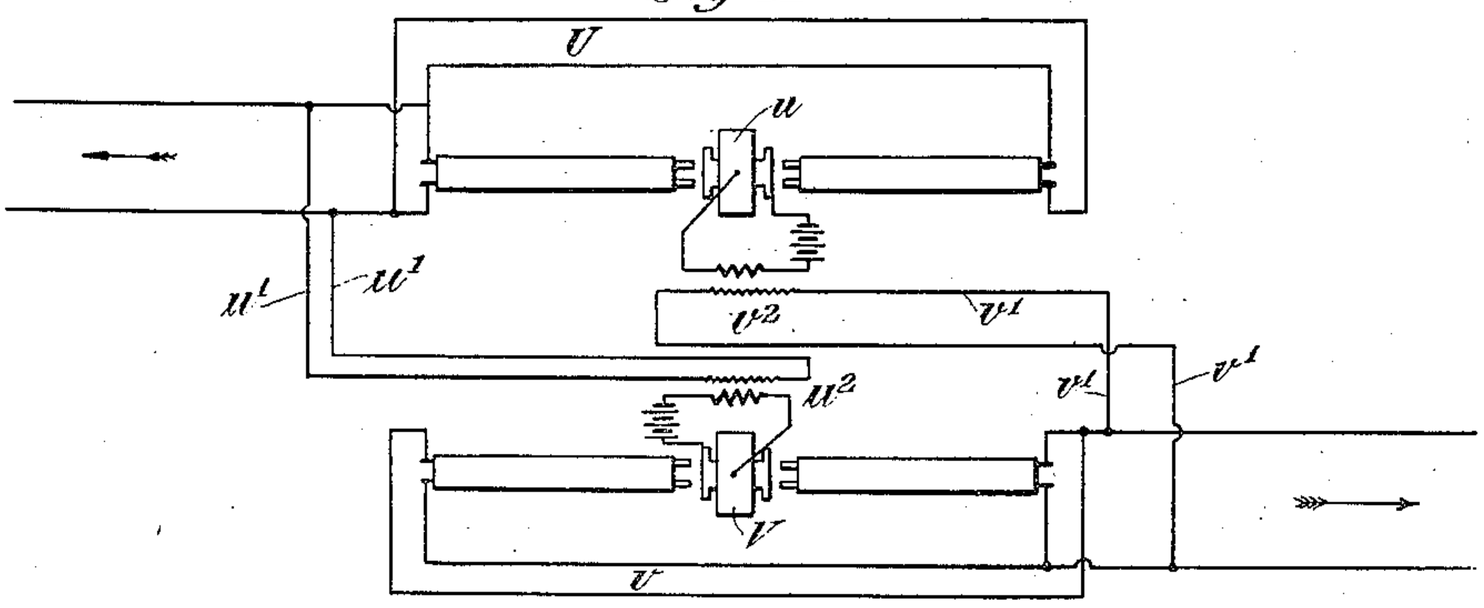


Fig: 16

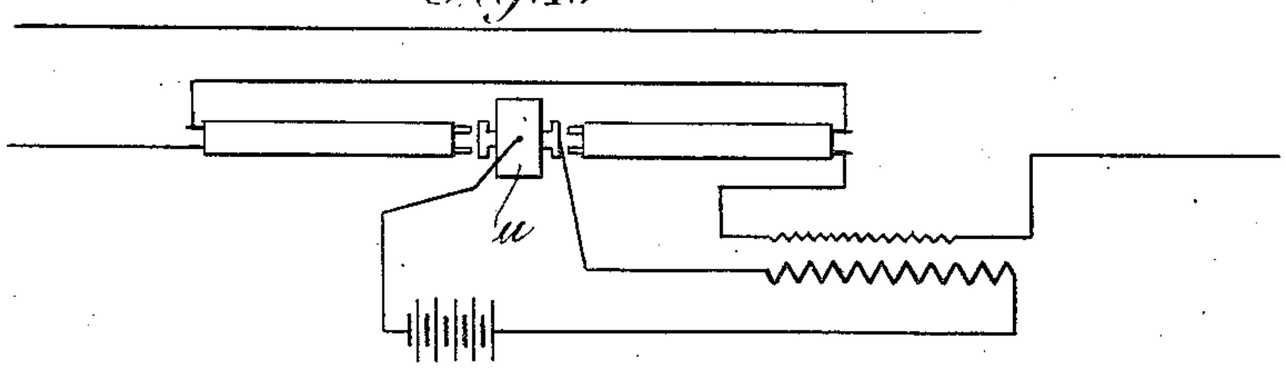
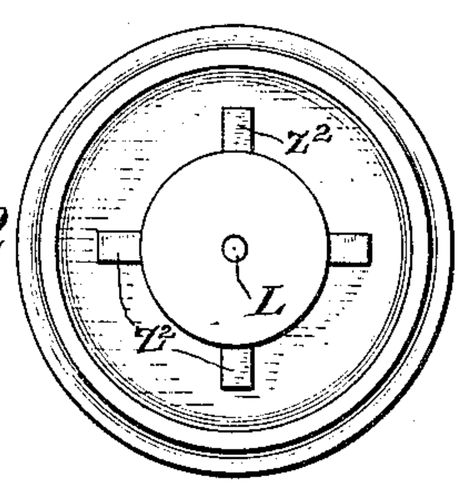


Fig: 12



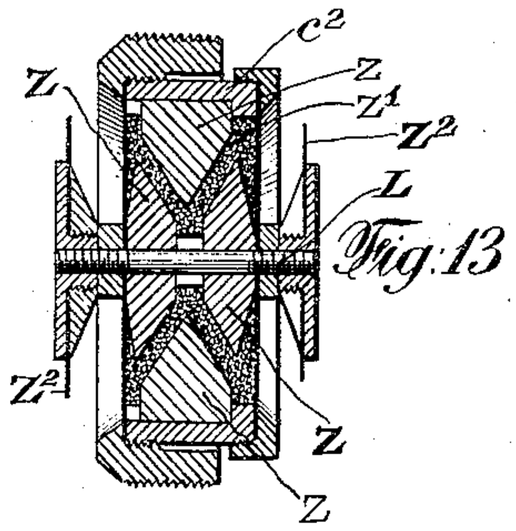


Fig: 13

Fig: 14

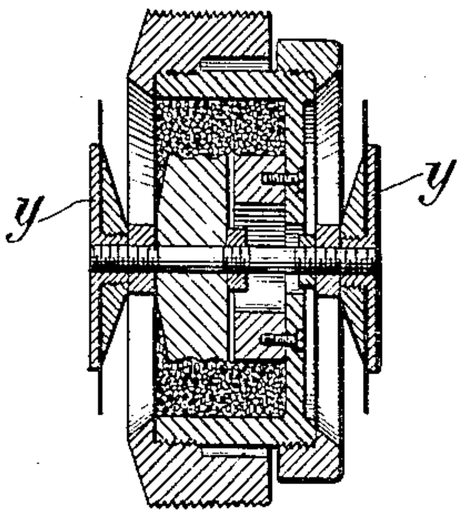
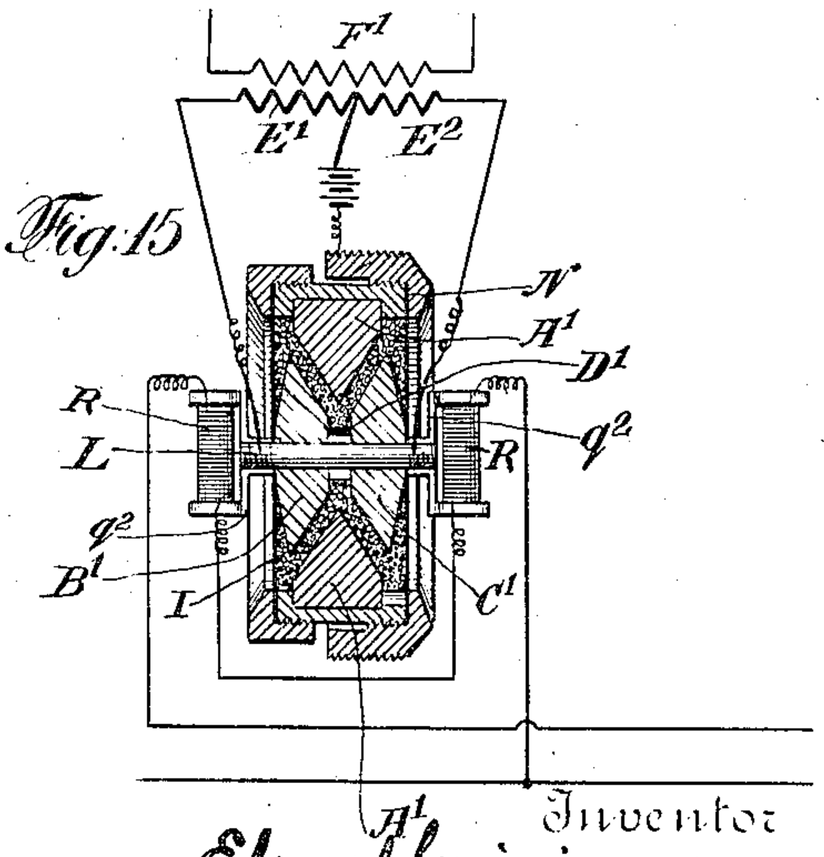


Fig: 15



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UNITED STATES PATENT OFFICE.

ELWOOD GRISSINGER, OF BUFFALO, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

TELEPHONE-REPEATER.

1,198,213. Specification of Letters Patent. Patented Sept. 12, 1916.

Application filed December 12, 1908. Serial No. 467,126.

To all whom it may concern:

Be it known that I, ELWOOD GRISSINGER, of Buffalo, in the county of Erie, and in the State of New York, have invented a certain new and useful Improvement in Telephone-Repeaters, and do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, in which—

Figure 1 is a side elevation of a telephone repeater or relay, embodying my invention; Fig. 2 is a vertical, longitudinal section of the parts carried by the central standard in Fig. 1; Fig. 3 is an end view of one of the central standards and the parts carried thereby; Fig. 4 is a like view of one of the intermediate standards and the parts carried thereby; Figs. 5 to 8 are detail views of one of the armatures shown in Fig. 1; Fig. 9 is a view of one of the permanent magnets, and its armature, showing the magnetic circuit therethrough; Fig. 10 is a diagrammatic view, showing a circuit repeating in both directions, and using but one repeater; Fig. 11 is a like view showing the use of two repeaters; Fig. 12 is a side elevation of a central casing with its armatures and electrodes, which is another embodiment of my invention; Fig. 13 is a vertical transverse section of the parts shown in Fig. 12; Figs. 14 and 15 are like views of other embodiments of my invention; and Fig. 16 is a view of my telephone repeater used as a "booster."

Letters of like name and kind refer to like parts in each of the figures.

The object of my invention has been to provide a telephone repeater by the use of which variations in the current of a telephone circuit can be increased in force and particularly to produce a telephone repeater by the use of which such variations in the current can be reproduced in another circuit and, if desired, can be increased in force, and to such ends, my invention consists in the telephone repeater or relay hereinafter specified.

In carrying my invention into practice, I provide a frame, preferably consisting of a wooden base A having secured thereto a metal plate B whose upper surface is preferably accurately formed in a plane. Upon the upper surface of the plate B are secured five standards; viz., a central one C, two standards D and D, each of which is intermediate the central standard and one of the ends of the plate, and two standards E and E near the ends of the plate. On each of the standards D and D is a preferably annular frame d in which is supported a preferably cylindrical hard-rubber casing F that has in it a magnet f, which is either a permanent or an electro-magnet. The poles are directed toward the central standard. I have shown the magnets as bi-polar, permanent magnets having soft iron pole pieces f' and f'. The pole-pieces are each provided with bobbins f^2 and f^2, the bobbin of each magnet being connected in series with the other and through insulated binding posts f^3 and f^3 and wires f^4 and f^4 with the line wires G and G of the sending telephone circuit. Each casing F is supported within its frame d by three or more rollers d' and d' that are mounted in the forked ends of rods d^2 and d^2, which latter are guided in sockets in the frame d and rest on screws d^3 and d^3 threaded into such sockets. The screws afford means for laterally adjusting the positions of the poles of the magnet, and the rollers permit longitudinal adjustment thereof. A rod H is supported by each of the end standards E and E, and each of such rods passes through a hole in its standard in which it is prevented from turning by a spline and groove. Each rod is provided with a screw-thread of very fine pitch, and has a nut h thereon, such nut bearing against the outer side of the standard. The inner end of each rod H is connected by ball-and-socket joint with the outer end of the adjacent magnet f and is provided with a nut h' between which and the inner face of the standard E a coil spring h^2 surrounding the rod H is confined. The central standard has secured thereto, as by screws, a preferably annular frame C′ in which are secured a series of blocks c' and c', preferably three in number, upon the inner faces whereof are formed portions of a screw-thread. Such thread can, however, if desired, be formed directly on the frame C′. A cylindrical shell c^2 is supported by the blocks c' and c' and a screw-thread on the exterior of such shell engages the thread on the said blocks. A screw passing through one of such blocks can be made to bear on the shell and lock the same. An annular casing c^3 is supported within the shell c^2, and such casing is provided with an exter-

nal screw-thread which engages an internal screw-thread on the shell. A diaphragm I is clamped between an end of the casing c^3 and a flange c^4 on the shell c^2. On the opposite end of the casing c^3 a ring c^5 is screwed, and a second diaphragm K is clamped between such end of said casing and a flange on such ring.

A wall c^6 is formed in the casing c^3 near one end thereof, and such wall is provided with a central aperture. A threaded rod L, preferably formed of light material, such as aluminum, is passed through the aperture in the wall, which aperture is large enough to prevent contact, and through apertures in the diaphragms, and the diaphragm K is clamped between nuts c^7 and c^8 on such rod. An electrode M, preferably formed of hard polished carbon is, with the diaphragm I, clamped on the said rod by a nut c^9 which engages one side of such electrode and a nut c^{10} which engages the diaphragm. A second electrode N, also preferably formed of hard polished carbon, is secured to the wall c^6, as by screws, and such electrode is provided with a central opening so that it shall not come into direct contact with the rod L. The space c^{11} outside of the electrodes and between the diaphragms is filled with a variable resistance medium O, such as granulated carbon. In this embodiment of my invention the face of at least one of the electrodes adjacent to the other electrode, is preferably covered with paper, as is also a small margin of the edge of the outer surface adjacent to such face, and the space between the electrodes is so small that none of the granulated carbon can enter it, the purpose being to prevent too short a path for the current in passing from one electrode to the other. In this form of my invention the variation of the resistance medium is chiefly due to mere disturbance of the equilibrium thereof and to changes in the path of the current. The diaphragms are chiefly for the purpose of sustaining the rod L and the parts it carries, and for retaining the granular carbon. It is desirable to have the diaphragms formed of the material which, having sufficient strength, is yet moved with the least expenditure of energy. I prefer the flimsiest kind of fabric, although I have used stiff material, such as mica, with good results. The circuit is formed through the electrode N by a wire c^{12} attached to the ring c^5 and to a binding screw c^{13} attached to, but insulated from, the plate B. Between the electrodes, the circuit is formed through the granular carbon, and from the electrode M it passes by a wire c^{14} having a terminal c^{15} on the rod L and having its opposite end attached to a binding screw c^{16} supported by, but insulated from, the plate B. The binding screw c^{13} is connected to a wire running to the primary circuit of an induction coil O′ which circuit is connected to one pole of a battery P whose opposite pole is connected with the binding screw c^{16}.

On the ends of the rod L nuts Q and Q are screwed, and each of such nuts has oppositely extending arms q and q to which are attached the flanges q' and q' of spool-shape armatures q^2 and q^2. The flanges q' and q' are opposite the pole pieces of the magnets. A plate of mica q^3 is interposed between each armature and its nut. A bobbin R is preferably, although not necessarily, placed on each armature, and such bobbins are connected together in series or multiple with each other and with the line wires G and G of the sending telephone circuit, or the circuit from which the message is to be repeated. The sending circuit is thus connected by four parallel circuits, so that its current is divided and passes simultaneously from one line wire G through the bobbins on the pole pieces of each of the two magnets, and through the bobbins of each of the two armatures over to the opposite line wire G.

It is desirable to have the magnets so close to the armatures that the latter shall, to a great extent, be sustained by the former and that there shall be the least possible leakage of lines of force between the said parts, while at the same time there must be sufficient space between the armatures and magnets to prevent actual contact during the movements of the armatures. The forces of attraction of the magnets on their armatures should be practically equal when no current is passing through the coils. To assist in the adjustment of the armatures and magnets, a pair of springs S and S are attached on opposite sides of each armature to a flange c^{17}, one of which is formed on each end of the annular frame C′. The free ends of the said springs have attached thereto blocks s and s, through each of which a screw s^2 passes, such screw having a head bearing on the block and having its shank threaded into the frame C′. A spring s^3 is secured in each block s in such position as to extend over the mica-plate q^3, before mentioned. By means of the screws s^2 and s^2 the springs s^3 can be made to bear upon the mica plates on opposite sides of the frame C′, and the armatures thus prevented from movement. The nuts h and h can then be turned to draw or allow the springs h^2 and h^2 to force the magnets to the requisite positions. When the magnets are adjusted, the springs s^3 and s^3 can be withdrawn from contact with the mica-plates. The line wires T and T of the circuit of the receiving telephone are connected with the opposite ends of the secondary circuit of the induction coil O′.

In the operation of my repeater, the bob-

bins on the pole pieces of one of the magnets, for instance, the right-hand magnet of Fig. 1, are formed in such direction that their action is to increase the attraction of the magnet for its armature, and the bobbin on its armature is so formed that the armature, being in effect a magnet, is attracted with increased force toward the magnet during the passage of a current. The bobbins on the opposite magnet, as the left-hand magnet, are, however, so formed that their action is opposed to the magnetism of the magnet and decreases the attraction thereof for its armature, and the bobbin on such armature is so formed as to oppose the magnetism induced therein by the magnet, so that the passage of currents through the bobbins on the pole pieces of such magnet and armature, respectively, decreases the attraction between the magnet and the pole pieces, or causes a repulsion therebetween. The effect of the combined action of all of the bobbins on the pole pieces and armatures is that, when an increased current passes through the sending circuit and through such bobbins, the armature of the right magnet is drawn to the right, while the armature of the left magnet is repelled toward the right. Such movement of the armatures causes the electrodes to approach each other, thus disturbing the equilibrium of the granulated carbon and shortening the distance of the circuit from one electrode through the granulated carbon to the opposite electrode, so that an increased current passes from the battery through the primary circuit of the inductive coil. This induces a current in the secondary circuit of the induction coil, causing a high-tension current to pass through the circuit of the receiving telephone and to operate the latter, thus reproducing in the receiving telephone the sound which operated the sending telephone. By the use of a sufficiently strong battery, or other source of electricity, the impulse in the sending circuit can be repeated in another circuit, and this can, if desired, be increased in force so that the original sound can be carried to a much greater distance than was possible by the direct use of the original current. With very long distances between the sending telephone, several repeaters or relays, each operating the next one to it in series, can be used.

It will be observed that in my repeater or relay, the armatures can be made of the same cross-section as the pole pieces, so that neither the former nor the latter need become magnetically saturated, and each will thus be free to respond to the slightest increase or decrease of the current through its coil. When an armature smaller in available cross-section than the pole of the magnet is used, such armature becomes magnetically saturated and cannot fully respond to an increase or decrease in the force of the magnet. My armature, however, being of substantially the same cross-sectional area as the pole pieces, can fully respond to any change in the existing current of the magnet. A more efficient response also is obtained, because the initial or normal attraction between the magnet and the armature is brought to a maximum by making the armature of sufficient cross-sectional area to receive all the lines of force generated by the magnet. No springs, weights, levers or devices for mechanically increasing the motion of the electrodes are used in my repeater, and loss of energy due to the use of such elements is, therefore, avoided. By the use of the current of the sending telephone in the bobbins of both armatures and in the bobbins of the opposite magnets, the greatest possible movement of the armatures from the energy of such current is secured. The location of the two armatures between the opposed magnets causes the armatures to be supported laterally by magnetism, so that the diaphragms can be of most flexible material and oppose the least resistance to the movements of the armatures, thus imposing upon the diaphragms practically nothing but to retain the granulated carbon. Any desired number of magnetic fields in juxtaposition to each other can be used to operate the armatures. When an armature is provided with an exciting coil, it becomes *per se* a magnet and tends to pull or push the electrodes, toward or from its magnet and thus to increase the movement of the electrodes.

The repeater or relay illustrated in Fig. 1 will transmit messages from the sending to the receiving circuit, but will not transmit messages in the opposite direction. By connecting two repeaters, as illustrated in Fig. 11, messages can be repeated in both directions. As here shown, telephone line wires U and U are not only connected with repeater u by the four parallel circuits as in Fig. 1, but are connected by wires u' an u' with the secondary circuit u^2 of the induction coil of the opposite repeater V. Likewise, the line wires v and v of the opposite telephone circuit are connected by four parallel circuits with the repeater V, as in Fig. 1, and are also connected by wires v' and v' with the secondary circuit v^2 of the induction coil of the repeater u. In this system each message undergoes but a single transformation.

In Fig. 10 I have shown a system in which, by the use of but a single repeater, messages can be transmitted in both directions. Here the line wires W and W of one telephone circuit are connected to the bobbins of the pole pieces of one of the magnets w and, if desired, to a bobbin on the arma-

ture of such magnet. The line wires X and X of the opposite telephone circuit are connected to the bobbins of the other magnet x and, if desired, to the bobbin of the armature of such magnet. There are two induction coils x' and x', the primary circuits of which are connected in series with each other with the primary circuit x^2 of the repeater and with a battery or other source of electricity. The secondary circuits x^3 and x^3 of the induction coils are each connected with the line wires W and W, or X and X, one of the telephone circuits. A message coming in over wires W and W, for instance, causes like variations in the primary circuit of the repeater and in the primary circuit of the induction coil whose secondary circuit is connected with line wires X and X and thus causes the message to be repeated over the latter line wires. Likewise, when a message comes in over wires X and X, it causes like variations in the primary circuit of the repeater and in the primary circuit of the induction coil whose secondary circuit is connected with line wires W and W and causes the message to be repeated over the latter line wires.

Changes can be made which are within the scope of my invention. For instance, the repeater can be used in a vertical instead of a horizontal position. As shown in Fig. 14, instead of the armatures illustrated in Fig. 2, and having bobbins thereon, plain armatures Y and Y, without bobbins can be used. Such armatures can be made in the form of disks. In other respects than the armatures, the construction illustrated in Fig. 14 is the same as that in Fig. 2.

In Figs. 12 and 13, I have illustrated a casing with its electrodes, armatures, etc., for a repeater in which are used an electrode consisting of two parts Z and Z on the rod L and having cone-shape adjacent faces, and an electrode z that is annular and of wedge-shape cross-section, the latter being sustained by the casing c^2 in the annular V-shape space between the electrodes Z and Z. The granulated carbon z' in this instance is between the electrodes and is compressed by their movements. The outer faces of the parts Z and Z are cone-shape so that they shall not come into contact with the diaphragms. The inner face of one of the parts Z or one of the faces of the electrode z is insulated. In this instance I have shown armatures similar to those illustrated in Fig. 14 and I have shown behind the armatures mere strips z^2 and z^2 of mica, instead of sheets of such material. If desired, permanent magnets can be used for the armatures instead of soft iron ones. The coils or bobbins on the armatures can, if desired, be inclosed in a thin iron shell so as to prevent a counter electro-motive force in such coil. Where the sending telephone current is divided in passing through the repeater; as where it passes simultaneously through two or more circuits formed by a coil or coils on a magnet or magnets, and through a coil or coils on one or more armatures, it is desirable that the electrical dimensions of such circuits should be equal.

In Fig. 15, I have illustrated a casing with its electrodes, armatures, etc., for a repeater in which are used a central electrode A′ that is annular and of wedge shape in cross-section, such electrode being supported by the casing. As before, diaphragms I and N support a rod L on whose ends are armatures of any desired form. I have illustrated armatures q^2 and q^2 having bobbins R and R constructed and connected as described in connection with Figs. 1 to 9. On the rod L are electrodes B′ and C′ which are of conical shape, their conical surfaces being adjacent each other and oppositely disposed. A section D′ of rubber tubing is placed on the rod L and between the electrodes B′ and C′, to confine the paths of the current to the faces of the electrodes proper. The electrodes A′, B′ and C′ are of such size that there is space between them, and such space is filled with granulated carbon. The outer surfaces of the latter two electrodes are made slightly conical, so that they will not come into contact with the diaphragms during the movement of the parts. An induction coil is provided, such coil having two primary circuits E′ and E^2 of equal electrical dimensions and preferably wound upon the same core. The primary coils are so wound and connected that the current will pass through them in opposite directions. One end of each is connected with the electrode A′ through a battery and the casing. The opposite ends of such circuits are connected to the outer faces of the electrodes B′ and C′. The secondary circuit F′ of the induction coil is connected with the receiving telephone circuit. In the operation of this form of my invention, when the armatures are moved, as for instance, to the left in Fig. 15, the circuit of resistance between electrodes C′ and A′ will be shortened or decreased and an increased current will flow through the primary circuit E^2. At the same time, the circuit or resistance between the electrodes A′ and B′ will be increased and a decrease will occur of the current flowing between such electrodes and through primary circuit E′. The effect of the two primaries will thus be in the same direction and will be added to each other, thus producing a strong induced wave in the secondary circuit and in the receiving telephone circuit.

If desired, the secondary circuit of the induction coils in all the forms I have illus-

trated can be connected with the line wires of sending telephone circuit, as illustrated in Fig. 16, so that the current induced in such secondary circuit, will be added to and superimposed upon the original current in such circuit; and the receiving telephone can be connected to the same line wires as the sending telephone.

Having thus described my invention, what I claim is:

1. In a telephone repeater or relay, the combination with a telephone circuit, of magnets having their poles opposite each other, armatures for such magnets, said armatures being connected together, coils on such magnets and on said armatures, which coils are connected to such circuit, the coils on one magnet and its armature being opposed to the magnetism therein, and the coils on the opposite magnet and its armature increasing the magnetism therein, a second telephone circuit, and electrodes by which such second circuit can be influenced, one of said electrodes being connected to such armatures, substantially as and for the purpose described.

2. In a telephone repeater or relay, the combination with a telephone circuit, of magnets having their poles opposite each other, coils on such magnets connected to said circuit, a casing between such poles, diaphragms formed of fabric extended across said casing opposite such poles, a rod extending through said diaphragms, armatures on such rod, electrodes, one of which is carried by said rod, a second telephone circuit, and means by which said second circuit can be influenced by the said electrodes, substantially as and for the purpose described.

3. In a telephone repeater or relay, the combination with two telephone circuits, of two induction coils each having its secondary circuit in one of such telephone circuits, two variable resistance mediums, each of which is in circuit with the primary circuit of one of such induction coils, each of such variable resistance mediums consisting of a stationary and a movable electrode, and a rod passing centrally through such electrodes, and to which rod one of said electrodes is attached, armatures on the end of said rod and magnets for such armatures, each of which is connected with one of such telephone circuits, substantially as and for the purpose described.

4. In a telephone repeater or relay, the combination with two telephone circuits, of two induction coils each having its secondary circuit in one of such telephone circuits, two variable resistance mediums, each of which is in circuit with the primary circuit of one of such induction coils, each of said variable resistance mediums consisting of a stationary and movable electrode, and a rod passing centrally through such electrodes, and to which rod one of said electrodes is attached, armatures on the ends of said rod, magnets for such armatures, and coils about such armatures, each of which coils is in circuit with one of said telephone circuits, substantially as and for the purpose described.

5. In a telephone relay or repeater, the combination with a telephone circuit, of a magnet having a coil connected with such circuit, rollers between which said magnet is held, such rollers being movable toward or from said magnet, an armature for such magnet, said armature having arms corresponding to the pole pieces of such magnet, means for adjusting said magnet longitudinally toward or from such arms, a second telephone circuit, and electrodes by which said second circuit can be influenced, one of which electrodes is connected to such armature, substantially as and for the purpose described.

6. In a telephone relay or repeater, the combination with a telephone circuit, of magnets having their poles opposite each other, armatures for such magnets, said armatures being connected together, coils about such magnets and about said armatures, which coils are connected to such circuit, the coils on one magnet and its armature being opposed to the magnetism therein, and the coils on the opposite magnet and its armature increasing the magnetism therein, two mechanically connected electrodes connected to said armatures and having an electrode located between the first-mentioned electrodes, an induction coil having two primary circuits connected so as to conduct currents in opposite directions therein, the like ends of such circuits being connected to the said first-mentioned electrodes, the remaining ends of such circuits being connected to said last-mentioned electrode, and a second telephone circuit connected to the secondary circuit of such induction coil, substantially as and for the purpose described.

7. In a telephone repeater or relay, the combination with a variable resistance medium, of an armature attached to and capable of operating such medium, a magnet for moving said armature, a flexible non-elastic support for such armature, means adjusting such magnet, springs, one of which is mounted opposite each end of said armature, and means for bringing said springs to bear upon the armature, so that the magnet can be properly adjusted with relation to the armature, substantially as and for the purpose described.

8. In a telephone repeater or relay, the combination of a variable resistance medium, an armature for operating said me-

dium, oppositely facing magnets for operating said armature, said magnets being adjustable, a flexible non-elastic support for said armature, and means for yieldingly engaging the opposite faces of said armature while said magnets are being adjusted, substantially as and for the purpose described.

9. In a telephone repeater or relay, the combination with a variable resistance medium, of an armature attached to and capable of operating such medium, a spring plate carried by said armature, a magnet for operating such armature, means for adjusting said magnet with relation to such armature, a spring, and means for bringing said spring to bear upon such spring plate, so that the magnet can be properly adjusted with relation to the armatures, substantially as and for the purpose described.

10. In a telephone repeater or relay, the combination with a variable resistance medium, of opposite armatures attached to and capable of operating such medium, spring plates carried by said armatures, opposite magnets for operating such armatures, means for adjusting said magnets with relation to such armatures, springs, and means for bringing said springs to bear upon such spring plates, so that the magnets can be properly adjusted with relation to the armatures, substantially as and for the purpose described.

11. In a telephone repeater or relay, the combination of a bodily movable armature, a variable resistance medium operated by said armature, two non-resilient supports supporting said armature at points separated in a horizontal direction and isolating said armature as respects transmission of vibration, and magnets for operating said armature, said magnets having telephonic connections.

12. In a telephone repeater or relay, the combination of a bodily movable armature, a variable resistance medium operated by said armature, two non-resilient supports supporting said armature at points separated in a horizontal direction and isolating said armature as respects transmission of vibration, and oppositely directed magnets for operating said armature, said magnets having telephonic connections.

13. In a telephone repeater or relay, the combination of oppositely disposed electromagnets having telephonic connection, an armature maintained between them, such armature having a coil that has telephonic connection, and a variable resistance medium in operative connection with a telephone and operated by said armature.

14. In a telephone repeater or relay, the combination of oppositely disposed electromagnets having telephonic connection, an armature maintained between them by non-resilient means, such armature having a coil that has telephonic connection, and a variable resistance medium in operative connection with a telephone and operated by such armature.

15. In a telephone repeater or relay, the combination of an electro-magnet connected with a telephone circuit, an armature for such magnet, such armature having a coil that has a telephonic connection, flexible non-resilient means for supporting said armature and isolating the same as respects transmission of vibration, and a variable resistance medium in operative connection with a telephone and operated by said armature.

16. In a telephone repeater or relay, the combination of a bodily movable armature and non-elastic means supporting said armature and isolating the same as respects vibration, a variable resistance medium operated by said armature, and a multipolar magnet that is adapted to act upon said armature, said armature extending from pole to pole of said magnet, and having throughout its length substantially the same cross-section as a pole of said magnet.

17. In a telephone repeater or relay, the combination of a bodily movable armature and non-elastic means supporting said armature and isolating the same as respects vibration, a variable resistance medium operated by said armature, and a multipolar magnet under the influence of the sending circuit, that is adapted to act upon said armature, said armature extending from pole to pole of said magnet, and having throughout its length substantially the same cross-section as a pole of said magnet.

18. In a telephone repeater or relay, the combination with a telephone circuit of magnets having their poles opposite each other, armatures for said magnets, said armatures being connected together, coils on such magnets and about said armatures, which coils are connected to such circuit, the windings of the magnets and armatures being so wound that when the same current energizes them there is attraction between them at one end and repulsion at the other, a second telephone circuit, and electrodes by which such second circuit can be influenced, one of said electrodes being connected to such armatures, substantially as and for the purpose described.

19. In a telephone repeater or relay, the combination of multipolar magnets facing each other, a variable resistance medium, connected armatures for operating said variable resistance medium, said armatures extending substantially from pole to pole of their respective magnets, and coils about said armatures and said poles, said coils being in electric connection with the telephone circuits.

20. In a telephone repeater or relay, the

combination of multipolar magnets facing each other, a variable resistance medium, connected armatures for operating said variable resistance medium, said armatures extending substantially from pole to pole of their respective magnets, and being of substantially the same cross-section throughout the magnetic circuit as a pole of said magnet, and coils about said armatures and said poles, said coils being in electric connection with the telephone circuits.

21. In a telephone relay or repeater, the combination with a telephone circuit, of magnets having their poles opposite each other, armatures for such magnets, said armatures being connected together, coils about such magnets and about said armatures, which coils are connected to such circuit, the coils on one magnet and its armature being opposed to the magnetism therein, and the coils on the opposite magnet and its armature increasing the magnetism therein, two mechanically connected electrodes connected to said armature, and having an electrode located between the first mentioned electrodes, a multiple unit variable resistance medium, an induction coil having two primary circuits, connected so as to conduct currents in opposite directions therein, the like ends of such circuits being connected to the said first-mentioned electrodes, the remaining ends of such circuits being connected to said last-mentioned electrode, and a second telephone circuit connected to the secondary circuit of such induction coil, substantially as and for the purpose described.

22. A telephone relay or repeater comprising a receiving coil, the primary circuit of an induction coil, a granular resistance medium in such circuit subject to vibrations by the current undulations in the receiving coil, means including an armature for transmitting such vibrations to the resistance medium and a flexible non-elastic support for such means incapable of independent sustained telephonic vibration.

23. A telephone relay or repeater comprising a receiving coil, the primary circuit of an induction coil, a granular resistance medium in such circuit subject to vibrations by the current undulations in the receiving coil, means including an armature shaft for transmitting said vibrations to the resistance medium, said means adapted for movement endwise of said shaft, and a non-elastic support for such shaft.

24. A telephone relay or repeater comprising a frame or bed structure, opposing receiving coils thereon, a granular resistance medium in such circuit subject to vibrations by the current undulations in the receiving coils, means including connected armatures for transmitting such vibrations to the resistance medium, and a non-elastic support for such means isolating the same from the frame or bed structure as respects transmission of vibration from one to the other.

25. A telephone relay or repeater comprising a double-acting microphone composed of two resistance parts wherein the resistance is simultaneously increased and decreased respectively, two opposed receiving coils, two armatures secured to the vibratory member of said microphone, each armature inductively related to and closely confronting one of said coils, two permanent magnetic fields between which said armatures are balanced, a primary circuit having primary induction coil sections connected with such resistance parts and through which current flows in opposite directions to or from the said microphone, and a secondary coil in inductive relation to both said primary coil sections, the organization being such that operation of said microphone produces simultaneous decrease and increase in the primary coil sections cumulatively effective upon the secondary.

26. A telephone relay or repeater comprising a supporting frame or bed structure, a receiving coil thereon, the primary circuit of an induction coil, a granular resistance medium in such circuit subject to vibrations by the current undulations in the receiving coil, means for transmitting such vibrations and a support for such means which isolates the same from the said frame or bed structure in respect to the transmission of vibration from the one to the other.

In testimony that I claim the foregoing I have hereunto set my hand.

ELWOOD GRISSINGER.

Witnesses:
CHARLES W. STRANG,
FANNY E. RENNING.