No. 881,360. PATENTED MAR. 10, 1908.

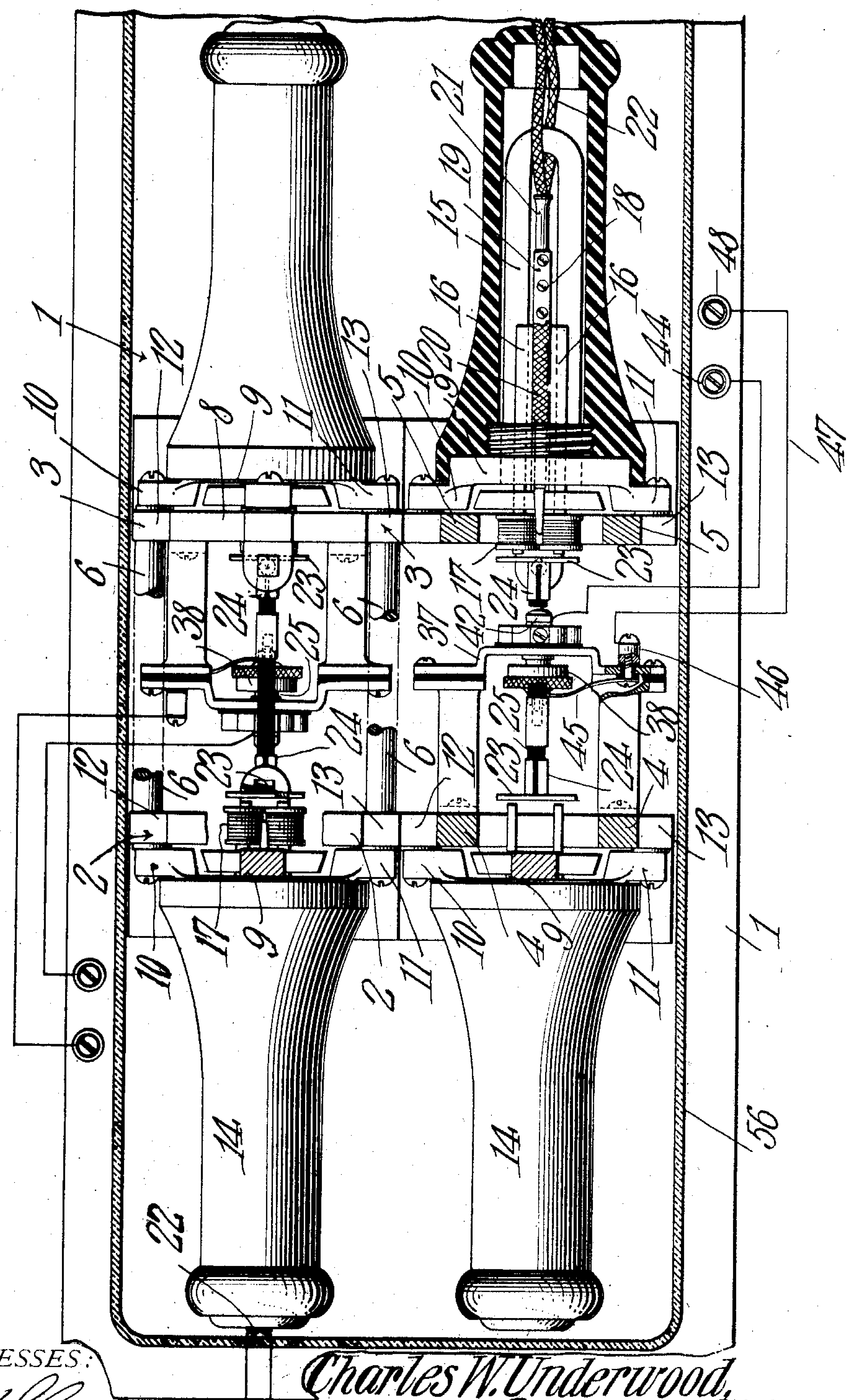
C. W. UNDERWOOD.

TELEPHONE RELAY.

APPLICATION FILED JULY 6, 1907.

3 SHEETS—SHEET 1.

Fig.1.



WITNESSES:

E. J. Stewart

F. T. Chapman

Charles W. Underwood,
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ATTORNEYS

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Fig. 2.

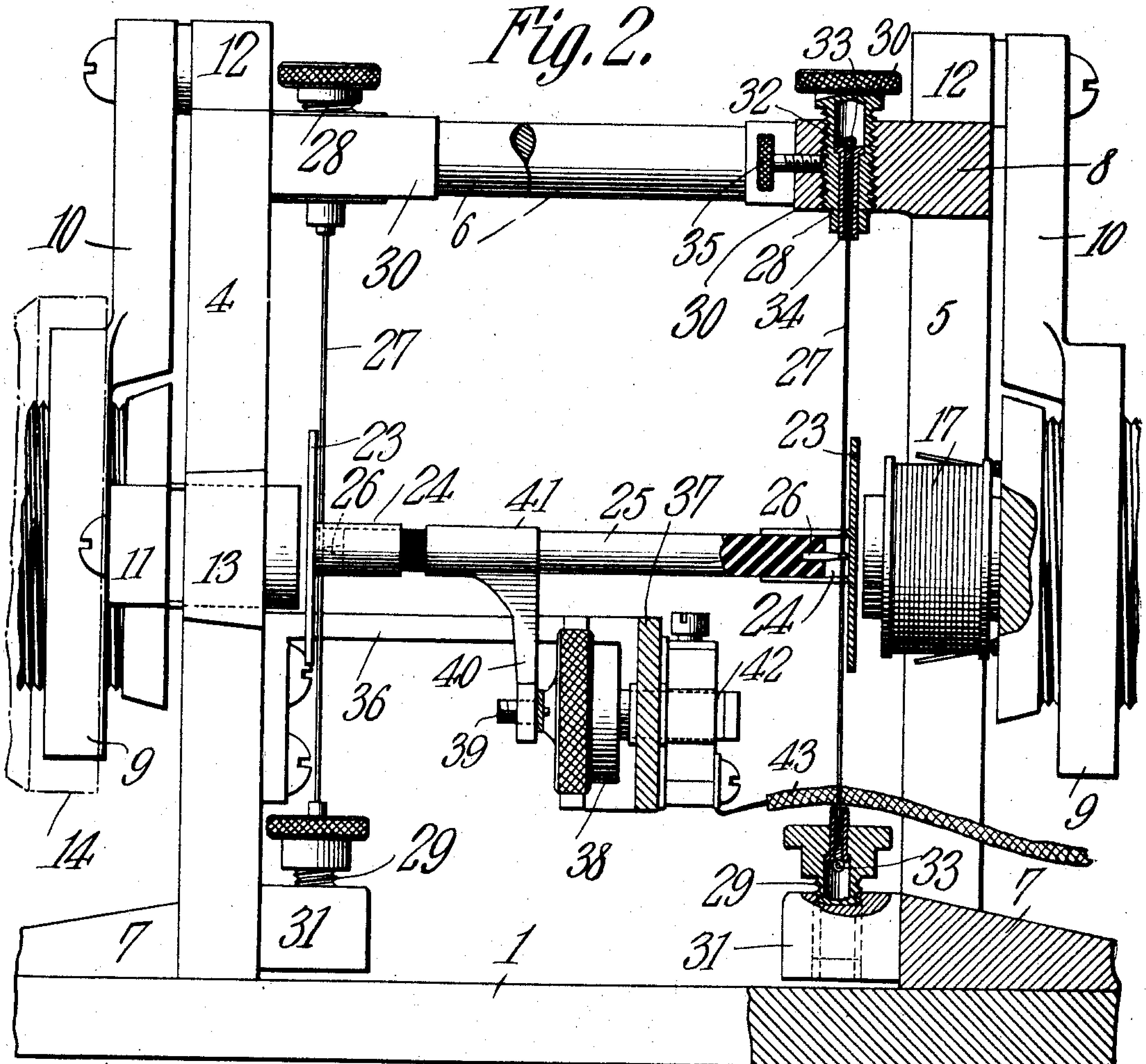
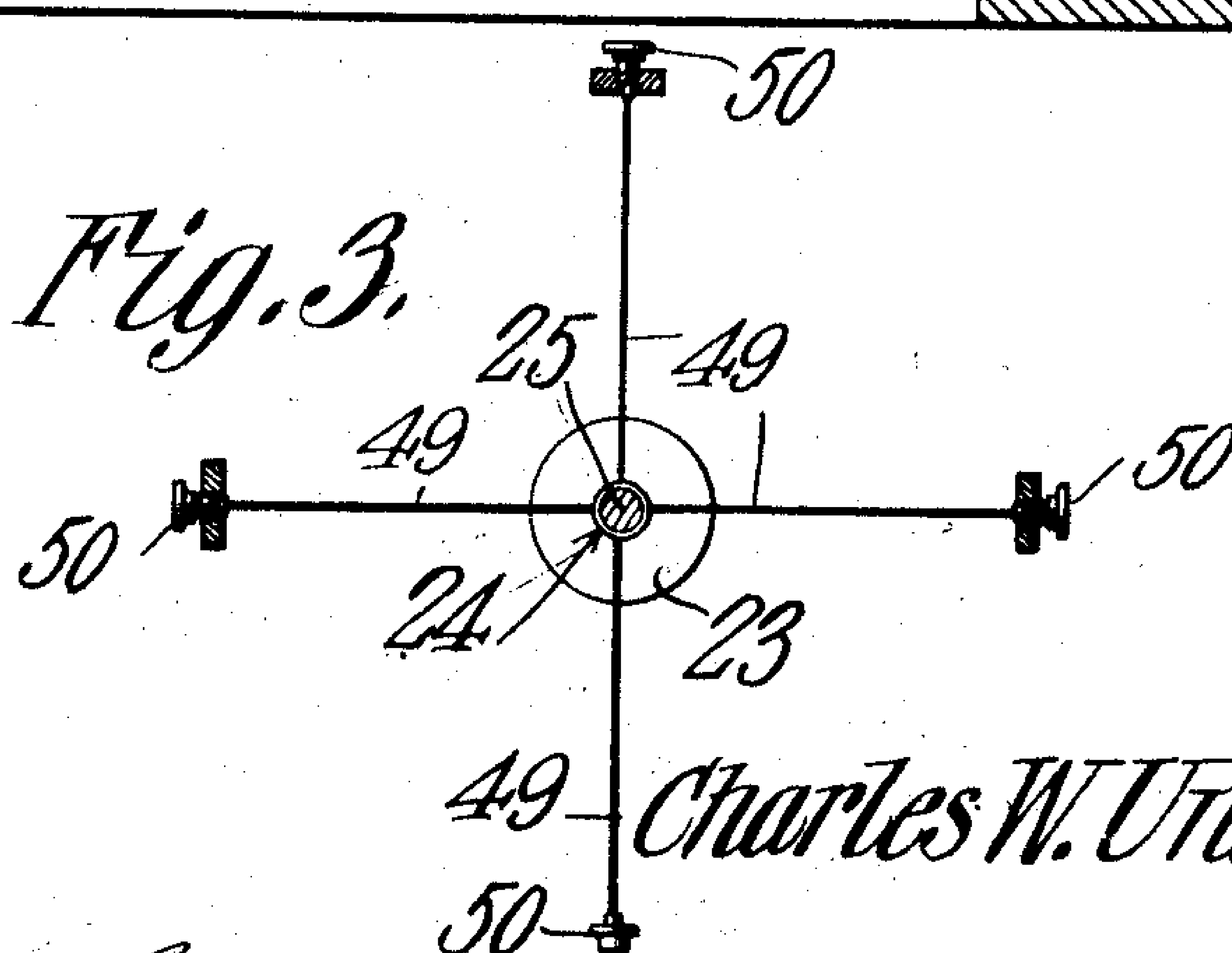


Fig. 3.



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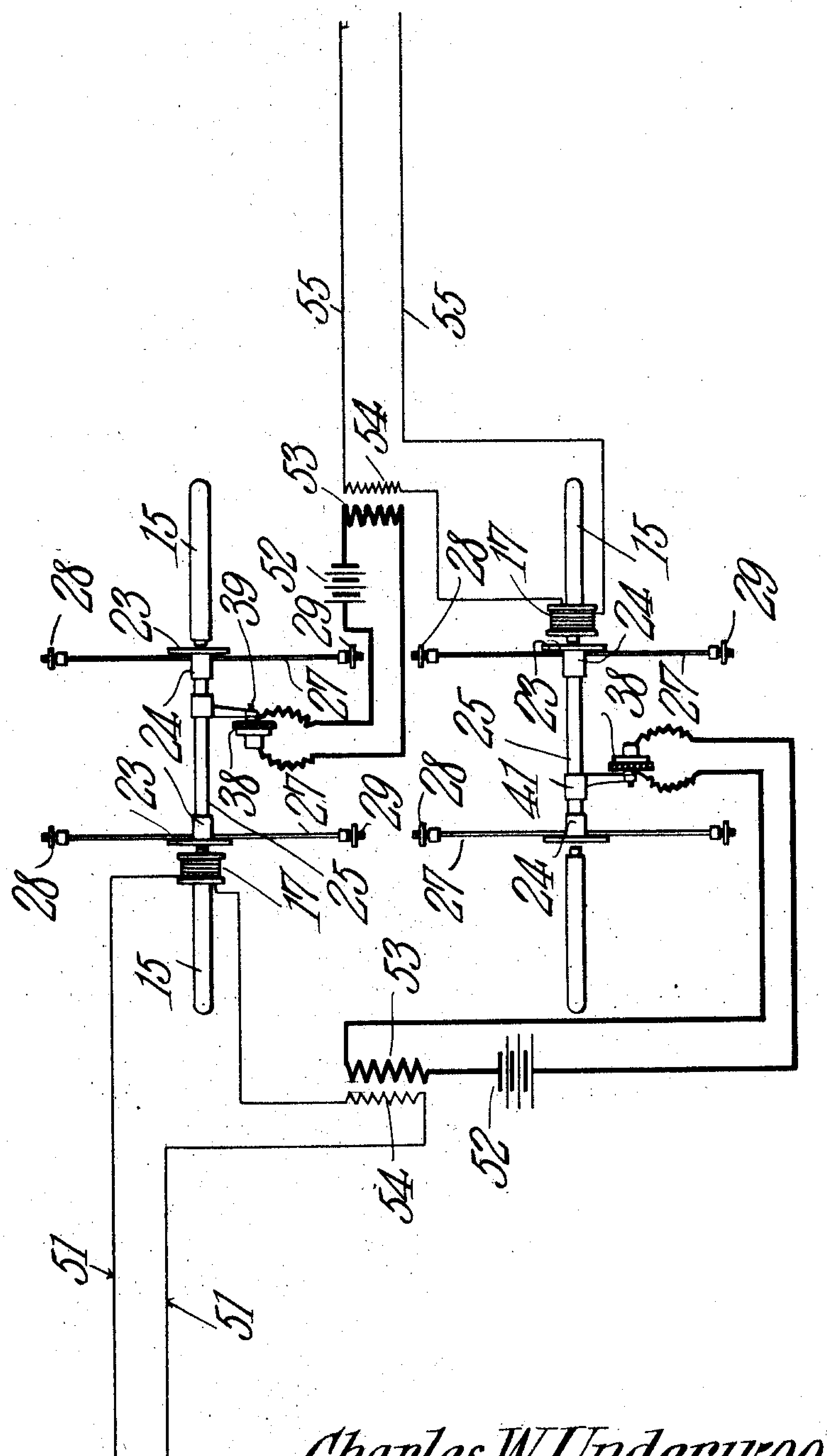
3 SHEETS—SHEET 3.

Fig. 4.



Charles W. Underwood,

INVENTOR.

WITNESSES:

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UNITED STATES PATENT OFFICE.

CHARLES W. UNDERWOOD, OF CROWLEY, LOUISIANA.

TELEPHONE-RELAY.

No. 881,360. Specification of Letters Patent. Patented March 10, 1908.

Application filed July 6, 1907. Serial No. 382,475.

To all whom it may concern:

Be it known that I, Charles W. Underwood, a citizen of the United States, residing at Crowley, in the county of Acadia and State of Louisiana, have invented a new and useful Telephone-Relay, of which the following is a specification.

This invention has reference to improvements in telephone relays, whereby the electrical undulations corresponding to sound waves passing over a line and acting upon a telephone receiver will, instead of being converted into air vibrations, be converted into mechanical vibrations which, in turn, are caused to act upon a microphonic or loose contact transmitter element, whereby electrical undulations are set up in a second circuit but with increased amplitude or strength, and these undulations, in turn, are either transformed into air vibrations at a distant telephonic receiver or are again converted into other electrical undulations, corresponding to the original undulations, in still a third circuit, and so on.

The invention, while applicable to the relaying of telephonic currents which have become highly attenuated from long distance transmission, is not primarily designed for such purpose but is intended more particularly for the strengthening of telephonic currents at comparatively frequent intervals in a long line, so that the line conductors may be made of a material of less conductivity than copper, and far less costly. For instance, it is possible to transmit telephonic currents over long distances by means of iron wire conductors by the use of relays constructed in accordance with my invention, which relays may be installed at frequent intervals in the line, say, at intervals of fifty or a hundred miles more or less. In this way, by augmenting the energy upon the line from time to time without materially affecting the characteristics of the electrical undulations corresponding to the sound waves as originally impressed upon the line, the original sounds uttered before the first transmitter will be received at the distant end of the line with practically no diminution of force. Now, I have found by practical tests that by replacing the diaphragm of a telephone receiver by a light armature and supporting the latter by tightly stretched wires preferably radiating from a circumscribed and centralized point of connection, made as small as possible, and by connecting such armature to a telephonic transmitter element so that the impulses imparted to the armature by the telephonic receiver are caused to act upon the transmitter element, increased electrical energy may be thrown upon a second line in the form of electrical undulations corresponding to all characteristics of the original undulations.

I have found by an extended series of tests that a diaphragm such as is used in a telephonic receiver or transmitter does not respond to the impulses coming over the line with that degree of sensitiveness requisite for transferring to the microphonic element impulses of such magnitude as to throw upon the second line impulses sufficiently augmented as to exceed the impulses at the receiver end of the first line. By supporting a small armature closely adjacent to the poles of the receiver magnet, upon either wires or thin, narrow, metallic ribbons and placing said wires or ribbons under critical longitudinal stress with their points of connection with the armature or armature carrier midway between their ends, and with such points of connection centralized with relation to the magnetic field produced by the receiver magnet and preferably reduced to an area of very small proportions, I have found that there is a very marked increase in the effect upon the armature of the electrical undulations acting on the receiver, and this effect is sufficiently energetic to produce in the transmitter element a sufficient amplitude of movement to cause electrical undulations upon the second line far in excess of the undulations reaching the telephone receiver. Now, since at each relay there is an augmented or increased amount of electrical energy thrown upon the next succeeding line, it is possible to overcome the attenuating effects of comparatively high resistance conductor wires, such as iron wires, so that the electrical effects upon each succeeding telephonic receiver may be practically all alike, since at each relay there is additional energy thrown upon the line, and resistance and other losses are thereby overcome.

I find that by placing the armature of the receiver in magnetic equilibrium I add very materially to the sensitiveness of the relay. This I do by the use of a permanent magnet in line with and facing the polar ends of the receiver magnet, and mounting another armature in proper relation to the first armature and mechanically connected thereto, with both armatures axially connected at a circumscribed point of connection with radially disposed wire or narrow ribbon supports under longitudinal stress, and all the parts so adjusted as to bring the armatures into magnetic equilibrium with relation to the opposed magnetic poles. Under these conditions the permanent pull of the receiver magnet is balanced, and, consequently, the effects of variations of magnetism produced by the undulatory currents corresponding to sound waves, passing through the receiver currents, have a sensibly greater effect upon the armature than when the latter is not magnetically balanced. In addition, there may be other tension wires disposed at right angles to the first-mentioned wires and put under such a degree of stress as will prevent a movement of the armature or armatures under the influence of shocks or jars to which the instrument may be subjected in use, so that the axis of the armature acted upon by the receiver magnet may be maintained at the initially adjusted point of centralization with reference to the magnet poles.

The invention will be fully understood from the following detailed description, taken in connection with the accompanying drawings forming part of this specification, in which,—

Figure 1 is a plan view, with parts in section, of the improved relay arranged for the transmission of sound waves in both directions; Fig. 2 is a section through one of the relay elements upon a larger scale than shown in Fig. 1; Fig. 3 is a detail view showing the manner of supporting the receiver armature; and Fig. 4 is a diagram illustrating the introduction of a relay between two outlying stations.

Referring to the drawings, there is shown a suitable base 1 upon which are erected two sets of opposed standards 2—3 and 4—5. The standards 2—3 are joined by connecting bars 6 near their upper ends, and the standards 4—5 are similarly joined. The bars 6 connecting the standards 2—3 are shown in Fig. 1, while the bars 6 connecting the standards 4—5 are shown in Fig. 2. Each standard is composed of two side members joined by a base plate 7 and a top bar 8.

Arranged centrally with relation to the side bars of each standard is a ring 9 having radial arms 10—11 so disposed that the arm 10 is secured to an ear 12 formed on the top cross bar 8, while the arms 11 project in opposite directions from the ring 9 and are made fast to ears 13 formed on the side bars of the respective standard. The ring 9 is formed with an interior screw-thread which receives a bushing 14 carrying a permanent magnet 15 provided with soft iron pole pieces 16 on the ends of which are telephone receiver coils 17. The pole pieces 16 are separated by a block 18 which carries terminal sockets 19 connected to the terminals of the coils 17 by conductors 20, and these sockets receive the terminal plugs 21 of flexible conductors 22, which, in turn, may be coupled up to the main line conductors of the telephone system.

In the structure forming the relay which constitutes the subject-matter of the present invention there are two pairs of opposed permanent magnets 15 with the supporting structures already described, but only one permanent magnet of each pair is supplied with the receiver coils 17. Now considering but one pair of permanent magnets, say, those carried by the standards 4—5, it will be seen that the pole pieces of these two magnets face each other but are separated by a considerable distance. Adjacent to each magnet is a disk-shaped iron armature 23 having an axial sleeve 24 on the face away from the polar end of the magnet, and these sleeves receive the ends of a connecting rod 25, preferably of insulating material such as wood or vulcanized fiber or vulcanized rubber, the length of the rod 25 being such that when the armature disks are properly mounted thereon they will be brought into very close relation to but will still be out of contact with the polar extremities of the magnets. Projecting axially from the ends of the rod 25 are pins or studs 26. Each of these studs is reduced at its free end to as small an area as may be, and there has secured to it by a minute drop of solder or otherwise the middle point of a wire or narrow, thin band 27 of metal. The pins or studs 26 may or may not touch the center of the draphragm.

Let it be considered for the purposes of the following description that the part 27 is a wire, with the understanding, however, that a thin, narrow band is the equivalent of a wire and may be substituted therefor without materially affecting the operation of the device. Each end of the wire is carried to an adjusting screw 28 or 29, as the case may be. The screw 28 is tapped into a lug 30 projecting from the top cross bar 8, while the screw 29 is tapped into a lug 31 projecting from the base 7. It is immaterial for the purposes of the present invention how the ends of the wire 27 are secured in the screws, and I have shown, merely by way of example, one way in which these wires may be fastened. As shown in the drawings the ends of the wires are formed into loops 32 through which may be passed pins 33, each engaging the end of a hollow sleeve 34 passing through the bore of the screw and also receiving the corresponding end of the wire 27. This structure permits the placing of the wire under longitudinal strain or tension without subjecting said wire to a twisting strain, although I have found in practice that a slight twisting of the wire is not harmful.

The sleeves 24 which carry the armature disks 23 are slotted longitudinally on opposite sides so that they may be slipped on to the ends of the rod 25 after the wire 27 has been fastened to the studs 26, and these sleeves will offer no resistance to the movement of the wire with relation to the rod 25 when the latter is caused to reciprocate in the direction of its longitudinal axis, as will hereinafter appear. There are two wires 27, one at each end of the rod 25, and there are therefore four screws 28—29, and each of these screws may be engaged by a clamp screw 35 although but one such screw is shown in the drawings, in Fig. 2. Now, by the proper manipulation of the screws 28 and 29 acting on each wire 27, the point of connection between the studs 26 and the wires 27, which point is central to the armature disks 23, may be brought into exact coincidence with the center of the magnetic field produced by the telephone receiver magnet and by the opposing magnet at the other end of the rod 25. When this adjustment which is at right angles to the direction of adjustment of the receiver magnets, is obtained the wires 27 are put under longitudinal stress by the proper manipulation of the two screws 28 and 29 until a critical stress under which the instrument will operate to best advantage, is obtained. In addition to this, the magnets may by means of the screw bushing 14 be brought into such relation of their polar ends to the armatures 23 that these armatures, with the connecting rod 25, are brought into a state of magnetic equilibrium. Now, when electrical undulations corresponding to sound waves are passed through the coils 17 the magnetic pull upon the corresponding armature 23 is varied accordingly after the manner of an ordinary telephone receiver. When the current is in the proper direction to augment the strength of the magnet 15 the armature 23 opposite the telephone receiver is pulled toward the magnet poles against the action of the permanent magnet controlling the armature 23 at the other end of the rod 25. Since the normal magnetic pull of the two magnets is in equilibrium, there is practically no resistance to the movement of the armature 23 toward the telephone receiver magnet except that offered by the stress of the wires 27. I have found from actual tests that by making the connection of these wires at their central points of as small an area as possible, so as to localize or centralize these connections with reference to the armature disks, that the sensitiveness of the structure is greatly augmented.

Fast upon one of the standards, say the standard 4 of the telephone receiver set under consideration, are brackets 36 carrying at their ends a bridging bracket 37 to the central portion of which is secured the microphonic elements 38 of an ordinary telephone transmitter. Since this microphonic element may be of the usual type there is no need of describing it in detail. To the stem 39 of this element 38 there is secured an arm 40 fast on a sleeve 41 encircling the rod 25 and secured to the latter for movement therewith. The microphonic element 38 is provided with a back stud 42, as is usual, and to this stud there is connected a conductor 43 which may lead to a binding post 44 on the base 1, while the stem 39 is connected by a conducting strap 45 to an insulated binding post 46 fast on the bracket 37 and, in turn, connected by a conductor 47 to a binding post 48 upon the base 1.

It will be observed that the arrangement of the microphonic element with relation to the telephonic receiver is such that when the pull of the receiver magnet is augmented by an increased pulsation of current passing through the coils 17 and the armature 23 is therefore most energetically actuated, the carbon particles in the microphonic element are subjected to a compression movement, while when the armature moves away from the magnet under the action of the tension wires 27, the movable part of the microphonic element is then actuated in the direction of least resistance to its movement. Thus at all times the microphonic element when actuated in the direction in which it offers the greatest resistance mechanically, is subjected to the strongest pull which the telephonic receiver is capable of exerting.

In order that the armatures 23 may not be subjected to lateral disturbances, other tension wires 49 under the action of adjusting screws 50 may be provided at right angles to the main tension wires 27, and these latter named wires 49 may be put only under such strain as may be found necessary to prevent such lateral disturbance.

In each relay there are provided two telephone receivers, each with its opposing permanent magnet for establishing magnetic equilibrium. It is possible, however, to omit the opposing permanent magnet and so adjust the tension wires 27 as to prevent the constant pull of the magnet carrying the coils from bringing the armature into contact with the polar extremities of such magnet. While such an arrangement is within the scope of my invention, still I find the best results are obtained when the armatures are maintained in a state of magnetic equilibrium.

Referring now to Fig. 4, let it be assumed that electrical undulations corresponding to speech waves are coming over the line wires 51—51 from a distant point and pass through the telephone receiver coils 17 of the relay. The corresponding armatures 23 are set into vibration and actuate the microphonic element 38 under the control of this particular receiver included in the line 51—51. The microphonic element or transmitter 38 is included in a circuit which also includes a battery 52 and the coarse wire coil 53 of a telephone induction coil, the fine wire coil 54 of which is included in the second line circuit 55, at the distant end of which there may be another receiver arranged for the production of sounds which may be directly heard by a listener, or this receiver may form part of a second relay by means of which the electrical undulations are transmitted to still a third line circuit, and these undulations may again be transmitted through a third relay to a fourth line circuit, and so on. Suppose, however, that the listener at the further end of the system should desire to reply, so that the speaker at the first-named end of the system may hear the reply. For this purpose there is included in each relay a return circuit acting in the reverse order to the outgoing circuit. Referring again to the diagram of Fig. 4, it will be seen that in the line conductors 55 there is included the receiver coils 17 of another telephonic receiver which may be mounted upon the same base-board as the receiver including the coils 17 connected up in the circuit of the line wires 51. The receiver which is included in the line wires 55 acts upon another microphonic element or transmitter 38 in the circuit of which may be included a battery 52 and coarse wire coil 53 of a telephone induction coil, the fine wire coil 54 of which is included in the line wires 51. It will thus be seen that each relay therefore includes an outgoing unit and an incoming unit, so that conversation may be carried on in both directions as in the ordinary telephone systems. In order to prevent such mechanical resistance to the action of the instrument as may be offered by the air, the entire relay may be inclosed in an air-tight case 56 and the air may be exhausted therefrom so that the moving parts will work in a vacuum and the air resistance to mechanical movement of these parts may be eliminated.

While the relay forming the subject of the present invention may be introduced in a line having an ordinary telephone set at each end, so that electrical undulations which have become attenuated through long distance transmission may be transformed into much more powerful undulations in a second circuit, with a marked increase in volume or loudness and without substantial loss in clearness so that telephonic conversations may be held over greatly increased distances, still, it is the particular purpose of the present invention to relay the electrical impulses at comparatively frequent intervals. By this means the electrical energy may be augmented to such an extent and at such frequent intervals that it is quite possible to use iron line conductors and thus effect a large saving in the cost of the installation of telephone lines.

In the foregoing description emphasis has been laid upon the fact that the connection between the wire 27 and the armature support is of very limited area and central to the said armature. This I find to give the best results, but results far better than can be obtained with a diaphragm supporting the armature 23, although not so good as with the structure hereinbefore described, may be obtained by connecting the wire 27 at points somewhat remote from the axial line of the rod 25, and these connections may be made even at the periphery of the armature 23, although, as before stated, the results are not as good as when the connection is made at a point localized to the center of the armature. In any event, the wire or narrow band extending radially with relation to the armature 23 and supported at its ends under initial longitudinal strain or stress, I find gives results far exceeding the results obtained by a diaphragm peripherally supported. I find that the stretched wire support for the armature is exceedingly sensitive to the slightest impulse due to the effect of telephonic currents passing through the coils of the telephone receiver, and, consequently, the transmitter will throw upon the second circuit a faithful reproduction of the original impulses, which, however, are greatly augmented in said second circuit. The transmissional losses due to the action of a diaphragm, I find practically eliminated when the stretched wire support is used.

I claim:—

1. In a telephone relay, a telephone receiver magnet and coils, a telephonic transmitter, an armature in operative relation to the telephone receiver magnet and mechanically connected to the transmitter element, and a wire support for the armature having a localized central connection thereto, said wire being under longitudinal strain or stress.

2. In a telephone relay, a telephone receiver magnet and coils, another permanent magnet having its polar extremities facing but spaced from the polar extremities of the telephone receiver magnet, connected armatures in operative relation to the polar ends of the opposed magnets, and wire supports for the armatures having a localized central connection thereto and said wire being under initial longitudinal strain or stress.

3. In a telephone relay, a telephone receiver magnet and coils, a telephonic transmitter, an armature in operative relation to the telephone receiver magnet, and mechanically connected to the transmitter element, a wire support for the armature having a localized central connection thereto, and

means for putting said wire under longitudinal strain or stress and for centering the armature to the polar extremities of the receiver magnet.

4. In a telephone relay, a telephone receiver magnet and coils, a support therefor in which the receiver-magnet is adjustable longitudinally, an armature in operative relation to the telephone receiver magnet, a wire support for the armature having a localized central connection thereto, means for adjusting the armature in a direction at right angles to the direction of adjustment of the receiver magnet and for putting the wire under initial longitudinal strain or stress, and a telephonic transmitter mechanically connected to the armature.

5. In a telephone relay, a telephone receiver magnet and coils, an armature in operative relation to the receiver magnet, a wire support for the armature having a localized central connection thereto and under initial longitudinal strain or stress, a telephonic transmitter, and connections between the armature and transmitter so arranged that the transmitter parts are moved in the direction of compression when the receiver magnet is strengthened by the passage of a current impulse.

6. In a telephone relay, a telephone receiver connected up to a telephone line, an armature under the control of said receiver, a wire support for the armature having a localized central connection thereto and under initial longitudinal stress or strain, a telephonic transmitter mechanically connected to said armature and included in a second telephonic line circuit, a telephonic receiver connected up in the said second line circuit, an armature therefor, wire supports for said last-named armature, said supports having a localized central connection to the armature and being under initial longitudinal stress or strain, another telephonic transmitter mechanically connected to said second armature, and electrical connections between said second transmitter and the first-named telephone line circuit.

7. In a telephone relay, a telephone receiver magnet and coils, an armature in operative relation to the magnet, a wire support for the armature having a localized central connection thereto and arranged to be put under initial longitudinal strain or stress, other wire supports arranged at substantially right angles to the first-named wire support and also connected to the armature in the same manner as the first-named wire support, a telephonic transmitter, and mechanical connections between the armature and said transmitter.

8. In a telephone relay, a telephone receiver magnet and coils, a telephonic transmitter, an armature in operative relation to the telephone receiver magnet and mechanically connected to the transmitter element, and a support for the armature disposed radially with relation to the axis of the armature, said support being of small cross-sectional area and under initial longitudinal stress or strain.

9. In a telephone relay, a telephone receiver magnet and coils, a telephonic transmitter, an armature in operative relation to the telephone receiver magnet and mechanically connected to the transmitter element, a support for the armature of small cross-sectional area disposed radially with relation to the axis of said armature and under initial longitudinal stress or strain, and a vacuum chamber inclosing the receiver, transmitter, armature, and armature support.

10. In a telephone relay, a telephone transmitter, a telephone receiver, and a tightly stretched support for the receiver armature having a connection of small area to said receiver, said connection being centralized with relation to the magnetic field of the receiver.

In testimony that I claim the foregoing as my own, I have hereto affixed my signature in the presence of two witnesses.

CHARLES W. UNDERWOOD.

Witnesses:
JAS. M. WALKER,
WM. F. SALTER.