L. H. DARROW.

TRANSMISSION EQUALIZATION ARRANGEMENT.

APPLICATION FILED OCT. 2, 1919.

1,415,868.

Patented May 16, 1922.

2 SHEETS—SHEET 1.

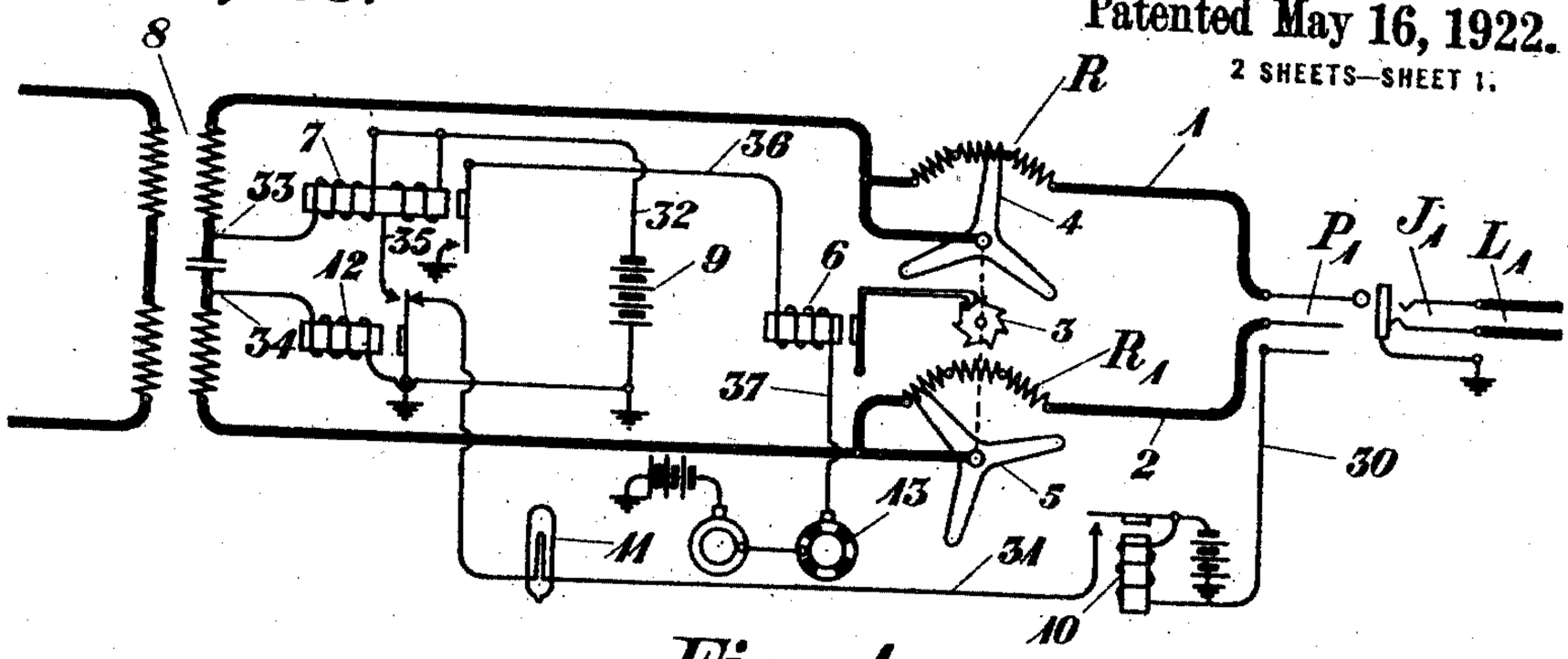

Fig. 1

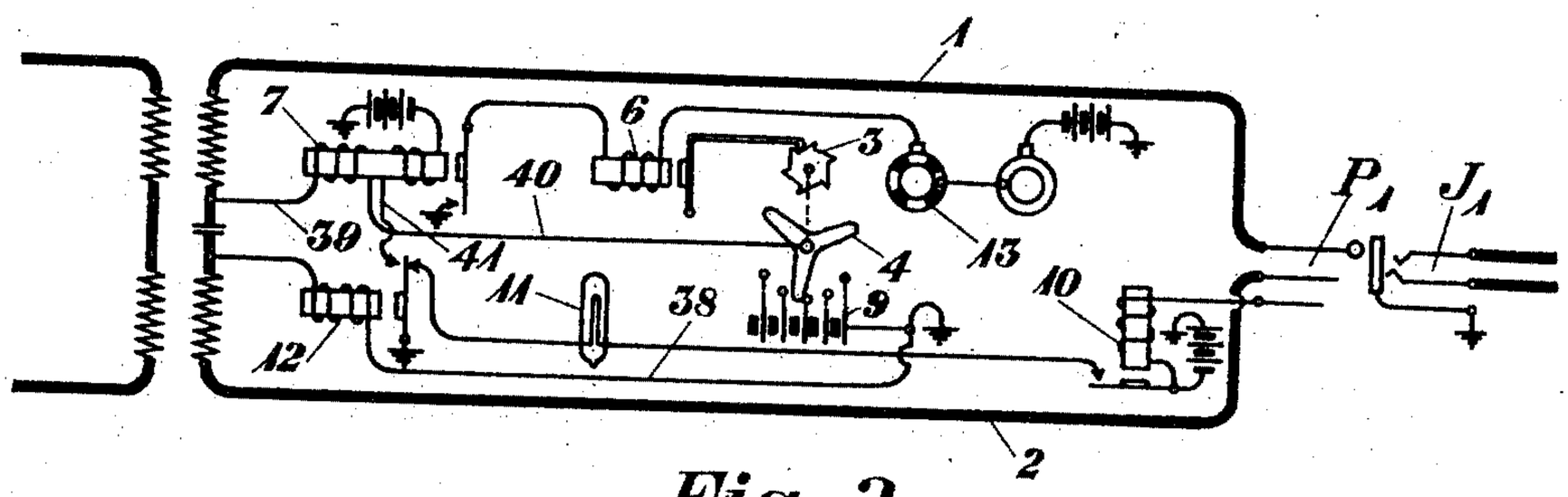

Fig. 2

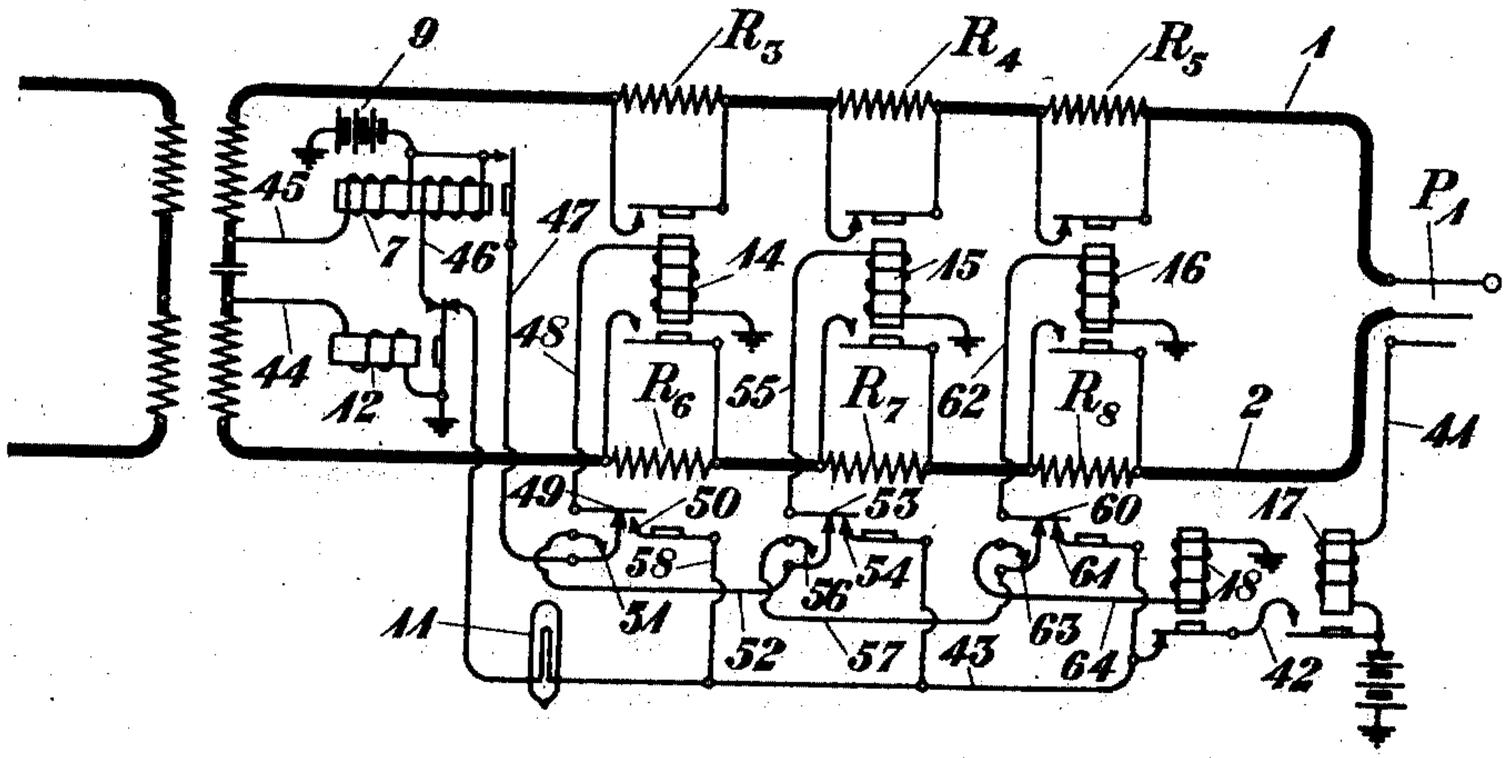

Fig. 3

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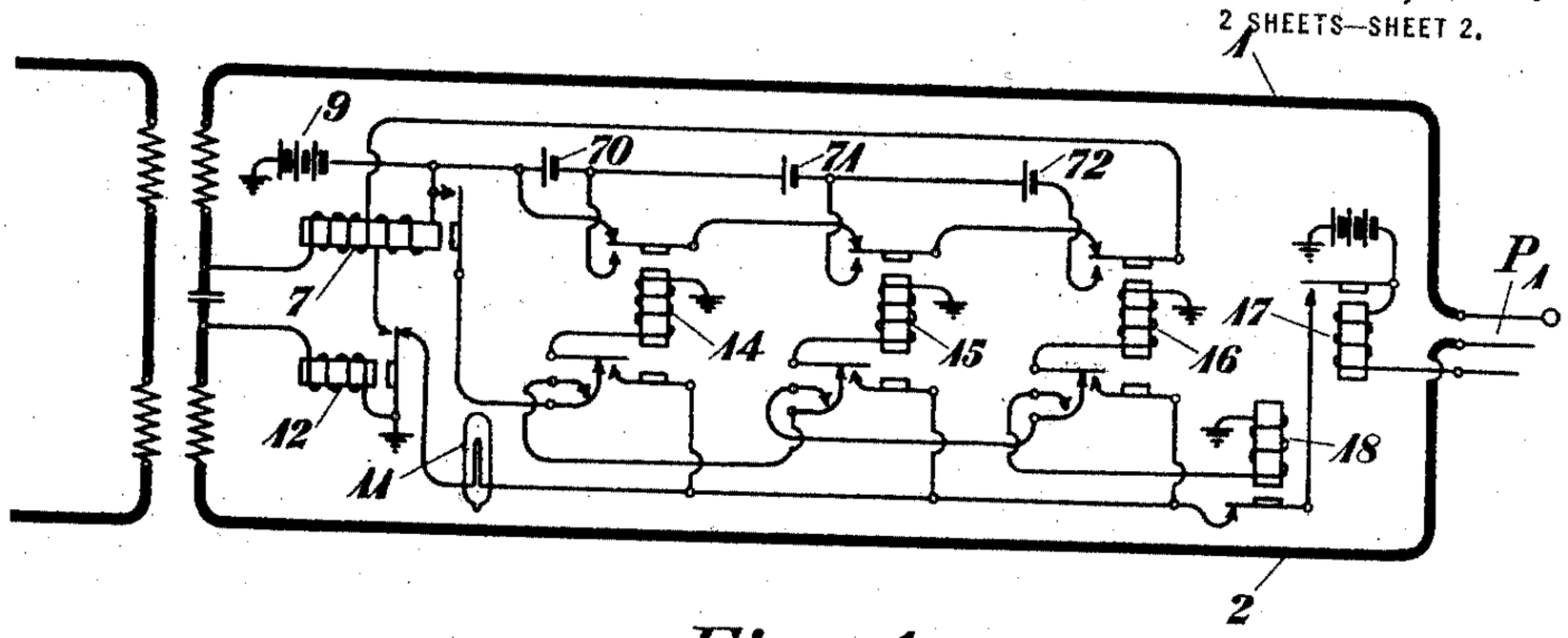

Fig. 4

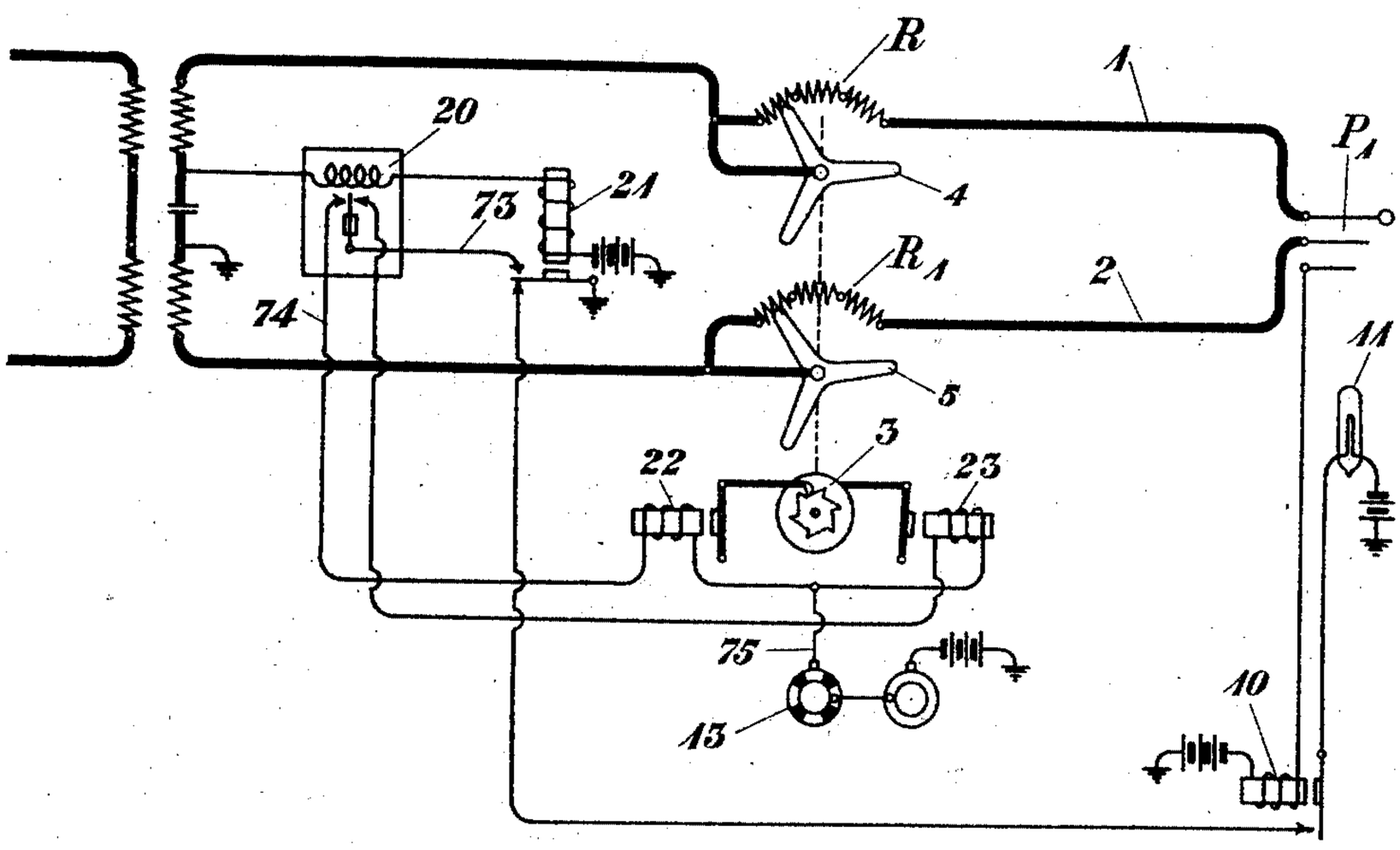

Fig. 5

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TRANSMISSION-EQUALIZATION ARRANGEMENT.

1,415,868. Specification of Letters Patent. Patented May 16, 1922.

Application filed October 2, 1919. Serial No. 328,013.

To all whom it may concern:

Be it known that I, LEO H. DARROW, residing at New York, in the county of New York and State of New York, have invented certain Improvements in Transmission-Equalization Arrangements, of which the following is a specification.

This invention relates to telephone systems and more particularly to the provision of means whereby the electrical characteristics of telephone lines may be equalized or rendered more uniform.

Telephone lines have, in general, different electrical characteristics varying with the lengths of the lines. For any particular type of line construction which may be employed the resistance, capacity, inductance and leakage of the circuit increase with the length. These variations in the electrical characteristics of the different subscribers' lines in a telephone system introduce a number of variable effects in the telephone service rendered from different stations. For example the different electrical characteristics result in different degrees of attenuation in the alternating telephone current passing over the subscribers' lines and thus give louder and more effective telephonic communication to subscribers connected by means of short lines than to subscribers connected by means of long lines. As a result, a subscriber having a long line, when connected with any other subscriber, does not receive as good telephone transmission as would a subscriber having a short line similarly connected. Furthermore, in the common battery systems now so generally employed in all but small communities, the resistance of the line causes a further effect on the transmission in that it reduces the amount of direct current which the transmitter receives from the central office battery and so renders it less efficient in the generation of the alternating telephone current. Likewise in common battery systems employing electro-magnetic receivers this variation in current supply introduces changes in the efficiency of the receiver which are undesirable.

In view of the conditions above referred to, it has not been heretofore possible to provide all subscribers with the same grade of transmission and it is one of the objects of this invention to provide means whereby this difficulty may be overcome and transmission over different lines equalized. Other and further features of the invention will appear from the description hereinafter given.

In the arrangements of this invention the transmission equalizing means are associated with the connecting means, such for example as a cord circuit or other means, by which connections are established with the lines, rather than with the lines themselves as in former arrangements. Associated with the connecting means or cord circuit is apparatus, such as a relay, which is so arranged that, when the cord circuit is connected with a line adopted as a standard with respect to resistance, it will not operate. However, when the cord circuit is connected to lines having resistances other than that of the standard line, the current flow over such lines will be greater or less than over the standard line and will operate the relay device. The relay device may be arranged to operate other relay means to add to or subtract series resistance elements from the line, until the resistance of the line has been made the same as that of the standard line. The vice. The relay device may be arranged to operate other relay means whereby the voltage of the operating current may be increased or decreased in proportion to a variation in the resistance of the line from that of the standard line. Such arrangements afford a means for equalizing transmission over subscribers' lines of different lengths or resistance values and for rendering more uniform transmission over such lines.

The invention may be more fully understood from the following description when taken in connection with the accompanying drawing in the Figures 1, 2, 3, 4 and 5 of which are illustrated a preferred form and modifications of the invention. Like numerals have been used to denote like parts in all of the figures of the invention.

In Fig. 1 of the drawing is illustrated a portion of a cord circuit which is used in establishing connections with subscribers' lines, such as the line L_1, a portion of which is shown terminating in the jack J_1. The cord circuit terminates in the plug P_1 and in the tip and ring conductors 1 and 2 of the cord are a plurality of resistance elements such as R and R_1. These resistance elements are controlled by the relay 6 which is of the "non-stop" type; that is, the contacts 4 and 5 of relay 6, which are mounted on a gear mechanism 3, always turn in one direction,

and operate so as to short circuit the resistance R and R_1, until all of them are short circuited, and then operate to connect all the resistances in series again, repeating the process. With this arrangement the resistance included in series in the conductors 1 and 2 may be varied. The relay 6 is controlled by the relay 7, the windings of which are arranged differentially for purposes which will be more fully pointed out hereinafter. Associated with the sleeve conductor of plug P_1 is the relay 10, which controls the supervisory signal 11, which in turn is further controlled by the line relay 12. The relay 7 controls the circuit for the relay 6, which circuit is completed through an interrupting apparatus 13, so that the relay 6 will operate intermittently.

The arrangements in Fig. 2 are substantially the same as those in Fig. 1, except that the relay 6 serves to control the voltage of the battery supply 9 rather than the series resistance of conductors 1 and 2.

In the arrangements illustrated in Fig. 3, the relay 7 controls the operation in sequence of the relays 14, 15 and 16, which relays in turn determine the number of series resistance elements, such as resistances R_3, R_4, R_5, R_6, R_7 and R_8, which should be included in the conductors 1 and 2.

In Fig. 4 the relay 7 controls the operation in sequence of the relays 14, 15 and 16, which relays in turn control the amount of current supply which should be applied to the conductors 1 and 2.

In the arrangements illustrated in Fig. 5 are shown series resistance elements R and R_1 included in conductors 1 and 2. These resistance elements are controlled by the relays 22 and 23, and the gear mechanism 3. The relays 22 and 23 are controlled by an ammeter relay 20 which responds to variations in the amount of current transmitted over the line.

The invention may be more fully understood from the following description of the operation of the arrangements illustrated in Fig. 1. When a subscriber on a line such as L_1 originates a call, and his line signal lights, the operator will answer by plugging in to the jack J_1 with the plug P_1. This will close the following circuit: from ground associated with the sleeve of the jack J_1, sleeve contacts of jack J_1 and plug P_1, conductor 30, winding of relay 10 to battery and ground. This will operate the relay 10 and thereby close the following circuit: from ground and battery, armature and contact of relay 10, conductor 31, signal lamp 11, contact and armature of relay 12 to ground. However, the signal lamp 11 will not light, as this last mentioned circuit will be held open by the relay 12, which operates over the following circuit when the plug P_1 is inserted in the jack J_1: from ground, battery 9, conductor 32, left hand winding of relay 7, conductor 33, tip conductor of the cord, resistance elements R, conductor 1, tip contacts of plug P_1 and jack J_1, tip conductor of the line L_1, through the subscriber's substation apparatus, ring conductor of line L_1, ring contacts of jack J_1 and plug P_1, conductor 2, resistance elements R_1, ring conductor of the cord, conductor 34, winding of relay 12 to ground. This circuit will operate relay 12 and close the following circuit: from ground, battery 9, conductor 32, right hand winding of relay 7, conductor 35, contact and armature of relay 12, to ground. As has been formerly pointed out, the windings of relay 7 are arranged differentially and are so adjusted that when the cord circuit is connected with a line whose resistance is taken as a standard, the currents flowing through both windings will be equal and the opposing fluxes set up in the core of relay 7 will be equal and neutralize each other. However, if the cord circuit is connected with a line having a resistance other than that taken as a standard, the currents flowing through both windings will not be equal and the flux caused by the left hand winding of relay 7 will not be equal to the flux caused by the right hand winding, and the relay 7 will operate. The operation of relay 7 closes the following circuit: from ground, contact and armature of relay 7, conductor 36, winding of relay 6, conductor 37, interrupter apparatus 13, to battery and ground. The closing of this circuit will cause relay 6 to operate intermittently, which will operate the gear mechanism 3 and cause contacts 4 and 5 to rotate. The contacts 4 and 5 will operate to short circuit more or less of the resistance elements R and R_1 included in series with the previously traced circuit including the left hand winding of relay 7, until the resistance of said circuit has been made the same as in the case when the cord circuit was connected with the standard line. At this point the currents flowing through the two windings of relay 7 will be equal and the flux caused by the left hand winding will again be equal and opposite to the flux caused by the right hand winding and the relay 7 will release, thereby opening the previously traced circuit through the winding of relay 6, and causing the relay 6 to stop operating. With this arrangement, transmission over subscribers' lines of different lengths and characteristics may be equalized by varying the series resistance included in the circuit. This arrangement equalizes both the battery supplied to the subscribers' lines and also the high frequency loss.

In the arrangements illustrated in Fig. 2 is shown an arrangement whereby the talking current supplied to subscribers' lines of different lengths is equalized by changing

the voltage of the battery supplied to the cord and line. When the plug P_1 is inserted in the jack J_1, talking current for the line is supplied from the cord circuit over the following circuit: from one of the terminals of battery 9, conductor 38, winding of relay 12, ring conductor of the cord, ring contacts of plug P_1 and jack J_1, over the ring conductor of the line, through the substation apparatus, over the tip conductor of the line, tip contacts of jack J_1 and plug P_1, over the tip conductor of the cord, conductor 39, left hand winding of relay 7, conductor 40, contact 4, to one of the terminals of battery 9. The closing of this circuit operates relay 12 and closes the following circuit: from ground and battery, right hand winding of relay 7, conductor 41, contact and armature of relay 12 to ground. In the same manner as pointed out with respect to Fig. 1, the fluxes set up in the core of relay 7 by the differentially arranged windings thereof, will neutralize each other when the cord is connected with a standard line, but when the resistance of the line is other than standard, these fluxes will not neutralize each other, and the relay 7 will operate. The operation of relay 7 will operate relay 6 and the gear mechanism 3, and cause the contact 4 to rotate across the terminals of battery 9, thereby changing the voltage of the current supplied over the previously traced circuit including the subscriber's line and the left hand winding of relay 7. As soon as this current from battery 9 has in this manner been increased or decreased sufficiently so that the flux set up by the left hand winding of relay 7 is equal to the opposing flux set up by the right hand winding thereof, the relay 7 will release, thereby releasing the relay 6, and the proper amount of current will be supplied to the subscriber's line to compensate for any changes between the line and the standard line.

The principle of the operation of the arrangement illustrated in Fig. 3 is substantially the same as the arrangement in Fig. 1, in that the transmission is equalized by varying the amount of series resistance elements included in the talking circuit. When a connection is made with a line having a resistance other than the standard, the differentially wound relay 7 will operate and close the following circuit: from ground and battery, contact and armature of relay 7, conductor 47, contact 49, conductor 48, winding of relay 14, to ground. The closing of this circuit will operate relay 14, which will pull up its armatures and close short circuits about the resistance elements R_3 and R_6, thereby reducing the total resistance of the talking circuit. If this reduction in resistance is sufficient to make the resistance of the talking circuit equal to that of the standard talking circuit, the relay 7 will release. Relay 14 will be locked up over the following circuit: from ground, winding of relay 14, conductor 48, contact 50, armature of relay 14, conductor 58, conductor 43, contact and armature of relay 18, conductor 42, contact and armature of relay 17 (which was operated when the plug P_2 of the cord was inserted in the jack of the line), to battery and ground. However, if to reduce the resistance of the talking circuit to a standard it is necessary to further decrease the resistance of the circuit, the relay 7 will not release. Accordingly, upon the operation of relay 14 the following circuit will also be completed: from ground and battery, contact and armature of relay 7, conductor 47, contact 51, conductor 52, contact 53, conductor 55, winding of relay 15, to ground. This will operate relay 15, which will close short circuits about resistance elements R_4 and R_7 and further reduce the resistance of the talking circuit. In case the subscriber's line is a party line, and the connection is made for one of the parties such as the party furthest from the central office, and while the connection is up the party nearest the central office removes his receiver from the switch hook, the cord circuit will equalize the current supplied to the line, so that both transmitters in parallel receive only the predetermined value of the current. In case the second subscriber finding the line busy, should again hang up, the current flow to the first subscriber would then not be equalized. Relay 7 would then operate and remain operated until all of the relays 14, 15, etc., had been operated. When the relay 16 operates, the following circuit is closed: from ground and battery, contact and armature of relay 7, conductor 47, contact 51, conductor 52, contact 56, conductor 57, contact 63, conductor 64, winding of relay 18, to ground. This will operate relay 18 which will open at its contact the previously traced locking circuits for the relays 14, 15 and 16. All of these relays then release and the process of short circuiting the resistance elements starts in again from relay 14, and continues until the proper balancing point for relay 7 is reached. While only three relays, such as relays 14, 15 and 16 have been illustrated, and only the resistance elements R_3, R_4, R_5, R_6, R_7 and R_8, it is understood that a greater or smaller number of relays and resistance elements similarly arranged may be employed.

In the arrangements illustrated in Fig. 4, the operation is substantially similar to the arrangements of Fig. 3. However, the relays 14, 15 and 16 do not control the current supplied to the circuit by means of varying the resistance of the circuit, but rather by adding in series with battery 9 the batteries 70, 71 and 72 respectively.

In the arrangements illustrated in Fig. 5,

an ammeter relay 20 is employed in place of the differentially wound relay 7 of the other figures. The ammeter relay 20 is adjusted so that when the cord is connected with a line of standard resistance, it will not operate. However, should the cord be connected with a line having a resistance greater than standard, less current would flow through the ammeter relay, and the armature thereof would be deflected to the left, thereby closing the following circuit: from ground, armature and make contact of relay 21 (which operated when the cord was connected with the line) over conductor 73, armature and left hand contact of relay 20, conductor 74, winding of relay 22, conductor 75, interrupter 13, to battery and ground. The closing of this circuit will operate relay 22 and the gear mechanism 3 whereby the contacts 4 and 5 will be rotated in a manner so as to short circuit portions of the resistance elements R and R_1 in series with the talking circuit, thereby decreasing the resistance of the talking circuit until it is the same as that of a standard line, at which point relay 20 will release. This will release relay 22 and cause the aparatus to stop operating. In a similar manner, if the cord is connected with a line having less total resistance than a standard line, the armature of relay 20 will be deflected to the right, and a circuit completed through relay 23. This will cause the contacts 4 and 5 to rotate in a manner so as to increase the resistance elements R and R_1 connected in series with the talking circuit, and so increase the total resistance of the talking circuit to that of a standard line.

While the arrangements and transmission equalizing means of the invention have been illustrated, for purposes of convenience, as associated with cord circuits, it is pointed out that they may equally well be associated with other forms of connecting circuits such as trunk lines, and also may be used in connecting means employed in automatic telephony such as in district or incoming selectors in such systems. Accordingly while the arrangements of the invention have been disclosed in certain specific arrangements which have been deemed desirable, it is understood that they are capable of embodiment in many and widely varied forms without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In a telephone exchange system, subscribers' lines of differing electrical characteristics, a connecting means for establishing connections with said lines, a source in said connecting means for supplying talking current for said lines, a differentially wound relay in said connecting means, one of the windings of said relay being included in the talking circuit of said connecting means and a line, the other winding being included in a local circuit, said local circuit being so adjusted that when said talking circuit includes a line of predetermined electrical characteristics said relay will not operate, and means controlled by said relay for varying the current flow from said source over said talking circuit.

2. In a telephone exchange system, subscribers' lines of differing electrical characteristics, a cord circuit for establishing connections with said lines, a source in said cord circuit for supplying talking current for said lines, a differentially wound relay in said cord circuit, one of the windings of said relay being included in the talking circuit of said cord and a line, the other winding being included in a local circuit, said local circuit being so adjusted that when said talking circuit includes a line of predetermined electrical characteristics said relay will not operate, variable resistance elements included in the talking circuit of said cord, and relay means controlled by said differentially wound relay for controlling said variable resistance elements.

3. In a telephone system, subscribers' lines of differing electrical characteristics, a connecting circuit for establishing connections with said lines, a variable resistance included in series in the talking circuit of said connecting circuit, relay means in said connecting circuit responsive to variations in said electrical characteristics, and a step-by-step switch controlled by said relay for controlling said variable resistance.

In testimony whereof, I have signed my name to this specification this 30th day of September, 1919.

LEO H. DARROW.