Sept. 6, 1927. 1,641,233

W. T. POWELL

TELEPHONE SYSTEM

Filed Oct. 20, 1923 3 Sheets-Sheet 1

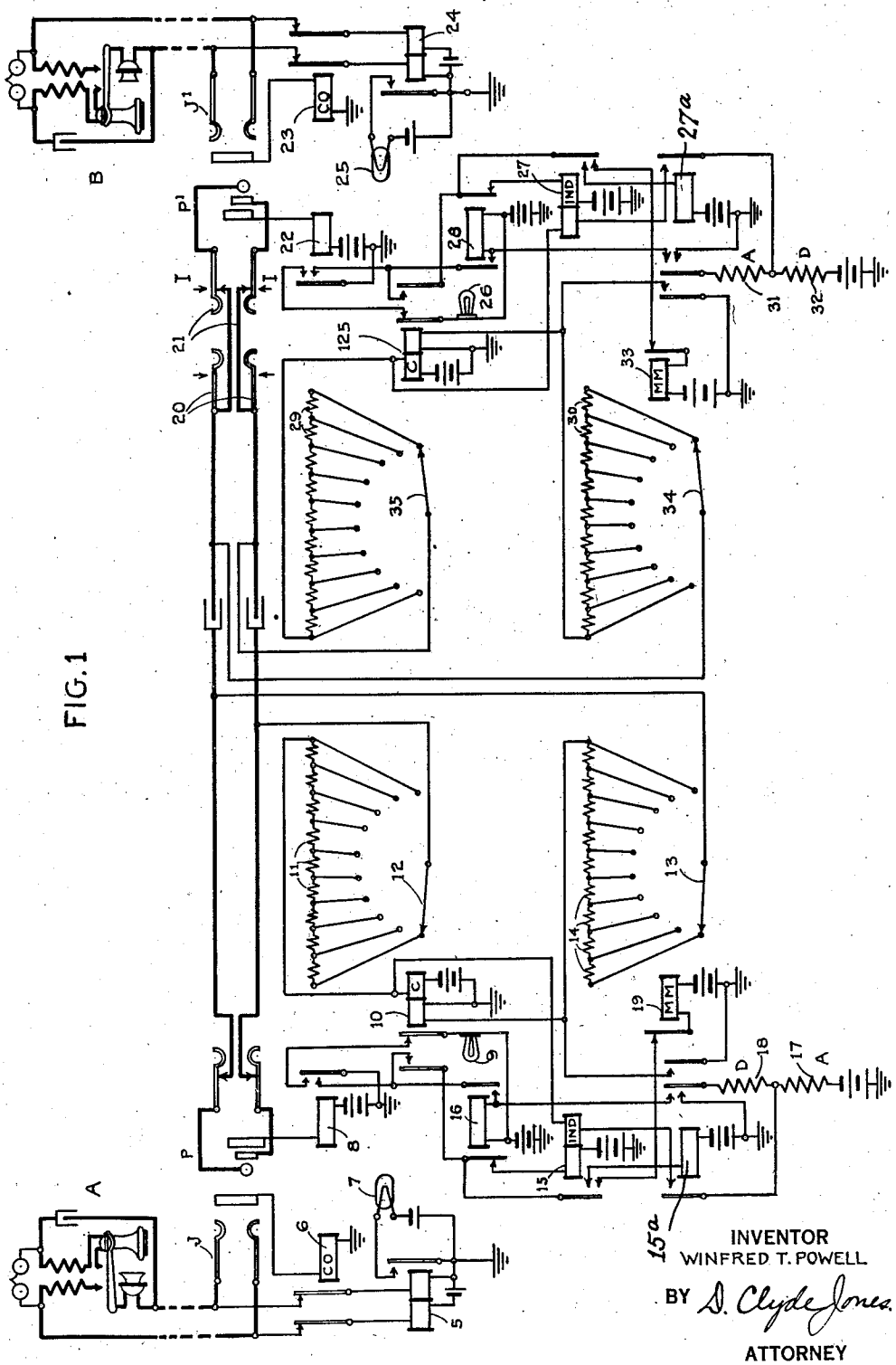


FIG. 1

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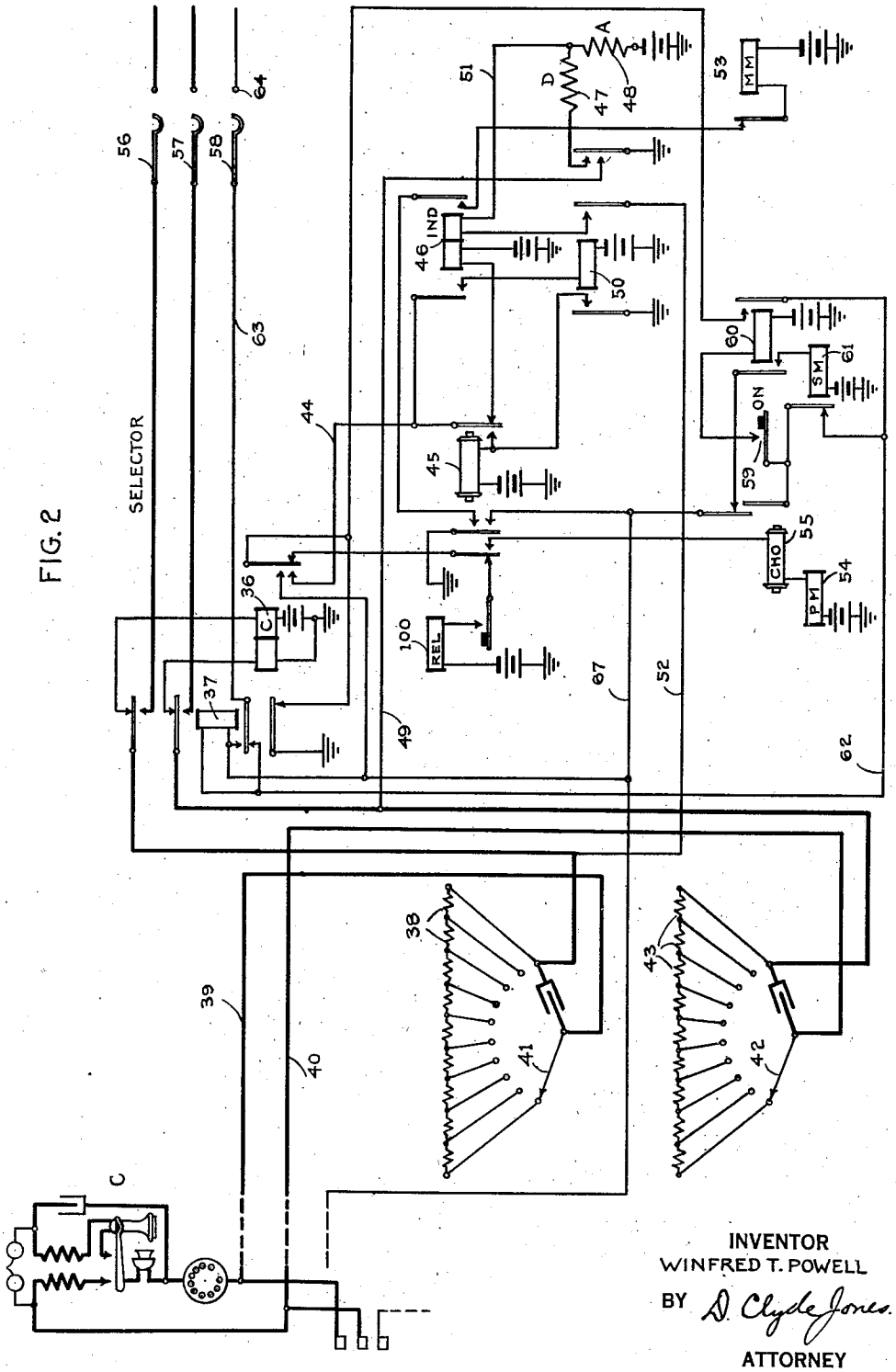
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TELEPHONE SYSTEM

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FIG. 2



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TELEPHONE SYSTEM

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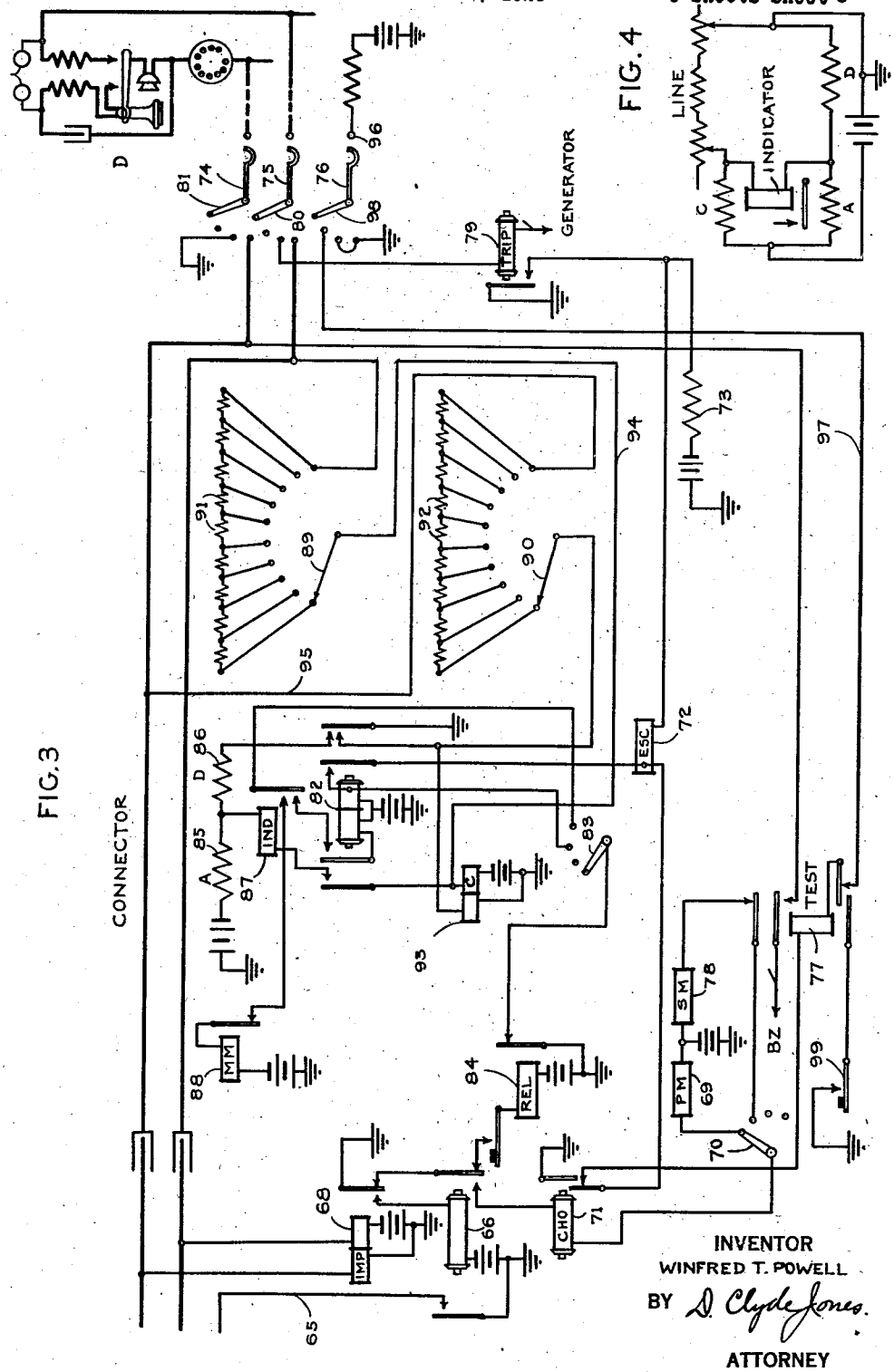


FIG. 3

FIG. 4

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Patented Sept. 6, 1927. 1,641,233

UNITED STATES PATENT OFFICE.

WINFRED T. POWELL, OF ROCHESTER, NEW YORK, ASSIGNOR TO THE STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, OF ROCHESTER, NEW YORK, A CORPORATION OF NEW YORK.

TELEPHONE SYSTEM.

Application filed October 20, 1923. Serial No. 669,862.

This invention relates to telephone systems and more particularly to means, for improving the transmission efficiency, of the various telephone lines in such telephone systems. It has long been recognized that if all of the telephone lines were equal in resistance and if the other electrical constants of all the telephone lines were uniform, it would be possible to produce a much more efficient transmitter or microphone than is now in use. The present transmitter must be designed to function on long or short telephone lines with the result that it is not operating at its full efficiency on all telephone lines.

One feature of the present invention resides in the provision of means for rendering all of the telephone lines of a telephone system of equal resistance. A further feature of the present invention resides in the means for supplying transmitter current of equal uniformity to all the telephone lines. An additional feature of the present invention is the automatic means which function as soon as the connection is established, to render the lines of the connection of equal resistance, so that uniform talking battery is supplied to the calling and called parties. Other features of the invention reside in the details of the circuit arrangements which will be more particularly pointed out in the description and the appended claims.

In the drawings, Fig. 1 represents a manual telephone system, in which the present invention is incorporated. At the left of Fig. 1 there is indicated a calling telephone line and its sub-station, which terminates at a manual switchboard and in the center portion of the Fig. 1 a manual cord circuit and resistance compensating means, are disclosed, while at the extreme right of Fig. 1 there is represented a called substation and its line conductors, which terminate at a manual switchboard. Figs. 2 and 3, when arranged in the order named, diagrammatically represent an automatic telephone system in which is shown the present invention. At the extreme left of Fig. 2 there is represented a calling substation and its telephone line, which line extends to the automatic exchange. At the right and center of Fig. 2 there is represented a selector switch, which will be referred to as a numerical switch. In Fig. 3 there is represented a connector switch, while at the extreme right of this figure there is represented a called sub-station and its telephone line, which terminates in the connector switch. In the lower left hand corner of Fig. 2, and near the center of Fig. 3, there are represented two rotary step by step switches, the contacts of which are connected through resistance units. It will be understood that the operation of these switches serves to include or eliminate certain of these resistance units from the various telephone lines of the connection. Fig. 4 represents a schematic showing of the Wheatstone arrangement for balancing the lines.

The mentioned rotary switch, may be of substantially the same character as that disclosed in the patent to Clement #1,107,153, granted August 11, 1914, while the selector and connector switches may be substantially the same character as those disclosed in the patents to Keith, Erickson and Erickson, 815,321, 815,176, both granted March 13, 1906, when said switches are modified to operate in a so-called two wire telephone system.

Referring to Fig. 1 it is believed that the invention will best be understood by describing the method of extending a telephone connection from a calling sub-station such as that designated A, to a called sub-station designated B. When the calling subscriber as sub-station A removes his receiver from its switch hook, the line relay 5 is energized in a circuit closed from grounded battery, its left hand winding, outermost armature and back contact of cut-off relay 6, over one side of the calling line through the sub-station circuits and the upper side of the calling line, inner back contact and armature of the cut-off relay 6, right hand winding of relay 5 to ground. The operation of the line relay 5, lights the line lamp 7, whereupon the operator inserts her answering plug P, into the jack J, of the calling telephone line. This operation is effective to close a circuit from grounded battery, winding of the sleeve relay 8, sleeve contacts of the plug P and the jack J, winding of the cut off relay 6 to ground. The sleeve relay 8 and the cut off relay 6 are op-

erated in this circuit and the last named relay disconnects the line relay from the control of the calling telephone line. When the line relay retracts its armature it extinguishes the line lamp 7. The operation of the sleeve relay 8 closes a break point in the operating circuit of the answering supervisory lamp 9, but it is not lighted at this time due to the fact that the supervisory relay 10, is operated. The operating circuit of this relay is closed from grounded battery, right hand winding of this relay through the resistance units 11, switch brush 12, the lower side of the cord circuit, ring contacts of the plug P and the jack J, lower side of the calling line through the sub-station circuits at A, upper side of the line, tip contacts of the jack J and the plug P, over the upper side of the cord circuit, switch brush 13, resistance units 14, left hand winding of supervisory relay 10 to ground.

The operation of the sleeve relay 8 and the supervisory relay 10 is effective to complete a circuit through the left hand winding of the indicator relay 15, from grounded battery, left hand winding of this relay, back contact and armature of relay 16, outer armature and front contact of relay 10, front contact and armature of relay 8 to ground. With the relay 15 operated, relay 15^a is energized from grounded battery, winding of this last named relay, front contact and armature of relay 15, armature and front contact of relay 10, front contact and armature of relay 8 to ground. With the relay 15^a energized, the resistance units 17 and 18 are included in a circuit to ground through the inner armature and front contact of relay 15^a; also a circuit is closed from ground through the front contact and armature of this last named relay, winding of relay 16 to grounded battery. The relay 16 on operation closes a locking circuit for itself through its right hand front contact and armature to ground through the contact and armature of relay 8. The energization of relay 16 opens the energizing circuit extending through the left hand winding of the indicating relay 15. It is assumed, however, that the resistance of units 11 and 14, together with that of the telephone line A, are not equal to the predetermined standard resistance represented by the resistance units 17 and 18. For this reason the relay 15 is maintained energized in a circuit including its right hand winding, which circuit extends across a Wheatstone bridge arrangement to be described. With the indicator relay 15 operated, the motor magnet 19 is actuated from grounded battery, its winding armature and back contact, front contact and armature of relay 15, outer armature and front contact of relay 10, front contact and armature of relay 8 to ground. Under the control of this circuit, the motor magnet 19, advances the brushes 12 and 13 of the rotary switch, in a step by step motion until stopped by the deenergization of the indicator relay 15. It should be stated that the resistance units 17 and 18 represent two sides of a Wheatstone bridge, while the resistance of the calling telephone line A together with the resistance units 11 and 14, and the right hand winding of relay 10, represents the other pair of branches of the mentioned bridge. The right hand winding of indicator relay 15 is included in the neutral path of the mentioned bridge circuit. A schematic showing of this mentioned Wheatstone bridge arrangement, is shown in Fig. 4. When the rotary switch has advanced its brushes 12 and 13, until the resistance units 11 and 14 have been varied so that both arms of the Wheatstone bridge are of equal resistance, the indicator relay 15 deenergizes whereupon the operating circuit of the motor magnet 19 is opened.

The above described operations have taken place in response to the insertion of the plug P into the jack J of the calling line. The operator now depresses her listening key 20, and connects her head set (not shown) to the cord circuit now connected to the calling telephone line and inquires the designation of the wanted telephone line. On receiving this designation the operator then inserts the plug P′ into the jack J′ of the wanted telephone line and depresses the ringing key 21, to connect the ringing current to the called telephone line. The insertion of the plug P′ into the jack J′ completes a circuit for energizing the sleeve relay 22, and the cut-off relay 23 of the called line in series. The operation of the cut-off relay 23, disconnects the line relay 24 from the called line, to prevent the lighting of the line lamps 25, when the called party answers. The operation of the relay 22 completes a circuit from ground, armature and front contact of relay 22, inner armature and back contact of the called supervisory relay 125, supervisory lamp 26 to grounded battery. The lamp 26 is lighted in this circuit until the called party responds, at which time the supervisory relay 125 energizes and opens the circuit of the lamp 26. With the supervisory relay operated, an actuating circuit is closed from grounded battery, right hand winding of the indicator relay 27, back contact and armature of relay 28, outer armature and front contact of relay 125, front contact and armature of relay 22 to ground. The operation of the relay 27 completes an energizing circuit for the relay 27^a, which closes circuits for the left hand winding of relay 27 and for the relay 28, which function in a manner similar to relays 15 and 16, previously referred to.

The operation of the relay 27ª also closes a circuit through the resistance units 31 and 32 to ground to complete one side of a Wheatstone bridge arrangement. The operation of the indicator relay 27 through its left hand winding shows that the combined resistances of the called line and the resistance units 29 and 30, are not equal to the predetermined desired resistance indicated by the resistance units 31 and 32. A Wheatstone bridge arrangement is also established for the called end of the connection, in which the resistance units 31 and 32 represent the two branches of the Wheatstone bridge, while the left hand winding of relay 125, the resistance units 29 and 30, together with the resistance of the called line represent the other pair of arms of the Wheatstone bridge. It will be noted that the left hand winding of relay 27, is bridged across the circuit including the mentioned two sets of arms. Since the indicator relay 27 is operated, a circuit is extended for the motor magnet 33, traceable from grounded battery, winding, armature and back contact of the motor magnet 33, front contact and armature of relay 27, front contact and armature of relay 125, armature and front contact of relay 22 to ground. Under the control of this circuit the motor magnet 33 advances the brushes 34 and 35 of the rotary switch, in a step by step motion, until sufficient of the resistance units 29 and 30 have been eliminated from the called line circuit so that the resistance units equal the combined resistance of the units 31 and 32. At that time the indicator relay 27 deenergizes to stop the operation of the motor magnet 33.

Talking battery is supplied to the calling sub-station through the windings of the supervisory relay 10 and through the resistance units 11 and 12, which have been retained in the circuit by the operation of the rotary step by step switch, whose brushes are indicated at 12 and 13. Talking battery is supplied to the called sub-station through the winding of the supervisory relay 125, and through the resistance units 29 and 30, which have been retained in the circuit, by the operation of the rotary switch, whose brushes are designated 34 and 35.

At the close of the conversation the subscribers at sub-stations A and B, replace their receivers on their respective switchhooks, which effects deenergization of the relays 10 and 125. When relay 10 thus retracts its armatures, it completes a circuit for lighting the supervisory lamp 9, which is a signal to the operator to remove the answering plug from the answering jack of the calling line. Similarly, when the supervisory relay 125 deenergizes, the supervisory lamp 26 is lighted to signal the operator to disconnect the plug from the called line. The brushes 12, 13, 34 and 35 of the rotary switch remain in the positions last used. The apparatus of Fig. 1 is then in readiness for use on a succeeding call.

By referring to Figs. 2 and 3, it will be seen how the present invention may be applied to an automatic telephone system. When the calling subscriber at C, removes his receiver from its switchhook, one or more nonnumerical switches function to extend this calling line to the selector switch of this figure. As soon as this portion of the connection is established, the relay 36 is energized from grounded battery, its right hand winding, uppermost armature and back contact of relay 37, through the resistance units 38 in series, brush 41 over the upper side of the established connection, including the conductor 39, through the sub-station circuits at C, in series over the lower side of the established connection including the conductor 40, the brush 42, resistance units 43, upper, inner armature and back contact of relay 37, left hand winding of relay 36 to ground. Relay 36 is energized in this circuit and operates its armature to close a circuit extending from ground, lowermost armature and back contact of relay 37, armature and front contact of relay 36, conductor 44, right hand armature and back contact of relay 45, left hand winding of relay 46 to grounded battery. The operation of relay 46 effects the energization of relay 50 over conductor 44 and indicates that the resistance of the mentioned portion of the established connection, comprising the circuit of relay 36, is not equal to the predetermined resistance indicated by the units 47 and 48. With relay 50 operated, relay 45 operates and closes a locking circuit for itself over conductor 44. As in the previously described arrangement, the resistance units 47 and 48, represent two arms of a Wheatstone bridge, whereas the circuit described as including the right hand winding of relay 36, the resistance units 38, and the conductor 39 of the establishing connection through the sub-station C, conductor 40, the resistance units 43, brush 42, conductor 49, outermost front contact and armature of relay 50 to ground, form the other two arms of this Wheatstone bridge. It will be noted that the right hand winding of the indicator relay 46 is in the neutral path of this Wheatstone bridge, including the conductor 51, right hand winding of the indicator relay, inner front contact and armature of relay 50, conductor 52 to the other side of the Wheatstone bridge. Since the indicator relay is actuated, an operating circuit is closed for the motor magnet 53, of the rotary switch, whose brushes are indicated at 41 and 42. The circuit of this magnet is traceable from grounded battery, winding of this magnet, its armature and back contact, front contact and armature of relay 46, inner front con-

tact and armature of relay 45 to ground. Under the control of this circuit, the motor magnet advances brushes 41 and 42 in a step by step motion, until the proper number of resistance units 38 and 43 are included in the calling end of the connection so that both sets of arms of the Wheatstone bridge are balanced. At this time the indicator relay 46 deenergizes and stops the operation of the motor magnet 53.

These previous operations just described have all taken place as the result of initiating a call and the selector switch is now in readiness to be operated under the control of the calling subscriber. The subscriber operates his dial sender to transmit a code of impulses corresponding to the first digit of the called number. In response to each of these impulses of the first digit, the relay 36 vibrates its armature and on each retraction of the armature of relay 36, a circuit is closed from grounded battery, winding of the primary motor magnet 54, winding of the change-over relay 55, outer front contact and armature of relay 45, back contact and armature of relay 36, back contact and armature of relay 37 to ground. The change-over relay 55 and the primary magnet are energized in this circuit, and since the change-over relay 55 is slow to release, it holds its armature attracted until the close of this series of impulses. The motor magnet 54, however, when energized, advances the brushes 56, 57 and 58 of the selector one step in their primary movement. In response to each of the impulses of this series and the consequent retraction of the armature of relay 36, the primary magnet 54 is operated to continue the step by step primary movement of the brushes 56 to 58 inclusive. After the first step of the selector switch the off normal contacts 59 are closed, thereby completing a circuit for the relay 60, from grounded battery, winding of this relay, off normal contact 59, armature and continuity spring of relay 55, inner front contact and armature of relay 45 to ground. Relay 60 is thus operated and closes a break point in the operating circuit of the secondary motor magnet 61, but the circuit of the last named magnet is open at the back contact and continuity spring of relay 55. At the close of the first series of impulses, the armature of relay 36 is held operated, thereby interrupting the circuit of the change-over relay 55, which shortly afterwards retracts its armature. This is effective to complete the operating circuit of the secondary motor magnet 61, from grounded battery, winding of this magnet, left hand front contact and armature of relay 60, back contact and continuity spring of relay 55, inner front contact and armature of relay 45 to ground. Under the control of this circuit the motor magnet 61 advances the selector branches 56 to 58 one step in their secondary or trunk hunting movement. Let it be assumed that the test terminal of the first trunk tested, is characterized by a busy condition such as indicated by ground potential. The operation of the secondary motor magnet 61 interrupts the circuit of the relay 60, which circuit now extends from grounded battery, winding of this relay, off normal contacts 59, armature and back contact of magnet 61, conductor 62, inner back contact and armature of relay 37, conductor 63, test brush 58, test terminals as 64 of busy trunks over a conductor similar to 65, to ground, through the left hand front contact and armature of a relay similar to 66. It will be noted that the relay 37 is included in a circuit in multiple of that last described, which extends from conductor 62, winding of relay 37, conductor 67, inner front contact and armature of relay 45 to ground. Relay 37 is not operated at this time, due to the fact that it is shunted by the circuit previously described, as including conductor 63. When the secondary motor magnet 61 has advanced the brushes of the selector in the manner just described, it retracts its armature and thereby again closes the circuit of relay 60 which is operated to close the actuating circuit of motor magnet 61. This interaction between the relay 60 and the magnet 61, continues until the test brush 58 locates the test terminal of the idle trunk. Let it be assumed that the first idle trunk located is that shown in Fig. 3. This idle condition is indicated by the absence of ground potential on its test terminal 64, so that the shunting circuit of relay 37 no longer exists, and the relay 37 is operated to disconnect the relay 36 from the connection and to extend the connection through the brushes 56 and 57 of the selector, through both windings in series of the relay 68 to ground and grounded battery respectively. The relay 68 is thereby operated and closes an operating circuit for the slow releasing relay 66, which in turn applies a guarding potential through conductor 65, to the test terminals such as 64, at all switches, which have access to this trunk. This conductor, which applies the guarding potential to the terminal 64, together with conductor 63, closes a locking circuit for the relay 37, through the inner front contact and armature of this relay.

The connector switch is now in readiness for operation and the calling subscriber thereupon operates his dial sender to transmit a series of impulses corresponding to the tens digit of the wanted number. In response to each of these impulses, the impulse relay 68 vibrates its armature thereby completing the circuit for the primary motor magnet 69, from grounded battery, winding

of this magnet, side switch wiper 70 in its first position, change-over relay 71, right hand front contact and armature of relay 66, back contact and armature of relay 68 to ground. The change-over relay is also operated at this time and since it is slow releasing, it remains operated during this tens series of impulses. With the relay 71 operated the escape magnet 72 is maintained operated from grounded battery, resistance 73, winding of magnet 72, continuity spring and armature of relay 71 to ground. On the operation of the primary motor magnet 69, the brushes 74, 75 and 76 of the connector switch are advanced one step in their primary direction. In response to each of the tens impulses, the impulse relay 68 retracts its armature and thereby completes the operating circuit just described, for the primary motor magnet, which continues to advance the connector brushes. At the close of the tens series of impulses, the impulse relay 68, maintains its armature attracted for a relatively long period, thereby interrupting the operating circuit of the change-over relay 71, causing the deenergization of this relay. When the change-over relay deenergizes, it opens the circuit of the escape magnet, which deenergizes and moves the sideswitch wipers into their second position in the well known manner.

The calling subscriber now operates his dial sender to transmit a series of impulses corresponding to the units digit of the wanted number. In response to each of these impulses, the relay 68 again vibrates its armature and in this instance closes a circuit from ground its armature and back contact, armature and front contact of relay 66, winding of the change-over relay 71, side switch wiper 70 in the second position, upper armature and back contact of test relay 77, winding of the secondary motor magnet 78 to grounded battery. The change-over relay 71 is again operated and holds the escape magnet 72 operated, during the units series of impulses. Also the secondary motor magnet 78 is operated in this circuit and moves the brushes of the connector switch one step in their secondary direction. In response to each of the units impulses, the motor magnet continues to advance these brushes progressively.

Let it assumed that the wanted line is idle when it is tested by the test brush 76. Under this condition, when the change-over relay 71 deenergizes, the escape magnet 72 likewise deenergizes and moves the side-switch wipers into their third or ringing position. The relay 82 is now actuated from grounded battery, right hand winding of this relay, side-switch wiper 83, back contact and armature of the release magnet 84 to ground. Relay 82 on operation closes an operating circuit for the escape magnet 72 through the inner right hand armature and front contact of relay 82 to ground at magnet 84. Ringing current is now supplied from the ringing generator, through the winding of the trip relay 79, side-switch wiper 80, connector brush 75, over the lower side of the called line and through the bell at the wanted station, over the upper side of the called line, connector brush 74, side-switch wiper 81 in its third position to ground. Ringing current is supplied over the circuit until the called party answers, at which time the trip relay 79 attracts its armature and thereby short-circuits the escape magnet, which advances the side-switch wipers into their fourth position. It will be remembered that the relay 82 is also energized through the side-switch wiper 83 in its third position and the back contact and armature of the release magnet 84 to ground. When the side-switch wipers move into their fourth position, the operating circuit of the relay 82 is opened, but since this relay is slow to release, it maintains its armature attracted for a brief interval, so that if the resistance of the called line is not equal to the predetermined resistance indicated by the resistance units 85 and 86, then the indicator relay 87 is operated in the so-called neutral branch of the Wheatstone bridge to be described. As soon as the relay 87 is operated, a locking circuit is closed for the slow-releasing relay 82 from grounded battery its left hand winding, inner armature and front contact, front contact and armature of relay 87, side-switch wiper 83, in its fourth position, back contact and armature of magnet 84 to ground. Also with the relay 87 operated an actuating circuit is closed for the motor magnet 88, which advances the brushes 89 and 90 of the rotary switch in a step by step movement, thereby varying the number of resistance units 91 and 92, which are included in the called line, until the Wheatstone bridge is balanced. One pair of arms of the Wheatstone bridge including the resistance 85 and 86, is included in a circuit extending from grounded battery to ground through the right hand armature and front contact of relay 82. The other pair of arms of the Wheatstone bridge includes the right hand winding of relay 93, conductor 94, brush 89, resistance units 91, side-switch wiper 80 in its fourth position, connector brush 75 through the lower side of the called line and substation circuits in series, over the upper side of the called line, connector brush 74, side-switch wiper 81, conductor 95, resistance units 92, brush 90, outer right hand armature and contact of relay 82 to ground. It will be noted that the indicator relay 87 is connected across these two sets of arms of the Wheatstone bridge. The motor magnet 88 continues to advance the

brushes 89 and 90 of the rotary switch, until the resistance of the called line together with that of the resistance units 91 and 92, as well as the resistance of relay 93, is equal to the predetermined resistances 85 and 86. When such a condition exists the indicator relay deenergizes to open the operating circuit of the motor magnet 88 and to interrupt the holding circuit of the relay 82.

Talking battery is supplied to the calling party through both windings in series of the relay 68, the various link circuits and the resistance units 38 and 43, and the two sides of the calling line. Talking battery is supplied to the called party through both windings in series of relay 93 and the resistance units 91 and 92, which have been retained in the battery feed circuit, by the operation of the brushes 89 and 90.

It has been assumed that the called line was idle at the time when it was tested. Let it be assumed that the called line is busy at this time, which condition is indicated by the presence of ground potential on its test terminal 96. Under this condition when the change-over relay deenergizes at the close of the units series of impulses, the escape magnet 72 is maintained energized from grounded battery, resistance 73, escape magnet 72, continuity spring and back contact of the relay 71, winding of the test relay 77, its continuity spring and back contact, conductor 97, side-switch wiper 98 in its second position, connector brush 76, connector terminal 96 and through a multiple terminal at the connector switch which has previously seized the called line and the test brush such as 76 of that switch, to ground through a side-switch wiper similar to 98 in its third or fourth position. The escape magnet 72 is thus held operated to prevent the side-switch wipers from moving into their third or ringing position. The test relay 77 is also operated in this circuit and closes a locking circuit for itself, through its armature and continuity spring, off normal contacts 99 to ground. A source of busy tone current BZ is applied to the calling line through the armature and front contact of the test relay. This tone indicates to the calling subscriber that the connection cannot be completed.

At the termination of the connection or when the subscriber abandons the call, he replaces his receiver on the switch-hook. This causes the impulse relay 68 to deenergize, which results in the closing of circuits for the release magnet 84 of the connector switch, and the release magnet 100 of the selector switch, by which these switches are restored to their normal condition in the well known manner.

What I claim is:

1. In a telephone system, a plurality of telephone lines of varying resistance, means including automatic switches and link circuits for interconnecting said lines to complete voice transmission circuits, and means responsive to the interconnection of a pair of telephone lines for rendering the resistance of the transmission circuit of said pair of lines of a predetermined value.

2. In a telephone system, a plurality of telephone lines of varying electrical characteristics, a plurality of link circuits and automatic switches for interconnecting said telephone lines in voice transmission circuits, each link circuit having its ends conductively separated but inductively connected together, and means responsive to the interconnection of the telephone lines by a link circuit for supplying uniform current to each end of said link circuit.

3. In a telephone system, a plurality of telephone lines of varying length, each telephone line being provided with a transmitter arranged to be connected in series with the two sides of said telephone line, a plurality of link circuits and automatic switches for interconnecting said telephone lines with their transmitters in voice transmission circuits, and means variably operable in the course of interconnecting two telephone lines for supplying current of a predetermined value to the transmitters of said connection.

4. In a telephone system, a plurality of telephone lines of varying resistance, a telephone transmitter on each telephone line, means including link circuits for interconnecting two telephone lines and the transmitters thereon into a transmission circuit, a source of direct current for energizing each telephone transmitter, means including a step by step switch and resistance units for varying the resistance through which transmitter current flows from said source, and means including a Wheatstone bridge arrangement for variably operating said step by step switch until current of a predetermined value is supplied to the telephone transmitter through said resistance units.

5. In a telephone system, a plurality of telephone lines, each provided with a transmitter, means including link circuits for interconnecting said telephone lines, at least one of said link circuits having its ends conductively separated but inductively connected together, a source of current for energizing said telephone transmitters, a double wound current-feed relay and resistance units for each end of said link circuit, means including a step by step switch for bridging the windings of a battery feed relay to one end of said link circuit through certain resistance units, and means responsive to the connection of a link circuit to a telephone line for variably operating said switch to include resistance units in said bridge circuit until current of predetermined value

is supplied to said telephone transmitter from said source of current.

6. In a telephone system, a plurality of telephone lines, means including link circuits for interconnecting said telephone lines, each link circuit being divided into sections, a source of current, resistance units for controlling the supply of current to each section of a link circuit, a Wheatstone bridge arrangement for each link circuit, said Wheatstone bridge arrangement having one pair of arms comprising resistance of a predetermined value, the other pair of arms of said Wheatstone bridge including said telephone line and resistance units, a relay in the neutral path of said Wheatstone bridge, and means controlled by said relay for varying the number of said resistance units.

7. In a telephone system, a plurality of telephone lines, each provided with a transmitter, a plurality of link circuits for interconnecting said telephone lines, each link circuit being divided into sections by condensers, a source of current connectable to each section of the link circuit of a connection for supplying transmitter current to the lines connected to said link, a Wheatstone bridge arrangement for each link section including a part of the two sides of its associated telephone line in series, and variable means controlled by said Wheatstone bridge arrangement for including a variable amount of resistance in series with each link section, whereby current of a predetermined value is supplied to each telephone transmitter.

8. In a telephone system, a plurality of telephone lines, each telephone line being provided with a transmitter, link circuits and automatic switches for interconnecting said telephone lines to form voice transmission circuits, each link circuit being divided into sections inductively connected together, a source of current connected to each section through a bridge circuit, artificial resistance associated with each section of a link circuit, and means responsive to the completion of a connection to a link circuit for introducing the proper amount of artificial resistance in each bridge circuit whereby a predetermined amount of current is supplied to each transmitter.

9. In a telephone system, telephone lines serving as calling and called lines, said telephone lines having portions of varying characteristics, means including automatic switches for interconnecting said telephone lines, and means for equalizing one of said characteristics of an interconnection between a pair of said telephone lines.

10. In a telephone system, telephone lines serving as calling and called lines, said telephone lines having portions of varying impedance, means including automatic switches for interconnecting said telephone lines, and means for automatically compensating for certain variations of impedance in said telephone lines to render the mentioned portions thereof uniform as to certain impedance when connected to as called lines.

11. In a telephone system, telephone lines serving as calling and called lines, said telephone lines having portions of varying electrical characteristics, means for interconnecting said telephone lines, means for automatically compensating for a certain one of said variations in said telephone lines to render the mentioned portion thereof uniform as to one characteristic when connected to as called telephone lines, and means including an impedance bridge for controlling said automatic compensating means, said impedance bridge including a portion of one of said interconnected telephone lines.

12. In a telephone system, telephone lines serving as calling and called lines, said telephone lines having portions of varying impedance, means including automatic switches for interconnecting said telephone lines, and means including a progressively movable switch for varying the amount of impedance included in a portion of the called telephone line until said portion has impedance of a predetermined value.

13. In a telephone system, telephone lines serving as calling and called lines, said telephone lines having portions of varying impedance, means for interconnecting said telephone lines, means including a progressively movable switch for varying the amount of impedance included in a portion of the called telephone line until said portion has impedance of a predetermined value, and means including an impedance bridge for variably controlling said progressively movable switch.

14. In a telephone system, telephone lines serving as calling and called lines, said telephone lines having portions of varying impedance, means for interconnecting said telephone lines, a plurality of impedance elements, means including a progressively movable switch for simultaneously including impedance elements in each of the two sides of a called telephone line in series, and means including an impedance bridge for variably controlling said progressively movable switch.

In witness whereof, I hereunto subscribe my name this 12th day of October, A. D. 1923.

WINFRED T. POWELL.