A. R. KAHL.

TELEPHONE SYSTEM.

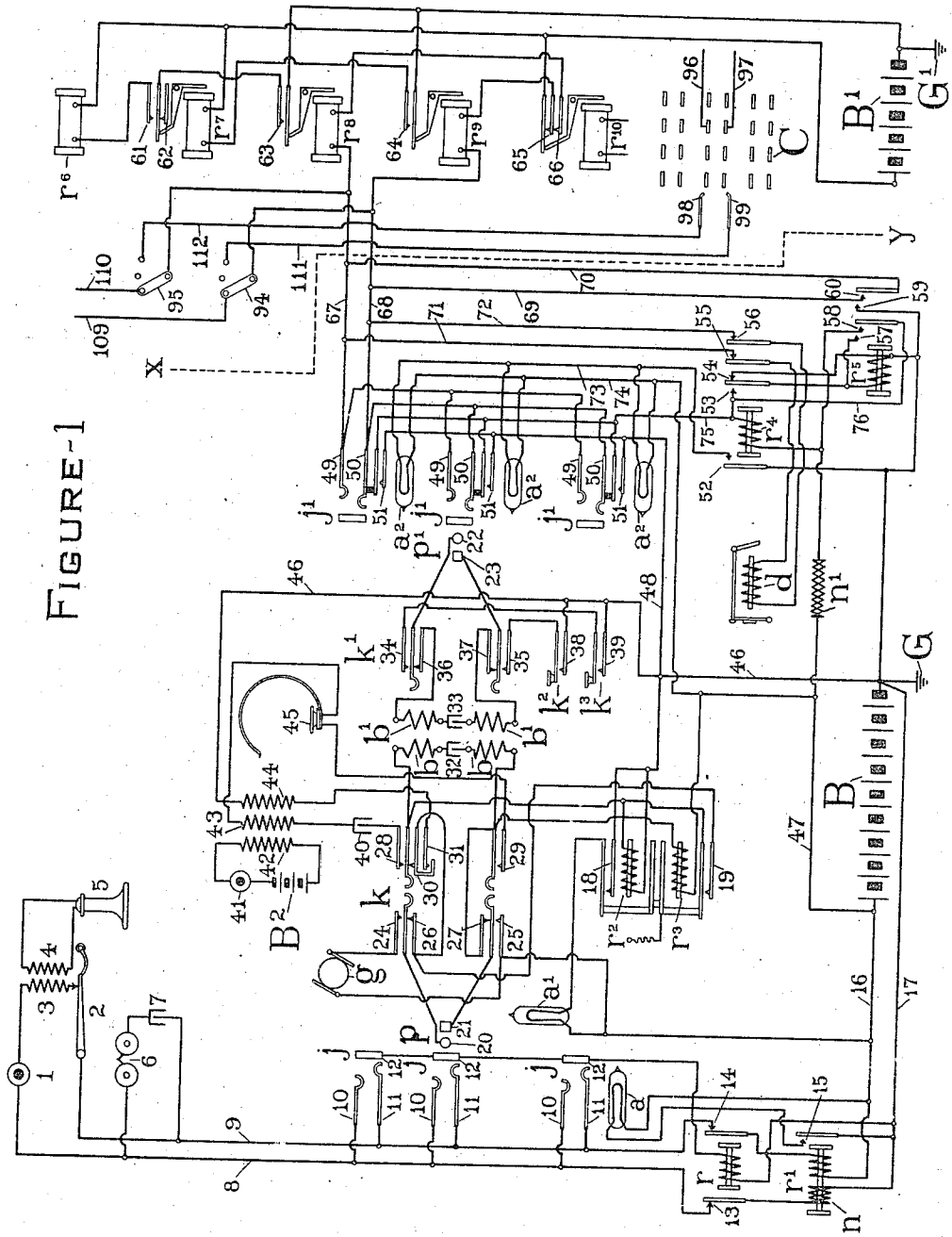
APPLICATION FILED JULY 16, 1907.

1,002,277.

Patented Sept. 5, 1911.

2 SHEETS—SHEET 1.

FIGURE-1



WITNESSES

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2 SHEETS—SHEET 2.

FIGURE-2

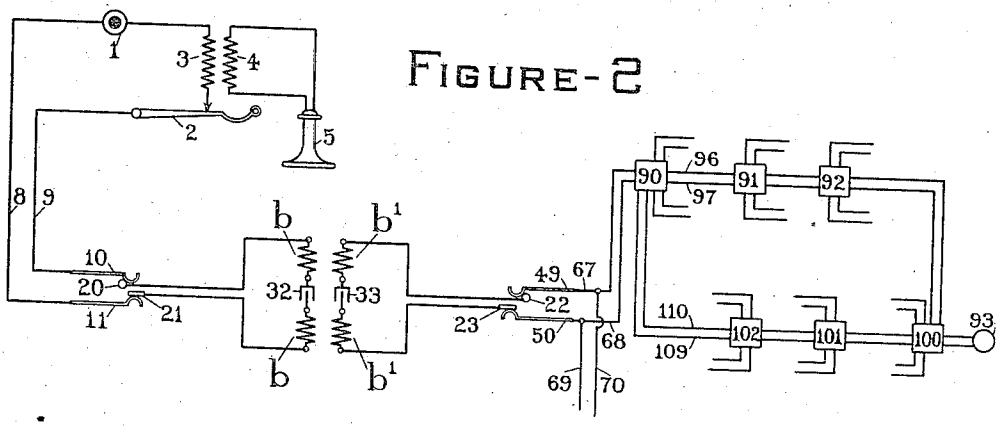


FIGURE-3

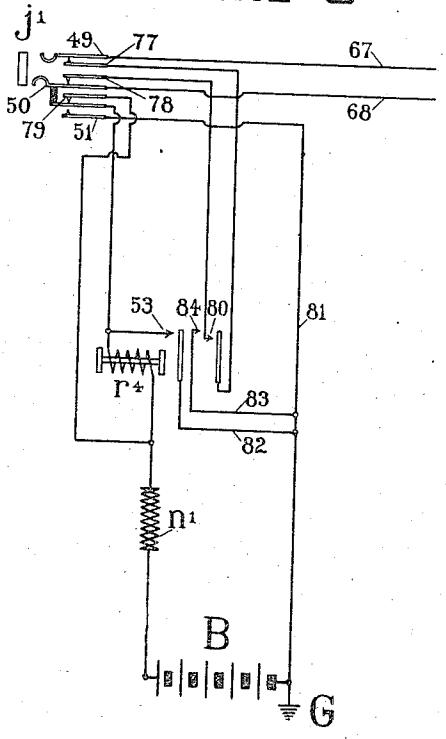
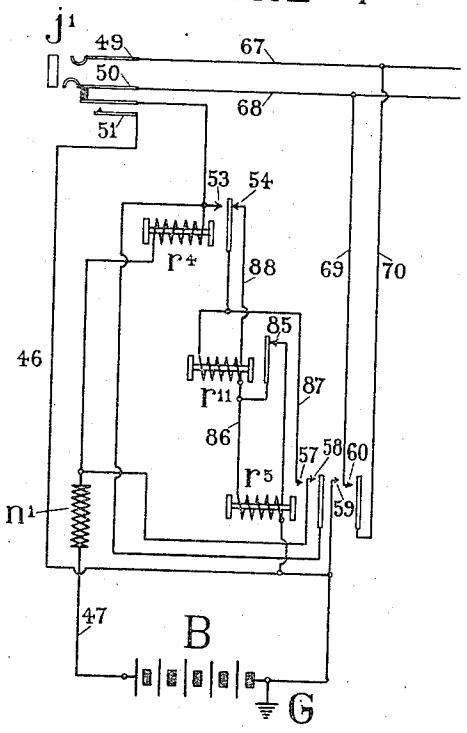


FIGURE-4



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UNITED STATES PATENT OFFICE.

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TELEPHONE SYSTEM.

1,002,277. Specification of Letters Patent. Patented Sept. 5, 1911.

Application filed July 16, 1907. Serial No. 384,087.

To all whom it may concern:

Be it known that I, ARTHUR R. KAHL, a citizen of the United States, residing in Rochester, in the county of Monroe and State of New York, have invented a new and useful Improvement in Telephone Systems, of which the following is a specification.

My invention relates to improved means for connecting and disconnecting manual and automatic telephone exchanges, and is, therefore, concerned with the usual mechanism involved in the operation of automatic telephone apparatus.

In operating automatic telephone systems, the common practice is to employ metallic circuits and to send impulses from one end of the line, usually the subscriber's station, to the automatic apparatus located at the exchange, first over one line conductor for operating one part of the automatic apparatus, and then over the other conductor for establishing a relation for selecting the required condition on the next apparatus, which selection is accomplished by again sending impulses over the first conductor, and so on, these impulses effecting a selection at the central office of the connection desired by the calling subscriber. At the close of the conversation, by means of replacing the receiver on the hook switch, impulses are sent over one or both line conductors simultaneously according to the system used, which impulses operate apparatus at the central exchange for clearing out and returning to normal condition all of the selecting apparatus that has been previously operated. The apparatus employed in automatic exchange work, on account of the mechanical work it necessarily does, is usually of comparatively heavy construction, and is therefore not as sensitive or rapid in its operation as apparatus commonly employed in manual exchange work. It is often necessary to connect by means of trunk lines from a manual telephone exchange to an automatic exchange, and in the trunk circuit thus used it is desirable to provide for restoring the automatic apparatus, by the mere act of taking down the connection at the manual exchange to said trunk line. In the past this result has been accomplished by using a multiplicity of ordinary electromagnetic mechanisms, or by the use of auxiliary mechanical devices, the result in either case being to give a sufficient length of impulse on disconnecting from such trunk line to positively release and restore to its normal condition the automatic apparatus previously operated to make connection with the desired automatic exchange subscriber.

It is the object of my invention to make use in a trunk connection of the character described, of ordinary electro-magnetic telephonic relays, and to reduce the number of these devices to a minimum without reducing the length of impulse imparted to the conductors extending to the automatic apparatus, when the connection with the trunk line is taken down.

It is also an object of my invention to eliminate any and all auxiliary mechanical devices that have heretofore been used in this connection to effect the proper length of releasing impulses.

It is a further object of my invention to produce an electro-magnetic device capable of use in electrical systems generally which shall be so arranged and connected as to have a natural rate of deënergization of longer time interval relatively than the time interval required for the energization of such device, without in any way impairing the sensitiveness or speed of energization of such device.

The several drawings illustrating my invention are as follows:

Figure 1 shows in diagrammatic view all of the electrical connections and apparatus essential to the operation of my invention. Fig. 2 shows in somewhat more diagrammatic view the complete connection between a subscriber to the manual exchange and a subscriber to the automatic exchange when connection is properly established for conversation. Figs. 3 and 4 are detailed views showing particular embodiments of my invention which will be explained later.

Similar letters refer to similar parts throughout the several views.

Referring to Fig. 1, when a subscriber to the manual exchange desires connection he removes his receiver 5 from the hook switch 2 thereby closing a circuit through such hook switch and primary winding 3 of his induction coil as follows: grounded side of battery B, wire 17, non-inductive winding n of line relay r^1, contact 13, line wire 8, transmitter 1, primary winding 3, hook switch 2, line wire 9, contact 14, energizing winding

of line relay r^1, wire 16, back to battery B. This energizes line relay r^1 and closes a circuit as follows: grounded side of battery B, wire 17, contact 15, line lamp a, wire 16, back to battery B and thus the signal lamp a is lighted, indicating to the operator that the subscriber corresponding thereto desires connection. The operator thereupon inserts plug p in answering jack j, the tip 20 and sleeve 21 of such plug making contact respectively with tip and sleeve springs 10 and 11. Sleeve 21 of the plug p makes contact at the same time with ring 12 of the answering jack, closing a circuit as follows: grounded side of battery B, wire 17, winding of cut-off relay r, ring 12, sleeve 21, contact 27, winding of sleeve relay r^3, wire 47, back to battery B. Thus the cut off relay r is energized and connection with battery B is cut off from the line wires 8 and 9 at contacts 13 and 14 respectively. Sleeve relay r^3 is also operated at this time closing contact 19 for a purpose to be described later. Tip supervisory relay r^2 is also energized at this time, current taking the following path: grounded side of battery B, wire 46, winding of tip supervisory relay r^2, contact 30, contact 26, tip 20, spring 10, line wire 8, transmitter 1, primary winding 3, hook switch 2, line wire 9, spring 11, sleeve 21, contact 27, winding of relay r^3, wire 47, back to battery B. Thus both relays r^2 and r^3 are energized which maintains contact 18 open and prevents the supervisory lamp a^1 from lighting.

The relays r^2 and r^3 have armatures extending longitudinally thereof and substantially parallel with their cores. These armatures are arranged adjacent to each other, as indicated in the drawings, and are separated by a block of suitable material attached to one of them. As a result, when the armature of the relay r^3 is attracted the contact 19 is closed and the armature of the relay r^2 is permitted to drop to a position closing the contact 18. With the relay r^3 still energized, if the relay r^2 is energized, its armature is attracted, thereby serving to open the contact 18. When the relay r^3 is deënergized, whether the relay r^2 is energized or not, the retracting spring attached to the armature of the relay r^3 serves to move it to its unattracted position and serves to move, as a result of the connections described, the armature of the relay r^2 to the position it would assume if attracted, as a result of which the contact 18 is opened.

In order to ascertain the connection desired, the operator throws the combined ringing and listening key k to the listening position which closes contacts 28, 29 and 31 and breaks contact 30 and establishes a circuit as follows: tip 20 of plug p, contact 26, contact 19, contact 28, condenser 40, secondary winding 43, receiver 45, contact 29, contact 27, sleeve 21 of plug p, which places the operator's receiver in circuit with the calling subscriber. The operator's talking circuit is as follows: battery B^2, transmitter 41, primary winding 42, back to battery B^2. Thus the operator ascertains the connection desired and on learning that the calling subscriber desires to communicate with a subscriber connected to the automatic exchange, plugs into one of the trunk jacks j^1 with the plug p^1 if the trunk connected with such jack is idle, which fact is indicated by the condition of the busy lamps a^2 associated with the multiple jacks j^1 connected to such trunk line. For such position of the plug p^1, tip 22 and sleeve 23 make contact respectively with tip and sleeve springs 49 and 50 by the spreading of which, contact 51 is closed and a circuit is established as follows: grounded side of battery B, wire 46, wire 48, contact 51, winding of relay r^4, resistance n^1, wire 47, back to battery B. Thus relay r^4 is energized and contacts 52 and 53 are made and contacts 54, 55 and 56 are broken. The closing of contact 52 completes a circuit as follows: grounded side of battery B, contact 52, wire 73, through the busy lamps a^2, a^2 in parallel, wire 74, wire 47, back to battery B. Thus busy lamps a^2 are lighted indicating that this particular trunk is busy. The opening of contacts 55 and 56 cuts off drop d from the conductors 67 and 68. The functions performed by the other contacts operated by relay r^4 will be explained later. The operator at the manual exchange now throws key k^1 so as to open circuit the cord and connect the selecting keys k^2 and k^3 to the sleeve and tip 23 and 22 respectively. The operator now sends the proper number of impulses by one of these keys as k^3 which by closing contact 39 establishes the following circuit: from the grounded side of battery B^1, ground G^1, ground G, wire 46, contact 39, contact 34, tip 22, spring 49, wire 67, winding of the relay r^8, contact 66, contact 65, back to battery B^1. This relay r^8 is the relay that is adapted to operate the first or vertical magnet of the first selector switch of the automatic mechanism; this magnet is not shown and neither are any of the mechanical parts connected with the automatic exchange indicated since these parts are well understood in the art and form no part of this invention; only such parts of the automatic exchange are indicated in connection with this drawing and specification as are essential to the description of this particular invention, which does not consist in operating an automatic exchange but does, in this embodiment, consist in effecting the operation of the so-called release magnet of such exchange, which magnet is well known in the art and performs functions which are also well known; there-

fore its energization and deënergization is believed to be sufficient to indicate the restoration of the mechanism of the automatic exchange to its initial condition after having been operated. Similarly the other relays indicated as a part of the automatic exchange apparatus may perform other functions additional to those indicated on this drawing and in this specification without necessitating a description of such apparatus and operations, since they form no part of this invention, and since the functions of all of these relays are well known in the art and call for no explanation. Thus it will be seen that the operation of the relay r^8 serves to operate the first automatic selector switch in one direction, usually vertically, as desired, according to the number of impulses sent by the key k^3. When the desired position in this direction is reached, key k^2 is depressed closing contact 38 and establishing a circuit as follows: grounded side of battery B^1, ground G^1, ground G, wire 46, contact 38, contact 35, sleeve 23, spring 50, wire 68, winding of relay r^9, contact 65, back to battery B^1. Thus relay r^9 which is known as the rotary relay, is operated and this relay, as is well known, besides closing contact 64 operates to move the first selector in a second direction, usually a motion of rotation, which continues until a connection to the proper second selector switch is secured. By the operation of the first selector switch just described, wipers 98 and 99 are moved into contact with those contacts C of the banks of contacts of such selector corresponding to the impulses sent by the operation of the key k^3 and at this same time switches 95 and 94, known as side switches, are moved in a manner well known, to their right hand position for which position trunk conductors 67 and 68 are connected by wires 112 and 111 with wipers 98 and 99 and thus to wires 96 and 97 and since these wires 96 and 97 lead to the vertical and rotary relays respectively of the second selector switch, such second selector may now be operated by means of keys k^3 and k^2. In the manner just described for the first selector, any number of selectors may be successively operated according to the size of the automatic exchange and finally the particular connector switch at which the desired subscriber's line terminates is similarly operated and talking connection is established between the calling and called subscribers as follows: winding b of the repeating coil, condenser 32, winding b, contact 27, sleeve 21 of plug p, spring 11, line wire 9, hook switch 2, primary winding 3, transmitter 1, line wire 8, spring 10, tip 20, plug p^1, contact 26, contact 30, to repeating coil b. The other side of this repeating coil is connected as follows: winding b^1, condenser 33, winding b^1, contact 37, sleeve 23, spring 50, trunk conductor 68, switch 94, wire 111, wiper 99, conductor 97, to and through the selector switches and connector switch and thus to the called subscriber, back to conductor 96, wiper 98, wire 112, switch 95, trunk conductor 67, spring 49, tip 22 of plug p^1, contact 36, to winding b^1; thus the two subscribers are connected inductively through the windings b and b^1 of the repeating coil in the cord circuit. Current is supplied to the subscriber connected with the manual exchange by the circuits already traced through relay windings r^2 and r^3 from battery B. In the modification shown in Fig. 1 the subscriber connected with the automatic exchange is assumed to have local battery apparatus and hence no battery connection is made to the automatic end of the cord circuit indicated. Should the operator move her key k to the listening position during a conversation to determine whether the connection is in use, provision is made to prevent opening the talking circuit which would otherwise occur at contact 30, by the closure of contact 19 by the operation of relay r^3, thus establishing a second electrical path from tip 20 through contacts 26 and 19 to winding b.

When the subscribers have finished conversing, the operator at the manual exchange is informed of the fact by the manual subscriber replacing receiver 5 on hook switch 2 thus breaking contact between primary winding 3 and such hook switch and opening the circuit through tip supervisory relay r^2. Thus contact 18 is closed and supervisory lamp a^1 is lighted, current taking the following path: grounded side of battery B, wire 46, contact 18, lamp a^1, wire 16, back to battery B. In response to this signal the operator withdraws the plug p from the answering jack j, which opens the energizing circuit of relay r, permitting the contacts 13 and 14 to be closed, for which condition relay r^1 remains deënergized since the energizing circuit is broken at hook switch 2 and thus the line apparatus connected with the manual exchange subscriber is restored to its normal condition. The operator also withdraws the plug p^1 from the multiple jack j^1 which first results in opening contact 51. This does not, however, permit the relay r^4 to become deënergized since a second energizing path is established to battery B as follows: grounded side of battery B, winding of relay r^5, contact 53, winding of relay r^4, resistance n^1, wire 47, back to battery B, and thus relay r^5 is energized and contacts 57, 58, 59 and 60 are closed. Attention is called to the fact that this relay r^5 was not operated during the time that the plug p^1 was in the jack j^1 for the reason that both terminals of its energizing winding were connected with the grounded side of battery B, one terminal being connected directly

with such terminal of the battery while the other terminal was connected through contact 53, wire 75, contact 51, wire 48 and wire 46; immediately on closing contacts 59 and 60, connection is established between ground G and trunk conductors 67 and 68 as follows: ground G, contacts 59 and 60, wires 69 and 70 to trunk conductors 68 and 67 respectively; thus relays r^8 and r^9 as well as the similar relays of the other selector and connector switches operated, are energized as their windings are connected with wires 67 and 68, the other terminals being connected through contacts 65 and 66 with the sleeve or live side of battery B^1. These relays remain energized as long as this grounded condition of the trunk conductors 67 and 68 is maintained. The energization of the relay r^9 closes contact 64 and establishes a circuit as follows: grounded terminal of battery B^1, contact 64, energizing winding of relay r^7, back to battery B^1. Thus relay r^7 which is known as the private or local magnet, is operated which closes contact 61. Since relay r^8 is operated at this same time thus closing contact 63, a circuit is closed as follows: grounded terminal of battery B^1, contact 63, contact 61, energizing winding of magnet r^6, back to battery B^1. Thus magnet r^6, which is known as the release magnet, is energized, which condition is maintained as long as wires 69 and 70 are grounded by the operation of relay r^5. Since the apparatus used in automatic exchanges is generally of relatively heavy construction, and since a number of selector switches are usually operated in effecting a connection, it is necessary that the release magnet r^6 be energized for a considerable time interval relatively, to permit the mechanism operated to return to its initial position, which is secured by the arrangement of the circuits used to deënergize relays r^4 and r^5. When the relay r^5 is energized by closing contacts 57 and 58 an external electrical path of low resistance is established between the terminals of the energizing winding of relay r^4, which results in the deënergization of such relay r^4 but at a rate much slower than its normal rate of energization due to the fact that a comparatively good path is provided for the flow of current induced by the gradually decreasing magnetic flux through the energizing winding of such relay r^4, which reacts upon such relay and tends to maintain its energized condition. When this relay is finally deënergized it opens contact 52 and thereby extinguishes lamps a^2, a^2 and also opens contact 53 and closes contacts 54, 55 and 56. By closing contact 54 an external electrical path of low resistance is established between the terminals of the energizing winding of relay r^5 as a result of which such relay is deënergized in a manner similar to that just described for relay r^4, and when such relay r^5 is completely deënergized contacts 57, 58, 59 and 60 are opened, thus removing the ground from the trunk conductors 67 and 68. Thus it will be seen that by utilizing the reactive effect of the self induction of the windings of relays r^4 and r^5, a considerable time interval is secured between the energization of relay r^5 (and the simultaneous grounding of the trunk conductors 67 and 68) and the deënergization of such relay, although such deënergization is a direct result of the act that energized it, and as a result the magnet r^6 is energized for a corresponding interval, such interval being of sufficient length to permit the complete restoration of the apparatus at the automatic exchange to its initial condition, and this interval may be made of suitable length by modifications indicated in connection with Figs. 3 and 4 if an interval different from that secured by the showing of Fig. 1 is necessary. The contact 57 is provided in connection with relay r^5 for the purpose of maintaining such relay r^5 energized while the armature of relay r^4 is falling away from contact 53 and making contact 54, the energizing circuit during this interval being as follows: grounded terminal of battery B, winding r^5, contact 57, contact 58, resistance n^1, back to battery B. This provides that the relay r^5 shall not be prematurely deenergized due to the opening of contact 53, but that such deënergization shall take place only as a result of the closing of contact 54 and the consequent slow release due to the inductive action already described.

If an automatic subscriber desires connection with a manual subscriber and the trunk 67, 68 should be selected by the automatic exchange for completing the connection to the manual exchange, such connection is completed from the proper connector switch by wires 109 and 110 and switches 94 and 95. At the same time this connection is effected, relay r^{10} of the selector shown in Fig. 1 (which selector is adapted to be operated only by impulses sent to the automatic exchange over the trunk 67, 68) known as the cut-off relay, is operated in a manner well known for the purpose of preventing the improper actuation of this selector after the line thereto has been made a part of a connection incoming at the manual exchange, since if this selector could be operated at this time such incoming connection would be broken at switches 94 and 95. When the connection just described has been established, the automatic subscriber sends an impulse over the line by any suitable means not shown and operates drop d. Replying to the signal thus given the operator inserts plug p^1 in the answering jack j^1 associated with the drop d and thus energizes relay r^4 as already described

which closes contact 52 and lights lamps a^6, a^2 as before described and also opens contacts 55 and 56 and thus cuts off drop d from the trunk conductors. The operator then ascertains the subscriber desired by moving the listening key as above described and then with the tip of plug p tests in her multiple, the ring of the jack j corresponding to the number of the desired subscriber. If this line is in use a connection is established by a sleeve 21 belonging to a second cord similar to the one shown, from battery B as already described for the first condition. Thus there is a difference of potential between the ring tested and the testing tip 20 of the plug, which results in a current flowing over the following circuit, the key k being thrown into its listening position at this time: grounded terminal of battery B, wire 46, tertiary winding 44 of the operator's induction coil, contact 31, contact 26, tip 20, ring 12, common tie to a second ring 12 in contact with sleeve 21 of the plug in contact with such ring, contact 27 of such second cord, winding of relay r^3, wire 47, back to battery B. Thus a current impulse is induced in the secondary winding 43 connected in circuit with the operator's receiver 45, which informs her of the fact that the tested line is busy. At this time the cord circuit is broken at contact 30 and since relay r^3 is not energized and therefore contact 19 is open, the click caused by such current flow is not communicated through the answering end of the plug to the ear of the calling subscriber. If the line tested is not busy, no click is produced since the only connection to the rings of the line for such a condition is through the energizing winding of relay r directly to the grounded terminal of battery B. If the line is not busy the operator inserts the plug p in the jack j of her multiple corresponding to the number of the subscriber desired, which energizes relay r^3 in a manner already described, thus closing contact 19 and permitting the armature of relay r^2 to drop, thus closing contact 18 and lighting lamp a^1. The operator then throws her key k to its ringing position, which opens contacts 26 and 27 thereby opening the cord circuit and closing contacts 24 and 25, thus connecting generator g with the tip and sleeve 20 and 21 and thus through springs 10 and 11 with line conductors 8 and 9 respectively, by which generator current is conducted through the ringer 6 and condenser 7 and thereby a signal is given to the substation whereby the subscriber is called and removes the receiver 5 from hook switch 2, thereby opening contact 18 and extinguishing lamp a^1 which was lighted when plug p was inserted in the jack j. For this condition the talking circuit is as already described and the operation of the apparatus upon disconnecting is the same including the grounding and restoring to initial condition of the apparatus at the automatic exchange, as that already described above.

In Fig. 1 the division line between the apparatus at the manual and automatic exchanges is indicated by dotted line x—y.

In Fig. 2 the completed connection from the manual subscriber to the automatic subscriber is diagrammatically shown and when the manual subscriber is the calling subscriber, the connection established between the manual exchange and the called subscriber 93 is as follows: winding b^1 of the repeating coil, condenser 33, winding b^1, sleeve 23, spring 50, conductor 68, first selector switch 90, conductor 97, second selector switch 91, connector switch 92, through first selector switch 100 to subscriber 93, thence back through first selector switch 100, connector switch 92, second selector switch 91, conductor 96, to and through first selector switch 90, conductor 67, spring 49, tip 22, back to winding b^1 of the repeating coil. When the automatic subscriber is the calling subscriber, this connection is established as follows: from subscriber 93, through first selector switch 100, second selector switch 101, connector switch 102, conductor 109, through first selector switch 90 to conductor 68, spring 50, sleeve 23, winding b^1 of the repeating coil, condenser 33, winding b^1, tip 22, spring 49, conductor 67, through first selector switch 90, conductor 110, connector switch 102, second selector switch 101, first selector switch 100, back to subscriber 93. The circuit from the manual subscriber to the manual exchange is the same for both cases as already described for Fig. 1.

In Figs. 3 and 4 means are shown for securing a shorter or longer time interval respectively of operation of the release magnet r^6 than that shown in Fig. 1.

Referring to Fig. 3, when plug p^1 is inserted in jack j^1, contact 51 is closed and contacts 77, 78 and 79 are opened. As a result of the closing of contact 51, relay r^4 is energized by the following circuit: grounded terminal of battery B, wire 81, contact 51, winding of relay r^4, resistance n^1, back to battery B. As a result of the energization of relay r^4, contacts 53, 80 and 84 are closed without, however, further operating the apparatus. At the close of the conversation when the plug p^1 is removed from the jack j^1, contact 51 is broken and contacts 77, 78 and 79 are closed. The closing of contacts 77 and 78 connects conductors 67 and 68 respectively through contacts 80 and 84 by wire 83 to ground G. The closing of contact 79 establishes an external electrical path of low resistance between the terminals of the energizing wind-

ing of relay r^4, which operates to deënergize this relay in the manner already described, as a result of which after the inductive effect has ceased, contacts 53, 80 and 84 are opened and the connections of conductors 67 and 68 to each other and to ground G are broken. The closing of contact 53 by the energization of relay r^4 is for the purpose of maintaining the energizing circuit of such relay through wire 82 when contact 51 is opened in order to prevent the premature deënergization of such relay due to open circuiting its energizing winding. Thus an arrangement is provided in which the interval of grounding of the conductors 67 and 68 is represented by the length of time required for a single relay to be deenergized.

In Fig. 4 a modification of the invention is shown involving a longer interval of grounding of conductors 67 and 68 than that provided for by the apparatus shown in Fig. 1. In this modification, when plug p^1 is inserted in jack j^1 contact 51 is closed, establishing the following circuit: grounded terminal of battery B, wire 46, contact 51, winding of relay r^4, resistance n^1, wire 47, back to battery B. Thus relay r^4 is energized, contact 53 is closed and contact 54 is broken. When the plug p^1 is removed from the jack j^1 at the close of the conversation, contact 51 is opened, but the relay r^4 is not deënergized since a second energizing path is established as follows: grounded terminal of battery B, contact 85, winding of relay r^{11}, contact 53, winding of relay r^4, resistance n^1, wire 47, back to battery B. Thus relay r^4 is maintained energized and relay r^{11} is also energized, the operation of the latter breaking contact 85 which causes the energization of relay r^5 by the following circuit: grounded terminal of battery B, winding of relay r^5, wire 86, winding of relay r^{11}, contact 53, winding of relay r^4, resistance n^1, wire 47, back to battery B. The energization of relay r^5 closes contacts 57, 58, 59 and 60 with the following results. The closing of contacts 59 and 60 connects conductors 67 and 68 together and to ground G, through wires 70 and 69. The closing of contact 58 establishes an external electrical path of low resistance between the terminals of the winding of relay r^4, thereby causing its deënergization in the manner already described in the other modifications, as a result of which, contact 53 is broken and contact 54 is closed. The closing of contact 54 establishes through wire 88, an external electrical path of low resistance between the terminals of the winding of relay r^{11}, thereby causing its deenergization and the closing of contact 85, which in turn establishes an external electrical path of low resistance through wire 86 between the terminals of the winding of relay r^5, thereby causing its deënergization and the opening of contacts 57, 58, 59 and 60. The opening of contacts 59 and 60 opens the connection between conductors 67 and 68 and also the connections of these conductors to ground G. The opening of contact 58 and closing of contacts 54 and 85 restores the apparatus to its normal initial condition. Contact 57 is provided for maintaining a closure of the energizing circuit of relays r^{11} and r^5 during the interval of opening of contact 53 so that such relays will not be prematurely deënergized but will only be deënergized as a result of the slow action due to the external paths established between the terminals of the windings of such relays already described. In the modification shown in Fig. 4 it will be noticed a time interval of grounding of conductors 67 and 68 is provided which is equal to the time required for three relays to be successively deënergized. Thus it will be seen that means are provided for securing any length of grounding of the trunk conductors 67 and 68 as desired, since any number of relays may be used in a series as indicated in Fig. 4, and that the interval thus secured is under any condition a maximum possible without introducing mechanical resistances or other undesirable elements to prolong this interval. It is obvious that the external electrical paths used to retard the deënergization of the several relays may be of any resistance as long as the paths provided are sufficiently good conductors to readily accommodate the current induced in such relays by the decreasing magnetic flux through their windings.

It will be understood that while I have shown my invention in use in connection with a trunk circuit for the purpose indicated in the above description, I do not limit myself to this modification, but claim this invention broadly as a means for effecting by a single operation the closure and subsequent opening of an electric circuit and for maintaining such closure for a maximum interval with a minimum amount of electrical apparatus involved.

What I claim is:

1. In a telephone system, a manual exchange, an automatic exchange, a source of electric energy, an electrical connection between such exchanges, means for grounding such connection and electro-magnetic mechanism adapted to be energized from such source of electric energy and adapted by its deënergization to limit the duration of such grounded condition, such deënergization resulting from closing an external electrical path between the terminals of an energizing winding of such mechanism whereby the natural rate of deënergization of such mechanism may be modified.

2. In a telephone system, a manual ex-

change, an automatic exchange, a source of electric energy, an electrical connection between such exchanges, means for grounding such connection and electro-magnetic mechanism associated with such manual exchange and adapted to be energized from such source of electric energy, the deënergization of said electro-magnetic mechanism being under the control of such manual exchange and being adapted to limit the duration of such grounded condition, such deënergization resulting from closing an external electrical path between the terminals of an energizing winding of such mechanism whereby the natural rate of deënergization of such mechanism may be modified.

3. In a telephone system, a manual exchange, an automatic exchange, a source of electric energy, an electrical connection between such exchanges, electro-magnetic mechanism at the automatic exchange, means for actuating said electro-magnetic mechanism from such manual exchange, means for grounding such connection, electro-magnetic mechanism at the manual exchange and means for limiting the duration of such grounded condition consisting in the deenergization of the latter electro-magnetic mechanism said mechanism being adapted to be energized from such source of electric energy, such deënergization resulting from closing an external electrical path between the terminals of an energizing winding of such latter mechanism whereby the natural rate of deënergization of such latter mechanism is modified and the mechanism at such automatic exchange previously actuated may be restored to its normal condition.

4. In a telephone system, a manual exchange, an automatic exchange, a source of electric energy, an electrical connection between such exchanges, electro-magnetic mechanism at such automatic exchange, means for actuating such mechanism from such manual exchange, electro-magnetic mechanism at the manual exchange and means whereby the severing of such connection between such exchanges operates to close an external electrical path between the terminals of an energizing winding of the latter electro-magnetic mechanism which is normally energized from such source of electric energy when such connection is established, such path operating to deënergize the mechanism at such manual exchange whereby the mechanism at such automatic exchange previously actuated may be restored to its normal condition.

5. In a telephone system, a manual exchange, an automatic exchange, an electrical connection between such exchanges, a source of electric energy at such manual exchange, electro-magnetic mechanism at such manual exchange adapted to be energized from such source of electric energy, a second source of electric energy at such automatic exchange, electro-magnetic mechanism at such automatic exchange in circuit with such electrical connection and such source of electric energy at such automatic exchange and adapted to be operated therefrom and means for closing a circuit between such connection and the other terminal of such last mentioned source of electric energy consisting in the deënergization of the electro-magnetic mechanism at such manual exchange resulting from closing an external electrical path between the terminals of an energizing winding of such last mentioned electro-magnetic mechanism.

6. In a telephone system, a manual exchange, an automatic exchange, an electrical connection between such exchanges, a source of electric energy at such manual exchange, electro-magnetic mechanism at such manual exchange adapted to be energized from such source of electric energy, a second source of electric energy at such automatic exchange, electro-magnetic mechanism at such automatic exchange in circuit with such electrical connection and such source of electric energy at such automatic exchange and adapted to be operated therefrom and means for closing a circuit between such connection and the other terminal of such last mentioned source of electric energy consisting in two electro-magnetic devices, the first of which is adapted to close an external electrical path between the terminals of an energizing winding of the second and thereby deënergize such second device, which deenergization is adapted to close an external electrical path between the terminals of an energizing winding of the first and thereby deënergize such first device, whereby the previously actuated electro-magnetic mechanism at such automatic exchange may be restored to its normal condition.

7. In a telephone system, a manual exchange, an automatic exchange, a source of electric energy, an electrical connection between such exchanges, means for grounding such connection, electro-magnetic mechanism adapted to be energized from such source of electric energy and adapted by its deënergization to limit the duration of such grounded condition, such deënergization resulting from short circuiting the terminals of an energizing winding of such mechanism whereby the natural rate of deenergization of such mechanism may be modified.

8. In a telephone system, a manual exchange, an automatic exchange, a source of electric energy, an electrical connection between such exchanges, means for grounding such connection and electro-magnetic mechanism associated with such manual exchange and adapted to be energized from such source of electric energy, the deënergi-

zation of said electro-magnetic mechanism being under the control of such manual exchange and being adapted to limit the duration of such grounded condition, such deënergization resulting from short circuiting the terminals of an energizing winding of such mechanism whereby the natural rate of deënergization of such mechanism may be modified.

9. In a telephone system, a manual exchange, an automatic exchange, a source of electric energy, an electrical connection between such exchanges, electro-magnetic mechanism at the automatic exchange, means for actuating said electro-magnetic mechanism from such manual exchange, means for grounding such connection, electro-magnetic mechanism at such manual exchange adapted by its deënergization to limit the duration of such grounded condition said mechanism being adapted to be energized from such source of electric energy, such deënergization resulting from short circuiting the terminals of an energizing winding of such latter mechanism whereby the natural rate of deënergization of such latter mechanism is modified and the mechanism at such automatic exchange previously actuated may be restored to its normal condition.

10. In a telephone system, a manual exchange, an automatic exchange, a source of electric energy, an electrical connection between such exchanges, electro-magnetic mechanism at such automatic exchange, means for actuating such mechanism from such manual exchange, electro-magnetic mechanism at the manual exchange and means whereby the severing of such connection between such exchanges operates to short circuit the terminals of an energizing winding of the latter electro-magnetic mechanism which is normally energized from such source of electric energy when such connection is established, such short circuit operating to deënergize the mechanism at such manual exchange whereby the mechanism at such automatic exchange previously actuated may be restored to its normal condition.

11. In a telephone system, a manual exchange, an automatic exchange, an electrical connection between such exchanges, a source of electric energy at such manual exchange, electromagnetic mechanism at such manual exchange adapted to be energized from such source of electric energy, a second source of electric energy at such automatic exchange, electromagnetic mechanism at such automatic exchange in circuit with such electrical connection and such source of electric energy at such automatic exchange and adapted to be operated therefrom and means for closing a circuit between such connection and the other terminal of such last mentioned source of electric energy consisting in the deënergization of the electro-magnetic mechanism at such manual exchange resulting from short circuiting the terminals of an energizing winding of such last mentioned electro-magnetic mechanism.

12. In a telephone system, a manual exchange, an automatic exchange, an electrical connection between such exchanges, a source of electric energy at such manual exchange, electro-magnetic mechanism at such manual exchange adapted to be energized from such source of electric energy, a second source of electric energy at such automatic exchange, electro-magnetic mechanism at such automatic exchange in circuit with such electrical connection and such source of electric energy at such automatic exchange and adapted to be operated therefrom and means for closing a circuit between such connection and the other terminal of such last mentioned source of electric energy consisting in two electro-magnetic devices, the first of which is adapted to short circuit the terminals of an energizing winding of the second and thereby deënergize such second device, which deënergization is adapted to short circuit the terminals of an energizing winding of the first and thereby deënergize such first device, whereby the previously actuated electro-magnetic mechanism at such automatic exchange may be restored to its normal condition.

13. In a telephone system, a manual exchange, an automatic exchange, a trunk line for connecting such exchanges, a source of electric energy, electro-magnetic mechanism at such automatic exchange for operating such exchange, means at such manual exchange for sending impulses from such source of electric energy over such trunk line adapted to operate the mechanism at such automatic exchange to connect such trunk line with the desired subscriber's line terminating at such automatic exchange, electro-magnetic mechanism at the manual exchange and means operated by taking down such trunk line connection for automatically energizing and deënergizing said electro-magnetic mechanism at such manual exchange whereby the trunk line at the manual exchange end is connected to and then disconnected from one terminal of such source of electric energy.

14. In a telephone system, a manual exchange, an automatic exchange, a trunk line for connecting such exchanges, a source of electric energy, electro-magnetic mechanism at such automatic exchange for operating such exchange, means at such manual exchange for sending impulses from such source of electric energy over such trunk line adapted to operate the mechanism at such automatic exchange to connect such trunk line with the desired subscriber's line termi-

nating at such automatic exchange, electro-magnetic mechanism at the manual exchange and means operated by taking down such trunk line connection for automatically energizing and deënergizing said electro-magnetic mechanism at the manual exchange whereby the manual exchange end of the trunk line is connected to and then disconnected from one terminal of such source of electric energy and the mechanism at such automatic exchange is restored to its normal condition.

15. In a telephone system, a manual exchange, an automatic exchange, a trunk line for connecting such exchanges a source of electric energy at such automatic exchange, electro-magnetic devices at such automatic exchange connected between the conductors of such trunk line and one terminal of such source of electric energy, keys at such manual exchange for connecting either of such trunk line conductors to the other terminal of such source of electric energy whereby either of such electro-magnetic devices may be operated as desired, a source of electric energy at such manual exchange, electro-magnetic devices in circuit with such second source of electric energy adapted to be automatically energized and deënergized when connection with such trunk line is taken down whereby such trunk line conductors are simultaneously connected to and then disconnected from the other terminal of such first source of electric energy.

16. In a telephone system, a manual exchange, an automatic exchange, a trunk line for connecting such exchanges, a source of electric energy at such automatic exchange, electro-magnetic devices at such automatic exchange connected between the conductors of such trunk line and one terminal of such source of electric energy, keys at such manual exchange for connecting either of such trunk line conductors to the other terminal of such source of electric energy whereby either of such electro-magnetic devices may be operated as desired, a source of electric energy at such manual exchange, electro-magnetic devices in circuit with such second source of electric energy adapted to be automatically energized and deënergized when connection with such trunk line is taken down whereby such trunk line conductors are simultaneously connected to and then disconnected from the other terminal of such first source of electric energy and the devices in circuit therewith at such automatic exchange are operated to restore the mechanism at such automatic exchange to its normal condition.

17. In a telephone system, a manual exchange, an automatic exchange, a trunk line for connecting such exchanges, a source of electric energy at such automatic exchange, electro-magnetic devices at such automatic exchange connected between the conductors of such trunk line and one terminal of such source of electric energy, keys at such manual exchange for connecting either of such trunk line conductors to the other terminal of such source of electric energy whereby either of such electro-magnetic devices may be operated as desired, a second source of electric energy, an electro-magnetic device adapted to be energized from such second source of electric energy, means for connecting a subscriber's line terminating at such manual exchange with such trunk line and means whereby the disconnection of such connecting means from such trunk line energizes such last mentioned device and subsequently deënergizes the same by closing an external electrical path between the terminals of an energizing winding of such device, such energization and deënergization serving to respectively connect the trunk line conductors to and disconnect the same from the other terminal of such first source of electric energy and to maintain such connection for a sufficient interval to operate the electro-magnetic devices at such automatic exchange whereby the mechanism of such automatic exchange is restored to its normal condition.

18. In a telephone system, a manual exchange, an automatic exchange, a trunk line for connecting such exchanges, a source of electric energy at such automatic exchange, electro-magnetic devices at such automatic exchange connected between the conductors of such trunk line and one terminal of such source of electric energy, keys at such manual exchange for connecting either of such trunk line conductors to the other terminal of such source of electric energy whereby either of such electromagnetic devices may be operated as desired, a second source of electric energy, electro-magnetic devices adapted to be energized from such second source of electric energy, means for connecting a subscriber's line terminating at such manual exchange with such trunk line and means whereby the disconnection of such connecting means from such trunk line energizes such last mentioned devices and subsequently deënergizes the same by closing external electrical paths between the terminals of energizing windings of such devices, such energization and deënergization serving to respectively connect the trunk line conductors to and disconnect the same from the other terminal of such first mentioned source of electric energy and to maintain such connection for a sufficient interval to operate the electro-magnetic devices at such automatic exchange whereby the mechanism of such automatic exchange is restored to its normal condition.

19. In a telephone system, a manual exchange, an automatic exchange, a trunk line

for connecting such exchanges, a source of electric energy at such automatic exchange, electro-magnetic devices at such automatic exchange connected between the conductors of such trunk line and one terminal of such source of electric energy, keys at such manual exchange for connecting either of such trunk line conductors to the other terminal of such source of electric energy whereby either of such electro-magnetic devices may be operated as desired, a source of electric energy at such manual exchange, a series of electro-magnetic devices adapted to be energized from such second source of electric energy, means for connecting a subscriber's line terminating at such manual exchange with such trunk line and means whereby the disconnection of such connecting means from such trunk line successively energizes such devices at such manual exchange and subsequently deënergizes the same in the same order by closing external electrical paths between the terminals of energizing windings of such devices, the energization and deënergization of the last device of such series serving to respectively connect the trunk line conductors to and disconnect the same from the other terminal of such first mentioned source of electric energy, the interval of such connection being determined by the number of devices in such series.

20. In a telephone system, a manual exchange, an automatic exchange, a trunk line for connecting such exchanges, a source of electric energy at such automatic exchange, electro-magnetic devices at such automatic exchange connected between the conductors of such trunk line and one terminal of such source of electric energy, keys at such manual exchange for connecting either of such trunk line conductors to the other terminal of such source of electric energy whereby either of such electro-magnetic devices may be operated as desired, a source of electric energy at such manual exchange, a series of electro-magnetic devices adapted to be energized from such second source of electric energy, means for connecting a subscriber's line terminating at such manual exchange with such trunk line, means for automatically energizing the first device of such series when such subscriber's line is thus connected with such trunk line, means whereby the disconnection of such connecting means from such trunk line establishes a second energizing path for such first device whereby a second one of such series is energized, which in turn energizes the next one of such series and so on each one of such series being energized by the operation of the one preceding it and means whereby the energization of the last device of such series deënergizes the first device of such series by closing an external electrical path between the terminals of an energizing winding of such first device, which in turn similarly deenergizes the second one of such series and so on, each one of such series being deenergized in this manner by the deënergization of the one preceding it, the energization and deënergization of the last device of such series serving to respectively connect the trunk line conductors to and disconnect the same from the other terminal of such first mentioned source of electric energy, the interval of such connection being determined by the number of devices in such series.

21. In a telephone system, a manual exchange, an automatic exchange, a trunk line for connecting such exchanges, a source of electric energy at such automatic exchange, electro-magnetic devices at such automatic exchange connected between the conductors of such trunk line and one terminal of such source of electric energy, keys at such manual exchange for connecting either of such trunk line conductors to the other terminal of such source of electric energy whereby either of such electro-magnetic devices may be operated as desired, a second source of electric energy, an electro-magnetic device adapted to be energized from such second source of electric energy, means for connecting a subscriber's line terminating at such manual exchange with such trunk line and means whereby the disconnection of such connecting means from such trunk line energizes such last mentioned device and subsequently deënergizes the same by short-circuiting the terminals of an energizing winding of such device, such energization and deënergization serving to respectively connect the trunk line conductors to and disconnect the same from the other terminal of such first source of electric energy and to maintain such connection for a sufficient interval to operate the electro-magnetic devices at such automatic exchange whereby the mechanism of such automatic exchange is restored to its normal condition.

22. In a telephone system, a manual exchange, an automatic exchange, a trunk line for connecting such exchanges, a source of electric energy at such automatic exchange, electro-magnetic devices at such automatic exchange connected between the conductors of such trunk line and one terminal of such source of electric energy, keys at such manual exchange for connecting either of such trunk line conductors to the other terminal of such source of electric energy whereby either of such electro-magnetic devices may be operated as desired, a second source of electric energy, electro-magnetic devices adapted to be energized from such second source of electric energy, means for connecting a subscriber's line terminating at such manual exchange with such trunk line and means whereby the disconnection of such

connecting means from such trunk line energizes such last mentioned devices and subsequently deënergizes the same by short-circuiting the terminals of energizing windings of such devices, such energization and deënergization serving to respectively connect the trunk line conductors to and disconnect the same from the other terminal of such first mentioned source of electric energy and to maintain such connection for a sufficient interval to operate the electro-magnetic devices at such automatic exchange whereby the mechanism of such automatic exchange is restored to its normal condition.

23. In a telephone system, a manual exchange, an automatic exchange, a trunk line for connecting such exchanges, a source of electric energy at such automatic exchange, electro-magnetic devices at such automatic exchange connected between the conductors of such trunk line and one terminal of such source of electric energy, keys at such manual exchange for connecting either of such trunk line conductors to the other terminal of such source of electric energy whereby either of such electro-magnetic devices may be operated as desired, a source of electric energy at such manual exchange, a series of electro-magnetic devices adapted to be energized from such second source of electric energy, means for connecting a subscriber's line terminating at such manual exchange with such trunk line and means whereby the disconnection of such connecting means from such trunk line successively energizes such devices at such manual exchange and subsequently successively deënergizes the same in the same order by short circuiting the terminals of energizing windings of such devices, the energization and deënergization of the last device of such series serving to respectively connect the trunk line conductors to and disconnect the same from the other terminal of such first mentioned source of electric energy, the interval of such connection being determined by the number of devices in such series.

24. In a telephone system, a manual exchange, an automatic exchange, a trunk line for connecting such exchanges, a source of electric energy at such automatic exchange, electro-magnetic devices at such automatic exchange connected between the conductors of such trunk line and one terminal of such source of electric energy, keys at such manual exchange for connecting either of such trunk line conductors to the other terminal of such source of electric energy whereby either of such electro-magnetic devices may be operated as desired, a source of electric energy at such manual exchange, a series of electro-magnetic devices adapted to be energized from such second source of electric energy, means for connecting a subscriber's line terminating at such manual exchange with such trunk line, means for automatically energizing the first device of such series when such subscriber's line is thus connected with such trunk line, means whereby the disconnection of such connecting means from such trunk line establishes a second energizing path for such first device whereby the second one of such series is energized, which in turn energizes the next one of such series and so on each one of such series being energized by the operation of the one preceding it and means whereby the energization of the last device of such series deënergizes the first device of such series by short circuiting the terminals of an energizing winding of such first device, which in turn similarly deënergizes the second one of such series and so on, each one of such series being deënergized in this manner by the deënergization of the one preceding it, the energization and deënergization of the last device of such series serving to respectively connect the trunk line conductors to and disconnect the same from the other terminal of such first mentioned source of electric energy, the interval of such connection being determined by the number of devices in such series.

ARTHUR R. KAHL.

Witnesses:
CHARLES E. HAGUE,
OSCAR M. LEICH.