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TELEPHONE TRUNK CIRCUITS.

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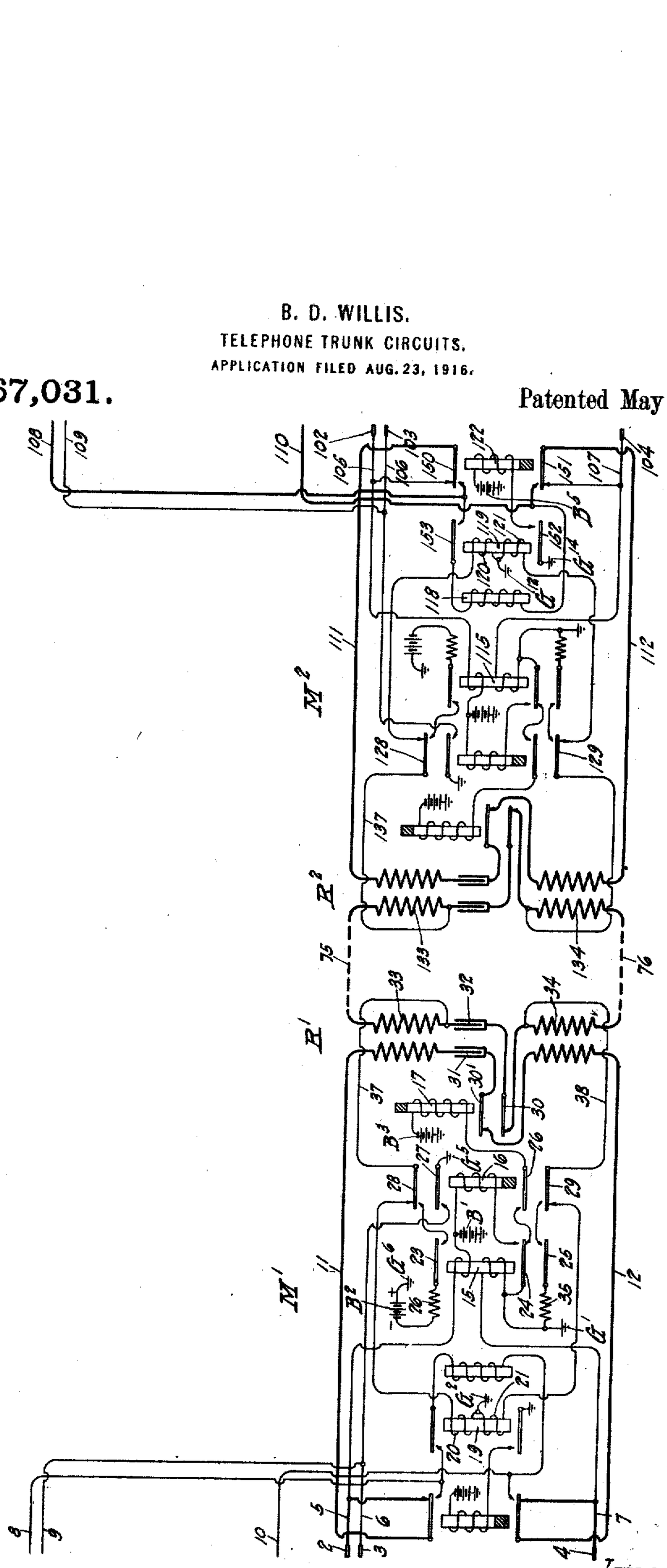

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TELEPHONE TRUNK-CIRCUITS.

1,267,031. Specification of Letters Patent. Patented May 21, 1918.

Application filed August 23, 1916. Serial No. 116,486.

To all whom it may concern:

Be it known that I, BERNARD D. WILLIS, a citizen of the United States of America, and a resident of Chicago, county of Cook, and State of Illinois, have invented certain new and useful Improvements in Telephone Trunk-Circuits, of which the following is a specification.

My invention relates in general to inter-office trunk circuits, but is more particularly concerned with circuits of this character which are adapted for use in automatic telephone systems. In U. S. Letters Patent #1,136,912, granted April 20, 1915, to T. G. Martin, there is shown and described a two-way trunk circuit for use in a two-wire or non-grounded automatic telephone system. The trunk circuit there illustrated is provided with a repeater at each end for transmitting operating impulses to an automatic switch at the other end over the two sides of the trunk line in series.

Such a trunk circuit is well adapted for use in a system in which the different offices or exchanges are only a few miles apart. In more extensive installations, however, comprising widely scattered exchanges, which may be separated by a hundred miles or more, it is advisable to lower the resistance of the impulse transmitting circuit by making use of a ground return. The repeaters at each end, therefore, may be arranged to receive impulses transmitted over the two sides of a line in series, and repeat these impulses over a ground return circuit to apparatus at the distant end, where the impulses are again translated to the series variety in order to operate the usual two-wire automatic switches. This method of operation, if special precautions are not taken, is open to the objection that the impulses are liable to be affected by variations in the ground potential at the opposite ends of the trunk circuit. In many localities the potential of ground may vary from negative values to fifteen or twenty volts above the ground potential at other points, which is sufficient to very seriously affect the quality of impulses transmitted over ground return circuits.

The object of my invention is to provide a trunk circuit of the general character set forth above which is adapted to automatically compensate for any variations in the ground potential which may occur, thereby securing accurate transmission of impulses regardless of such variations. The particular means employed to secure the foregoing results will be fully described hereinafter, and its operation explained, reference being had to the accompanying drawing, which shows diagrammatically a two-way automatic trunk circuit embodying the principles of my invention.

In the drawing, the reference characters 75 and 76 indicate the two line conductors of the trunk circuit, which terminate at opposite ends in the windings of the repeating coils R′ and R². Through the medium of repeating coil R′ the trunk conductors 75 and 76 are inductively connected to conductors 11 and 12, which in turn are adapted for connection either with conductors 5 and 7 or conductors 8 and 10, depending on the direction of the call. In a similar manner the repeating coil R² serves to inductively connect the line conductors 75 and 76 with conductors 111 and 112 which are adapted for connection either with conductors 105 and 107 or conductors 108 and 110.

The manner in which connections are established to or from the trunk circuit may be understood clearly by referring to the previously mentioned patent to Martin. Thus the bank contacts 2, 3, and 4 are assumed to be multiplied in the banks of first selector switches such as the one there shown and described, while the conductors 8, 9, and 10 extend to and terminate either in a line switch, as shown in the said Martin patent, or directly in a second selector switch. In the same manner, at the opposite end of the trunk circuit, the bank contacts 102, 103, and 104 are multiplied in the banks of first selectors in the distant exchange while the conductors 108, 109, and 110 extend either to a line switch or to a second selector switch.

The two groups of relays indicated collectively by reference characters M′ and M² comprise two repeaters through the medium of which the operating and talking circuits are established and controlled. It is thought that the functions of these relays can best be explained by describing the operations incident to the establishment of a connection over the trunk circuit. Accordingly it will be assumed that a calling subscriber has established connection through the medium of instrumentalities including

a selector switch with the bank contacts 2, 3, and 4 for the purpose of connecting via the trunk circuit with a subscriber in the distant exchange.

Upon the completion of the connection to the bank contacts 2, 3, and 4, the double-wound line relay 15 is energized over a circuit which may be traced as follows: ground at G', lower winding of line relay 15, and conductor 7 bank contact 4, thence by way of the lower selector wiper (not shown), the calling subscriber's loop and the upper selector wiper (also not shown), to the bank contact 2, and thence by way of conductor 5 and the upper winding of line relay 15 to the ungrounded pole of battery B'. On attracting its armature, the line relay 15 completes a circuit for the slow-acting release relay 16 as follows: ground at G', armature 24 and its working contact, and winding of relay 16 to the ungrounded pole of battery B'. Upon energizing, relay 16 prepares a circuit for relay 17 by means of the armature 26; switches the conductors 37 and 38 by means of armatures 28 and 29 from connection with the impulse receiving relay 19 into connection with contacts controlled by the line relay 15; and by means of armature 27 prepares a holding circuit for the selector switch which may be traced in part as follows: ground at G^5, armature 27 and its working contact, and conductor 6 to bank contact 3, whence the circuit extends back to a relay in the selector switch which is maintained energized in the usual manner to prevent the release of the said selector.

As a further result of the energization of relays 15 and 16 a circuit has been completed for the impulse receiving relay 119 in the repeater M^2 at the distant exchange. This is the circuit over which the operating impulses will be transmitted and it extends over the following path: ground at G^{12}, winding 120 of relay 119, armature 128 and its back contact, conductor 137, winding 133 of repeating coil R^2, trunk line conductor 75, winding 33 of repeating coil R', conductor 37, armature 28 and its working contact, armature 23 and its working contact, resistance 26, and battery B^2 to ground at G^6. At the same time a circuit is completed over the lower trunk line conductor 76 which corresponds in every particular to the circuit just described except that it includes the lower winding 121 of relay 119 and that the battery B^2 is omitted. Assuming that the ground potentials at the two exchanges are the same, this latter circuit extending from ground G' in one exchange to ground G^{12} in the other exchange will carry no current and may be for the present neglected.

Upon the completion of the circuit through its winding 120, relay 119 is energized by current flowing over the trunk line conductor 75, and upon attracting its armature, completes an energizing circuit for the slow-acting relay 122 which may be traced as follows: ground at G^{14}, armature 152 and its working contact, and winding of relay 122 to the ungrounded pole of battery B^5. By the attraction of armatures 150 and 151 of relay 122, the conductors 111 and 112 are shifted from connection with bank contacts 102 and 104 into connection with conductors 108 and 110, which latter conductors it will be assumed terminate in the windings of the line relay of a second selector switch.

This selector line relay will now be energized over a loop just completed by relay 119 and which may be traced as follows: conductor 108, armature 153 and its working contact, and winding of impedance coil 118 to conductor 110. On the energization of the selector line relay and the consequent energization of the associated slow-acting release relay, the conductor 109 is grounded in the well known manner, whereby the repeater M^2 is protected against seizure by a first selector switch through the medium of the ground potential on bank contact 103 and its multiples.

The foregoing operations have taken place as the result of the extension of the calling line to the repeater M', which extension may be assumed to have been accomplished by the calling subscriber through the removal of his receiver and the manipulation of his calling device in accordance with the first digit of the desired number. The calling subscriber may now operate his calling device in accordance with the second digit of the desired number thereby resulting in a series of interruptions of the circuit of the line relay 15. Responsive to these interruptions of its circuit the line relay 15 deënergizes a corresponding number of times and at the first deënergization completes a circuit for the slow-acting relay 17 which may be traced as follows: ground at G', armature 24 and its back contact, armature 26 and its working contact and the winding of relay 17 to the ungrounded pole of the battery B^3. Relays 16 and 17, being slow-acting, retain their armatures during a series of impulses, after which relay 17 is deënergized. In its energized condition relay 17 by means of its armatures 30 and 30' opens the bridged windings of repeating coil R' whereby the condensers 31 and 32 are prevented from interfering with the transmission of impulses. It will be clear now that at each deënergization of the line relay 15, the energizing circuit of the impulse receiving relay 119 at the distant exchange will be broken. Relay 119, therefore, vibrates its armature in synchronism with the relay 15 and interrupts at each de-

bridge of said conductors at one end, a connection from the middle point of said relay to ground, connections from the other end of said conductors to ground, and a battery in series with one of said last ground connections.

5. In combination, a relay comprising a continuous winding in one direction grounded at its middle point, line conductors connected at one end, respectively, to opposite ends of said winding, a battery, and means for connecting said line conductors to ground at the other end and for including said battery in series with one of said conductors.

6. In combination, a relay comprising a continuous winding in one direction grounded at its middle point, line conductors connected at one end, respectively, to opposite ends of said winding, a battery having its positive pole grounded, and means for connecting said line conductors at the other end, respectively, to ground and to the ungrounded pole of said battery.

7. In a telephone system, a ground return circuit connecting two exchanges and including a relay in one exchange, means in the other exchange for transmitting current impulses over said circuit to operate said relay, and automatic means for preventing differences in the ground potential at the two exchanges from interfering with the operation of said relay.

8. In a telephone system, a ground return circuit connecting two exchanges and including at one exchange one winding of a double-wound relay, means at the other exchange for transmitting current impulses over said circuit to operate said relay, and an automatic ground return compensating circuit also connecting the two exchanges and including the second winding of said relay, whereby the said relay is not affected by differences in ground potential at the two exchanges.

9. The combination with a relay and a ground return circuit therefor, of means for securing uniform operations of said relay unaffected by varying earth potentials, said means comprising a second ground return circuit for said relay so connected that fluctuations of current in said first circuit due to variations in earth potential are compensated for by corresponding fluctuations of current in said second circuit.

10. The combination with a relay provided with two windings, of separate ground return circuits for said windings, and a battery in one of said circuits, said battery and relay windings being so connected that currents in the circuit containing the battery caused by unequal ground potentials are counter-balanced by corresponding currents in the other circuit.

11. In a telephone system, means for repeating current impulses from one exchange to another, said means comprising a ground return circuit including a battery at one end and one winding of a relay at the other end, and a second ground return circuit including a second winding of said relay, whereby differences in ground potential between the two exchanges which oppose or assist the current from said battery also cause compensating currents to flow in said second circuit.

12. In a telephone system, an impulse transmitting relay and a differential impulse receiving relay, two opposing ground return circuits for the latter relay controlled by the former relay, and a battery in one of said circuits.

13. The combination with a relay having two windings, of separate circuits for said windings having a common conductor, an operating battery in one of said circuits outside the common conductor, and means for producing a series of interruptions in said circuits to operate said relay intermittently.

14. The combination with a relay provided with two windings, of separate circuits for said windings having a common earth return, a battery in one of said circuits only, the other circuit constituting a path for the flow of earth currents unopposed by artificial sources of potential, and means for producing a series of interruptions in said circuits to operate said relay intermittently.

15. The combination with a trunk line connecting two exchanges, of a relay provided with two windings in one exchange, a battery in the other exchange for operating said relay, ground return circuits for the said relay windings including, respectively, one conductor of said trunk line and said battery, and the other conductor of said trunk line exclusive of said battery, and means for producing a series of interruptions in said circuits to operate said relay intermittently.

16. The combination with a relay provided with two windings, of separate ground return circuits for said windings, a battery in one of said circuits, said battery and relay windings being so connected that currents in the circuit containing the battery caused by unequal ground potentials are counter-balanced by corresponding currents in the other circuit, and means for producing a series of interruptions in said circuits to operate said relay intermittently.

17. The combination with a relay having two windings, of separate circuits for said windings having a common conductor, a battery for operating said relay in one of said circuits outside the common conductor, a third circuit under the control of said first relay, and a second relay for producing a series of interruptions in said circuits to

energization the previously described controlling circuit of the selector switch in which the conductors 108 and 110 terminate. In this manner the selector switch is controlled to extend the connection in accordance with the second digit of the called number. It is understood that the slow-acting relay 122 remains energized during the momentary deënergizations of relay 119.

The remaining digits of the desired number may now be called one after the other and are repeated by the relays 15 and 119 to successive switches in the distant exchange in the manner just described until finally the connection is completed to the called subscriber's line. Thereafter the usual instrumentalities are brought into play to effect the signaling of the called subscriber and conversation may then be held over the completed connection in the customary manner. For the sake of clearness the talking conductors of the trunk circuit have been shown in heavy lines.

The foregoing is descriptive of the operation when the ground connections at the respective exchanges are at the same potential. It will now be assumed that due to the effect of street railway currents or other agencies, the ground at G′ and G^6 is at a higher potential than the ground at G^{12}. This difference of potential will be in opposition to the potential of the battery B^2 and the current flow over the trunk line conductor 75 and through the winding 120 of relay 119 will therefore be reduced. Such reduction of current flow in the winding 120 would seriously affect the operation of relay 119 were it not for the provision of the compensating circuit, over which current now flows as follows: ground at G′, resistance 35, armature 25 and its working contact, armature 29 and its working contact, winding 34 of repeating coil R′, trunk line conductor 76, winding 134 of repeating coil R^2, armature 129 and its back contact, and the winding 121 of relay 119 to ground at G^{12}. The direction of current flow in winding 121 is such that it assists the current in winding 120, whence it will be seen that the loss of current in the one winding is compensated for by a current in the other winding.

Assuming now that the potential at ground G^{12} is higher than the potential of ground at the other exchange, this difference in potential will be added to the potential of the battery B^2 and the current in winding 120 of relay 119 will accordingly be increased. But this difference in potential also results in a current in the lower winding 120 of relay 119 via the path previously traced except that now the current flow is in the reverse direction. Currents in the two windings of relay 119 now oppose each other, whence it will be clear that the effect of the increased current in winding 120 is counteracted by the current in winding 121. Relay 119 therefore will operate uniformly without regard to any difference in ground potential which may exist.

It has been already mentioned that the trunk circuit shown is adapted for two way operation. Since the equipment at one end is an exact duplicate of the equipment at the other end it is not thought to be necessary to explain in detail the operations which take place when the call is in the other direction. It may be stated, however, that the bank contacts 102, 103, and 104 may be seized by a selector switch, assuming, of course, that the trunk circuit is idle, after which the line relay 115 is operated in response to interruptions of the calling line to transmit impulses to the impulse receiving relay 19 at the other end of the trunk circuit. Relay 19 in turn operates to control a series of automatic switches over the conductors 8 and 10.

It will be seen from the foregoing that I have devised an exceedingly simple and efficient trunk circuit comprising a ground return impulse transmitting circuit, together with means for automatically compensating for differences in the ground potentials at opposite ends thereof.

While I have shown and described a certain specific embodiment of my invention I consider it probable that modifications may be made in order to adapt the invention for use in other telephone systems, or even for other purposes altogether. I do not, therefore, wish to limit myself to the precise form shown, but desire rather to include and have protected by Letters Patent all forms and modifications of my invention which come within the scope of the appended claims.

What I claim as my invention is:

1. The combination with a relay having two windings, of separate circuits for said windings having a common conductor, and a battery for operating said relay in one of said circuits outside the common conductor.

2. The combination with a relay provided with two windings, of separate circuits for said windings having a common earth return, and a battery in one of said circuits only, the other circuit constituting a path for the flow of earth currents unopposed by artificial sources of potential.

3. The combination with a trunk line connecting two exchanges, of a relay provided with two windings in one exchange, a battery in the other exchange for operating said relay, and ground return circuits for the said relay windings including, respectively, one conductor of said trunk line and said battery, and the other conductor of said trunk line exclusive of said battery.

4. The combination with a two conductor trunk line, of a relay continuously wound in the same direction and connected in

operate said first relay intermittently, whereby corresponding interruptions are produced in said third circuit.

18. The combination with a relay provided with two windings, of separate circuits for said windings having a common earth return, a battery in one of said circuits only, the other circuit constituting a path for the flow of earth currents unopposed by artificial sources of potential, a third circuit under the control of said first relay, and a second relay for producing a series of interruptions in said circuits to operate said first relay intermittently, whereby corresponding interruptions are produced in said third circuit.

19. The combination with a trunk line connecting two exchanges, of a relay provided with two windings in one exchange, a battery in the other exchange for operating said relay, ground return circuits for the said relay windings including, respectively, one conductor of said trunk line and said battery, and the other conductor of said trunk line exclusive of said battery, a third circuit under the control of said first relay, and a second relay for producing a series of interruptions in said circuits to operate said first relay intermittently, whereby corresponding interruptions are produced in said third circuit.

20. The combination with a relay provided with two windings, of separate ground return circuits for said windings, a battery in one of said circuits, said battery and relay windings being so connected that currents in the circuit containing the battery caused by unequal ground potentials are counterbalanced by corresponding currents in the other circuit, a third circuit under the control of said first relay, and a second relay for producing a series of interruptions in said circuits to operate said first relay intermittently, whereby corresponding interruptions are produced in said third circuit.

Signed by me at Chicago, Cook county, State of Illinois, this 4th day of August, 1916.

BERNARD D. WILLIS.