

Nov. 18, 1924.

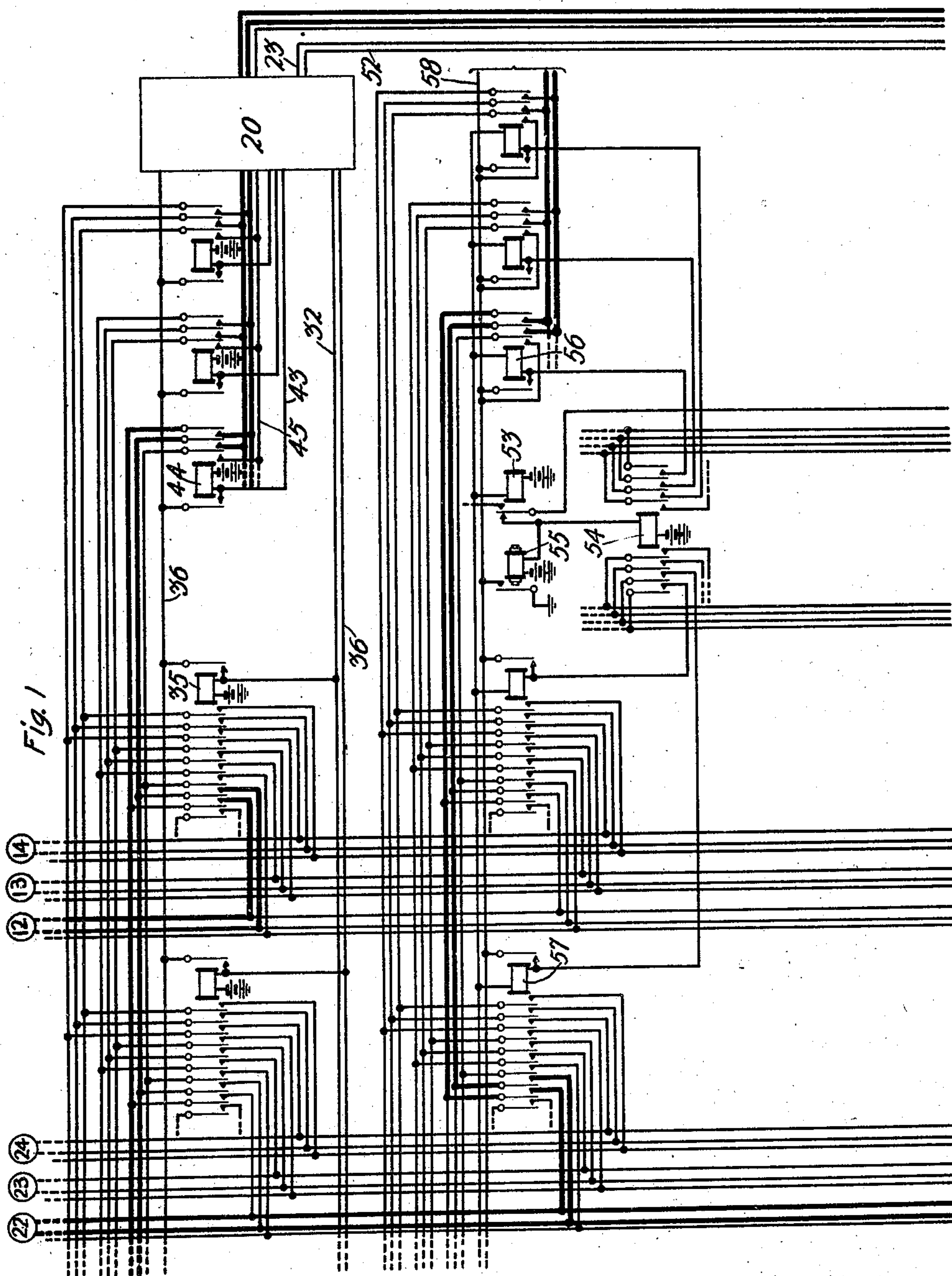
1,515,674

C. L. GOODRUM

TELEPHONE SYSTEM

Filed Dec. 23, 1920

3 Sheets-Sheet 1



Inventor:
Charles L. Goodrum
by E. R. Nowlan Att'y

Nov. 18, 1924.

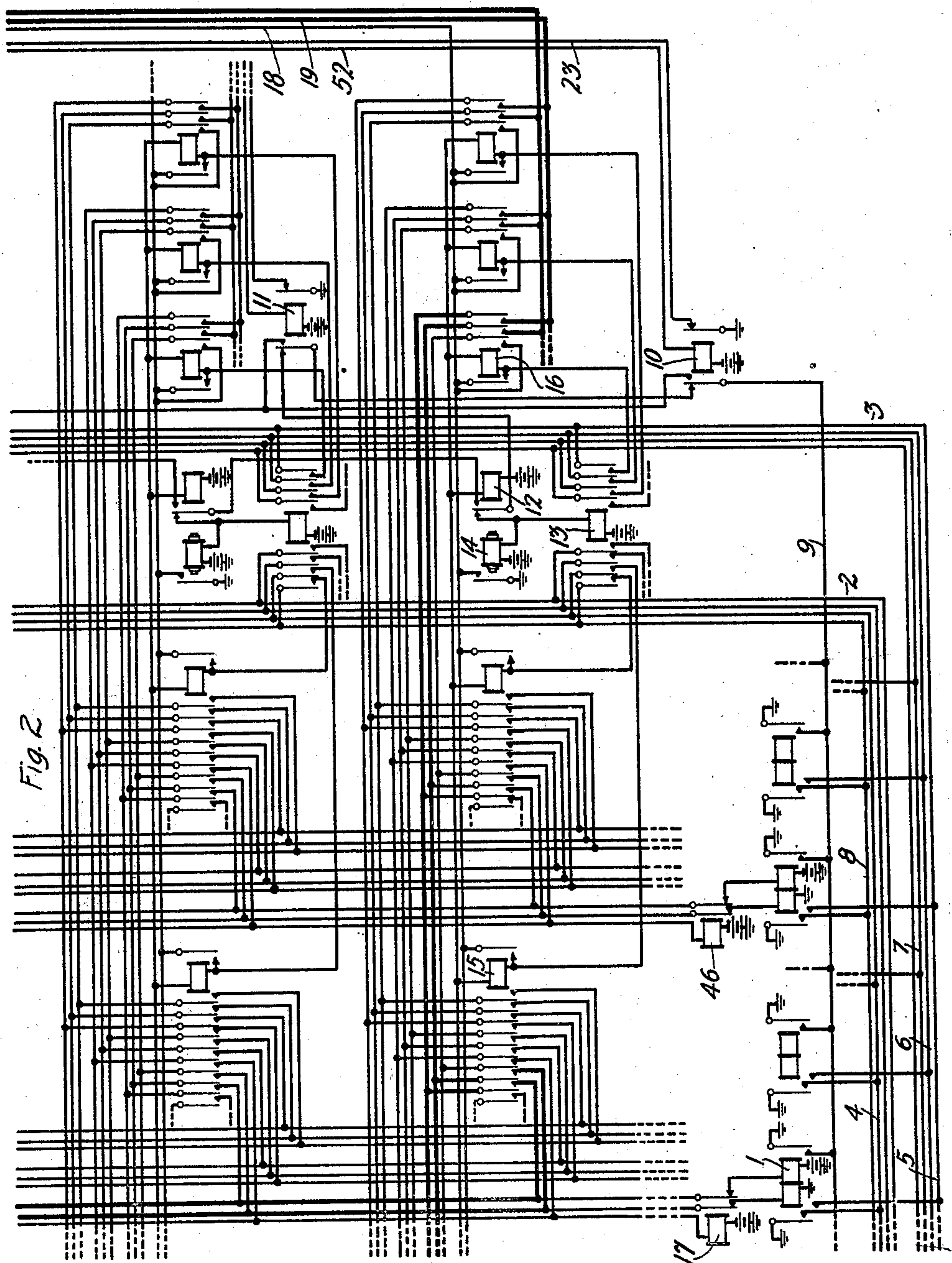
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3 Sheets-Sheet 2



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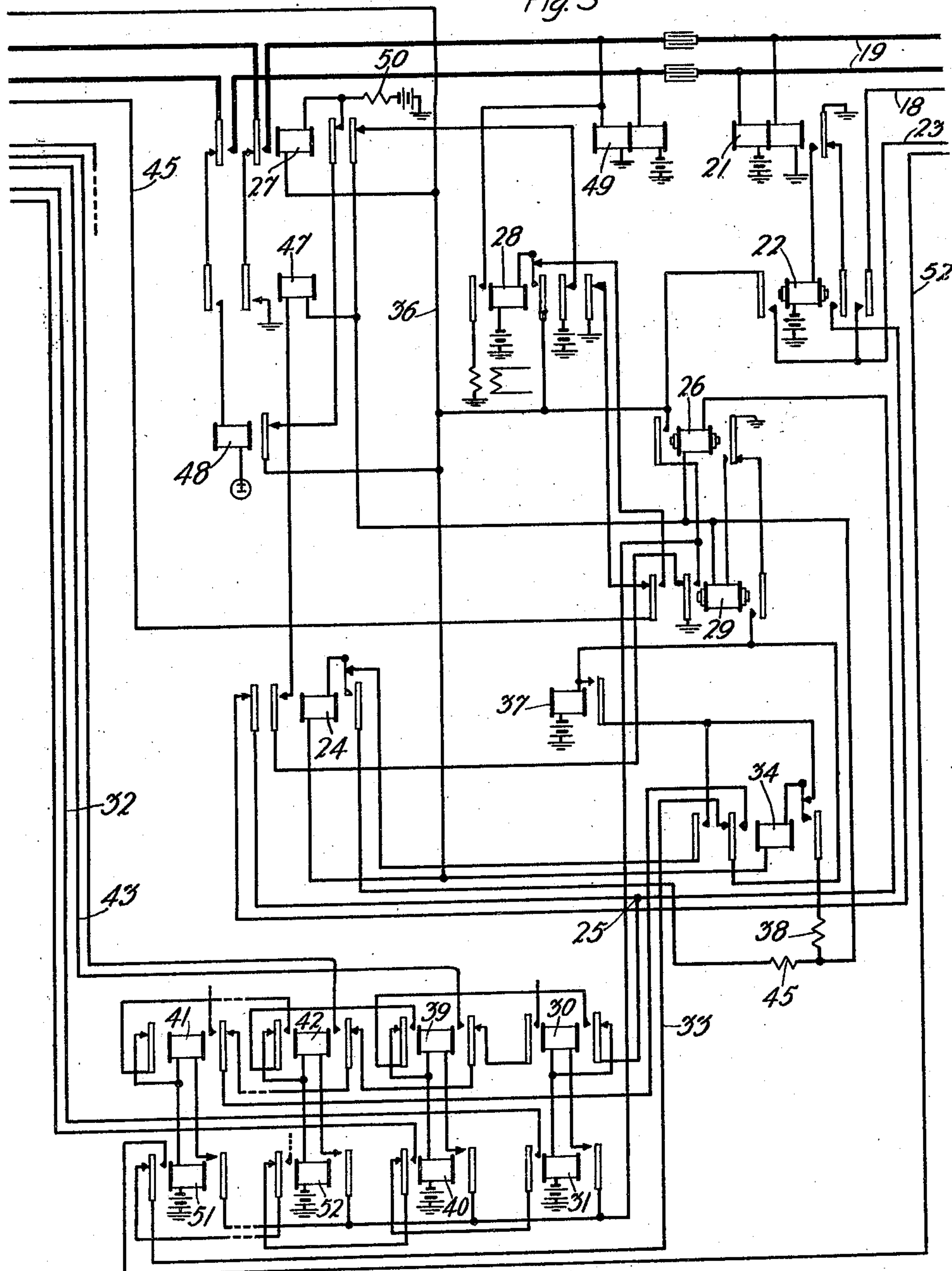
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3 Sheets-Sheet 3

Fig. 3



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UNITED STATES PATENT OFFICE.

CHARLES L. GOODRUM, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TELEPHONE SYSTEM.

Application filed December 23, 1920. Serial No. 432,678.

To all whom it may concern:

Be it known that I, CHARLES L. GOODRUM, a citizen of the United States, residing at New York, in the county of New York, State of New York, have invented certain new and useful Improvements in Telephone Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to improvements in telephone systems and has particular reference to a private branch exchange system.

Heretofore, systems have been designed which employed machine switching means and wherein connections are established between subscribers within the exchange and the central office over trunk or link circuits which are only temporarily employed in establishing connections, and thereafter released for use in completing other calls, the connection to the central office being then accomplished by a direct path from the subscriber's line to the central office trunk.

An object of the present invention is to provide a system of the above nature wherein the release of a trunk or link circuit, which is initially employed to extend a calling line toward the central office, is effected by mechanism common to a number of said circuits and the connection of the calling line to a central office trunk thereafter controlled by mechanism individual to said calling line.

Other objects will appear in the course of the following description when taken in connection with the accompanying drawings wherein Figures 1, 2 and 3, illustrate diagrammatically the system embodying the inventive idea involved.

Briefly stated, the invention comprises the usual line and cut-off relays for each subscriber's line of the system. A calling line is identified by two electrically distinguished circuits, one each in the principal direction of a two-coordinate system. Through these circuits and a common start conductor, connecting devices are operated to join the identified line with an idle link or trunk circuit. To establish a call to another subscriber within the exchange, the calling subscriber manipulates a variably operable impulse sender in response to which two conductors are successively identified, each conductor being in the principal direction of a two-coordinate system. The identi-

fication of these conductors, by the mechanism shown in Figure 3, then results in the selection of the called line and the connection thereof with the link circuit taken for use and the calling line.

When making a call to the central office, the calling subscriber's line is again identified by the line relay and an idle link circuit is again seized over the common start conductor. By transmitting the proper number of impulses over the line circuit from the calling substation, a switching device, common to the link or trunk circuit and the central office trunks is operated to effect the release of the link circuit taken for use and to transfer said start conductor to an idle central office trunk. Upon the operation of the switching device and consequent release of the link circuit, the calling line is again identified by the co-operation of its line and cut-off relays so that the two circuits first mentioned are again electrically distinguished. The common start conductor is now extended, by means of said switching device, to mechanism associated with the first idle central office trunk encountered and this mechanism thereupon operates to connect the calling line directly to the central office trunk.

The release of the connections, in each instance is under the control of the calling subscriber. When the receiver is replaced, release of all the selected mechanism involved in the connection will be practically instantaneous since it involves only the return to normal of mechanism having no movement except that from an actuated to a normal position.

It is believed that the invention will now be fully understood from the following detailed description of the various operations.

In order to facilitate the description of the invention only a few of the incoming lines, and outgoing trunks are shown. Let it be assumed that the subscribers' lines shown in Fig. 1 belong to those groups of lines numbered 20 to 29 inclusive and 10 to 19 inclusive. Six of these lines have been shown, namely, lines 22 to 24 inclusive of the first group and 12 to 14 inclusive of the second group. For the purpose of description, let it be assumed that line 22 of the first group desires a connection to line 12 of the second group.

Upon the initiation of the call on line 22, the line relay 1 individual thereto is energized. Through its left-hand armature, the line relay places a ground potential on two circuits, one each in the principal direction of a two-coordinate system. These circuits are contained in groups, the first group 2 being associated with the tens designation of the calling lines and the second group 3 being associated with the units designation of said lines. Thus, all of the line relays associated with lines 20 to 29 inclusive, upon actuating their armatures, will ground the circuit 4 in group 2. Also, line 22 will ground the circuit 5 in group 3; line 23 will ground the circuit 6 in group 3; line 24 will ground the circuit 7 in group 3 and so on. When calls are initiated in the group 10 to 19 inclusive, all of the line relays individual to the several lines of this group will ground the circuit 8 in group 2 and each line relay will ground a different circuit in the group 3 as just described in connection with the line relays of the group of lines 20 to 29 inclusive. In this manner the calling line is identified by the grounded circuits.

The energization of line relay 1 causes the extension of ground through the right-hand contact thereof over the common start conductor 9, the left-hand normal contacts of relays 10 to 11, the left-hand normal contact of relay 12 and from thence through the windings of relay 13 and slow-to-release relay 14 to grounded battery. Relays 13 and 14 energize and upon the energization of the former relay, the ground on the circuit 4 in group 2 is extended through the left-hand contact of relay 13 corresponding to the circuit 4, the winding of relay 15 and the winding of relay 12 to grounded battery. The circuit 5 of group 3 is likewise grounded through the inner left-hand contact of relay 1, the right-hand contact of relay 13 corresponding to circuit 5 and the winding of relays 16 and 12 to grounded battery. The relays 15 and 16 energize and lock through their left- and right contacts, respectively, to ground at the contact of relay 14. Relay 12 is energized in series with the relays 15 and 16, but before said relay 12 can close its alternate contact, a circuit is established for cut-off relay 17 individual to the calling line, which circuit is traceable from grounded battery, through the winding of relay 17, the corresponding contact of relay 15, the inner-most left-hand contact of relay 16 and the contact of relay 14 to ground. Relay 17 energizes to disconnect the line relay from the calling line and thereby causes the release thereof to disconnect ground from the circuits 4 and 5. Upon the energization of relay 12 the circuit for relays 13 and 14 is opened and relay 13 immediately releases. Relay 14, being slow to release, does not retract

its armature until ground is returned over the third conductor 18 of the link or trunk circuit 19 which has been selected. Relays 15 and 16, therefore, remain locked up and relay 17 energized to ground at relay 14. It is now apparent that the calling line 22 is extended through contacts of relays 15 and 16 to the link or trunk circuit 19.

Associated with each link circuit, as shown in Fig. 1, is a mechanism indicated by a rectangle 20 and shown in detail in Fig. 3. When the talking conductors of line 22 have been extended over the link 19 to the mechanism of Fig. 3, the line relay 21 thereat becomes energized to establish an obvious circuit for the slow-to-release relay 22. Upon the energization of the latter relay ground is extended from the right-hand contact of relay 10 over the conductor 23, the outer right-hand contact of relay 22 to the conductor 18 so that this ground replaces that at the relay 14 which has maintained relays 15, 16 and 17 in an energized condition. The armature of relay 14 is now fully retracted and relays 12, 15, 16 and 17 remain energized. Through its alternate contact, relay 12 extends the common conductor 9 through to relays associated with another link or trunk circuit whereby this circuit will be seized upon the initiation of another call. The connection is now in a stable condition and awaits the operation of the impulse sending device at the calling subscriber's station.

Under the assumption that line 12 is being called, the calling subscriber manipulates his sending device to interrupt the line circuit once and in response to this interruption, relay 21 is momentarily released. Relay 22, however, does not open its contacts and therefore upon the release of relay 1, a circuit is established from ground through the normal contact of relay 21, the inner right-hand contact of relay 22, the left-hand normal contact of relay 24 to the junction point 25 and from thence in one direction through the winding of slow-to-release relay 26, the outer right-hand contact of relay 27 and the middle right-hand normal contact of relay 28 to grounded battery. Relay 26 energizes and in so doing establishes an energizing circuit from ground through its right-hand alternate contact, winding of slow-to-release relay 29 and from thence over the energizing circuit of relay 26. The ground at the junction point 25 is also extended through the right-hand normal contact of upper or units counting relay 30 and the winding of the lower or tens counting relay 31 to grounded battery. The latter relay energizes in this circuit and through its right-hand contact closes a circuit for the upper counting relay 30 extending to ground at the inner

left-hand alternate contact of relay 29. Relay 30, is shunted by the ground extending from the junction point 25 to the other terminal of said relay. When relay 21 energizes at the termination of the single interruption of the line circuit, the shunt around the relay 30 is removed and said relay becomes energized in series with the relay 31. Since there has been only one interruption of the line circuit only the counting relays 30 and 31 will therefore be energized and the conductor 32, which is one of the conductors in the two groups of conductors, each in the principal direction of a two coordinate system, is now connected through the left-hand alternate contact of relay 31, the left-hand normal contacts of all the other lower counting relays to the conductor 33 leading to the left-hand normal contact of relay 34. The opening of the normal contact of relay 21 opens the energizing circuit for relay 26 which, after an interval releases to effect the deenergization of relay 29. Upon the closure of the normal contact of relay 26, but before relay 29 has opened its alternate contacts, a circuit is established from ground through the normal contact of relay 26, the right-hand contact of relay 29, the left-hand normal contact of relay 34, the conductor 33 and from thence through the left-hand contacts of the lower counting relays to the conductor 32. The ground on this conductor is extended to relay 35 (Fig. 1), the other terminal of said relay being connected to battery. This relay now energizes and locks through its right-hand contact to the conductor 36 which is grounded through the left-hand contact of relay 22 to the conductor 23 upon the initial energization of relay 22.

The ground which is extended through the right-hand normal contact of relay 26 and the right-hand alternate contact of relay 29 also effects the energization of relay 37 which, in closing its contact, extends said ground to one terminal of the relay 34. The other terminal of relay 34 is also connected to the grounded conductor 36 and therefore relay 34 does not energize at this time. Upon the opening of the right-hand contact of relay 29, the ground connected to the first mentioned terminal of relay 34 is removed and thereupon relay 34 energizes in series with relay 37, the latter relay being momentarily held energized in this circuit. Upon the closure of the right-hand alternate contact of relay 34 and the opening of the right-hand normal contact thereof, relay 37 releases and relay 34 locks through said right-hand contact, the resistance 38, the outer right-hand contact of relay 27 and the middle right-hand normal contact of relay 28 to grounded battery. The release of relay 29 also removes ground

from the inner left-hand alternate contact thereof and thereupon counting relays 30 and 31 restore.

The mechanism is now in condition to receive the series of impulses corresponding to the units digit of the called line. In the case assumed this units digit is 2 and upon the first interruption of the line circuit and consequent deenergization of relay 21, circuits are established for relays 26 and 29 and the counting relays 30 and 31 as previously described. The energization of counting relay 30 transfers the conductor extending to the junction point 25 through its right-hand alternate contact, the left-hand normal contact of the upper units counting relay 39 to grounded battery through the winding of the lower or tens counting relay 40. Therefore, upon the second interruption of the line circuit in response to the second impulse transmitted and the second closure of the normal contact of relay 21, the ground thereon is extended to the counting relay 40 which thereupon energizes to prepare an energizing circuit for counting relay 39, which is initially shunted and then energized in the same manner as described in connection with the other counting relays. Following the energization of relay 21 at the termination of the second impulse, relay 26 releases as previously set forth and a circuit is then established extending from ground through the normal contact of relay 26, the right-hand contact of relay 29, the inner left-hand alternate contact of relay 34, which has been previously locked, the right-hand normal contacts of upper counting relays 41 and 42, the right-hand alternate contact of counting relay 39, the conductor 43 and the winding of relay 44 (Fig. 1) to grounded battery. The latter relay energizes and locks through its left-hand contact to ground at the conductor 36. The conductor 43 is the second of the two conductors in the two groups of conductors, each in the principal direction of a two coordinate system. The ground extended from the right-hand normal contact of relay 26 also again causes the energization of relay 37 to extend said ground through the outer left-hand alternate contact of relay 34 to one terminal of the relay 24, the other terminal of which is connected to the conductor 36 to thereby shunt the latter relay. After the release of relay 29, the ground is removed from the first mentioned terminal of relay 24, whereupon this relay operates in series with the relay 37 which is momentarily held energized through the right-hand normal contact of relay 24. Upon the closure of the right-hand alternate contact of relay 24, relay 37 releases and relay 24 locks in a circuit extending from ground on the conductor 36, through the winding and right-hand alternate contact

of relay 24, the resistance 45, the outer right-hand contact of relay 27 and the middle right-hand normal contact of relay 28 to grounded battery. The release of relay 29 disconnects the holding ground from the energized counting relays, whereupon these relays restore to normal. Relays 35 and 44 are now energized and locked and the subscriber's lines are ready for connection through contacts of relay 27. Although the effect of the complete release of relay 29 is here described, it is to be noted that before this takes place, a test of the called line is made.

If the line is busy, this condition is denoted by ground on the third conductor of said line which will be extended through a corresponding contact of relay 35, the inner right-hand contact of relay 44, the conductor 45, the outer left-hand alternate contact of relay 29, which is still energized, the inner normal right-hand contact and winding of relay 28 to ground and battery. Relay 28 energizes and locks through its right-hand alternate contact to the conductor 36; and removes the battery from the middle right-hand normal contact to effect the release of relay 34 and prevent relay 24 from energizing as above described. The closing of the left-hand contact of relay 28 connects a source of busy tone to one winding of the called subscriber's battery feed coil 49 from whence, by induction, the busy tone is transmitted to the calling subscriber.

Upon the replacing of the receiver upon its switchhook at the calling substation in response to this busy tone, relay 21 releases to open the energizing circuit for relay 22 which, after an interval, opens its contacts. The ground on conductor 23 is thereupon disconnected from the conductor 36 to cause the release of relays 28, 35 and 44 which have been previously locked to this conductor. The deenergization of relay 22 also disconnects ground on conductor 23 from the conductor 18, whereupon relays 12, 15, 16 and 17 release. The circuit is now in its normal condition.

Assuming that the called line is idle, no ground will be found upon the conductor 45 to energize relay 28. Therefore, when relay 29 is fully released, ground is extended from the outer right-hand normal contact of relay 29, the conductor 45, the inner right-hand contact of relay 44, a contact of relay 35, and the winding of cut-off relay 46 of the called subscriber's line to grounded battery. The energization of relay 46 in this circuit places a busy potential on the called subscriber's line in a manner well known in the art and prevents seizure thereof by any other line. At the same time the ground is extended from the inner left-hand normal contact of relay 29 through the left-hand alternate contact of relay 24 which became

energized when relay 28 failed to operate, the winding of relay 47, the outer right-hand contact of relay 27 and the middle right-hand normal contact of relay 28 to grounded battery. Relay 47 energizes to connect ringing current through the winding of relay 48 and normal left-hand contacts of relay 27 to the called subscriber's line. While the ringing current is being applied to the called subscriber's line, sufficient current does not flow through the winding of relay 48 to energize the same, but upon the removal of the receiver from its switchhook at the called substation, this current is increased and relay 48 thereupon operates. It will be noted that prior to the energization of relay 48, relay 27 is shunted by current from the conductor 36 connected to both of the terminals of the winding of said relay but, upon the operation of relay 48, this current is removed from one of the terminals of relay 27 which thereupon operates over a circuit traceable from grounded battery through the resistance 50 and the winding of relay 27 to ground on the conductor 36. The operation of relay 27 disconnects battery from one terminal of the relay 47 which thereupon releases. This disconnection of battery at the middle right-hand contact of relay 28 from the outer right-hand contact of relay 27 also opens the locking circuit for relays 24 and 34 which thereupon release. The energization of relay 27 extends the link or trunk circuit 19 through the left-hand alternate contacts of said relays to the called subscriber's line and conversation may now proceed between the subscribers.

The circuit is now in the same condition as existed just prior to the description of the release when the calling subscriber replaces his receiver upon hearing the busy tone, with the exception that relay 27 is energized instead of relay 28 and cut-off relay 46 is also energized.

At the termination of the conversation, the calling subscriber by replacing his receiver upon its switchhook, effects the release of the relays as previously described in addition to relays 27 and 46 as will be understood by reference to the previous description.

Should the subscriber at substation 22 desire a connection to central office, the removal of the receiver from its switchhook energizes the line relay 1 which initiates the same operation as previously described to extend the subscriber's line through contacts of relays 15 and 16 to the trunk or link circuit 19 extending to the mechanism shown in Figure 3. It will be recalled that upon the energization of relay 14, a circuit is established for the cut-off relay 17 which disconnects the line relay 1 from the subscriber's loop so that this relay releases to remove

ground from the conductor 4, 5 and 9. The seizure of the mechanism 20 causes the energization of relays 21 and 22 so that ground from the right-hand normal contact of relay 10 is extended over the conductor 18 to hold relays 12, 15, 16 and 17 energized.

In order to secure a connection to a central office trunk, it is necessary for the calling subscriber to dial the digit 0 to transmit ten impulses to the mechanism of Figure 3. In response to these impulses, relay 21 vibrates its armature and upon each successive closure of the normal contact of said relay, a pair of the counting relays is energized. In response to the tenth impulse transmitted, counting relays 51 and 41 are energized and upon the closure of the left-hand alternate contact of relay 51, a circuit is established for the transfer relay 10 from grounded battery through the winding of said relay, the conductor 52, the left-hand alternate contact of counting relay 51, the left-hand normal contact of relay 34, the right-hand contact of relay 29 and the right-hand normal contact of relay 26 to ground, it being understood that relays 26 and 29 function in the same manner as previously described. The energization of relay 10 first removes ground from the right-hand contact thereof and in so doing causes the release of relays 12, 15, 16 and 17 which, at this time, are being held up by ground on conductor 18 which is joined to the conductor 23 through the outer right-hand contact of relay 22. The release of cut-off relay 17 again connects the line relay 1 to the subscriber's loop and this latter relay again operates to again identify the calling line and connect ground to the conductor 9 which is now extended through the left-hand alternate contact of relay 10 to relay mechanism associated with the first idle trunk leading to the central office. For purposes of convenience, only one central office trunk is shown in Figure 1 and assuming that this trunk is idle, the ground on conductor 9 is extended through the normal contact of relay 53 and the windings of relays 54 and 55 to grounded battery to energize these relays. The operation of relay 54 establishes a circuit extending from grounded battery through the winding of relay 53, the winding of relay 56, the outermost right-hand contact of relay 54 and from thence over conductor 5 to ground through the inner left-hand contact of line relay 1. Another circuit is established in series with the relay 53 through the winding of relay 57, the next to the outermost left-hand contact of relay 54, the conductor 4 and the outer left-hand contact of relay 1 to ground. Relays 53, 56 and 57 energize and lock temporarily to ground at the contact of relay 55. The energization of relay 53 opens the circuits for relays 54 and 55 but relay 55 does not

release until ground is returned over the third conductor 58 of the central office trunk. When relays 56 and 57 energize, a circuit is again established for cut-off relay 17 extending through corresponding contacts of relays 57 and 56 to ground at the contact of relay 55. The energization of relay 17 again disconnects the line relay 1 from the subscriber's loop to remove ground from the conductors 4, 5 and 9.

The foregoing operation takes place before relay 29 (Figure 3) has opened its right-hand contact through which relay 10 is maintained energized. Inasmuch as the operation of the relay mechanism associated with the central office trunk has now been effected, it is no longer necessary to maintain the transfer relay 10 energized and therefore upon the release of relay 29, the circuit for said relay 10 is opened and this relay is thereupon released and the mechanism associated with the trunk or link circuit 19 is again in its normal condition. The energization of relays 56 and 57 extends the calling subscriber's line through contacts of said relays to the talking conductors of the central office trunk circuit and immediately upon said extension of the line, relays at the central office, well known in the art, are operated to ground the third conductor 58 so that upon the release of relay 55 after an interval, the locking ground at the contact thereof, for relays 56, 57 and 17 is transferred to the conductor 58. It will thus be seen from the foregoing description that in establishing a connection from a subscriber to central office, the relays 1 and 17 are first employed to temporarily utilize the trunk or link circuit 19 and then to effect the completion of a direct connection from the calling line to the central office trunk. It is believed that the release of this connection will be fully understood from the foregoing description.

What is claimed is:

1. In a telephone system, a subscriber's line, a line relay therefor, a link circuit, a trunk, means controlled by said line relay for connecting said line to said link circuit, a subscriber controlled switching device for disabling said connection, and means thereupon controlled by said line relay for connecting said line to said trunk.

2. In a telephone system, a subscriber's line, a line relay therefor, a link circuit, a trunk, means controlled by said line relay for connecting said line to said link circuit, a subscriber controlled switching device for disabling said connection, and means thereupon controlled by said line relay through said switching device for connecting said line to said trunk.

3. In a telephone system, a subscriber's line, a link circuit, a trunk circuit, switching devices having permanently paired pri-

mary and secondary contacts for extending
said line to said circuits, a line relay and a
cut-off relay individual to said line, means
under control of said line relay for actuating
5 one of said devices to extend said line to
said link circuit, means responsive to said
extension of said line for operating said
cut-off relay to cut off said line relay means
associated with said link circuit for discon-
10 necting said link circuit from said line and
causing the deenergization of said cut-off re-
lay and means under control of said line
relay and said last means for actuating
another of said devices to extend said line to
15 said trunk circuit.

4. In a telephone system, a subscriber's
line, a link circuit, a trunk circuit, switch-
ing devices having permanently paired pri-
mary and secondary contacts for extending

said line to said circuits, a line relay and a 20
cut-off relay individual to said line, a starter
wire circuit under control of said line relay
for actuating one of said devices to extend
said line to said link circuit, means respon- 25
sive to said extension of said line for op-
erating said cut-off relay to cut off said line
relay, a relay associated with said link cir-
cuit for disconnecting said link circuit from
said line and causing the deenergization of
said cut-off relay, and a second starter wire 30
circuit under control of said line relay and
said last relay for actuating another of
said devices to extend said line to said trunk
circuit.

In witness whereof, I hereunto subscribe 35
my name this 20th day of December A. D.
1920.

CHARLES L. GOODRUM.