R. S. BAILEY.

TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED MAR. 22, 1921.

1,434,518

Patented Nov. 7, 1922.

2 SHEETS—SHEET 1.

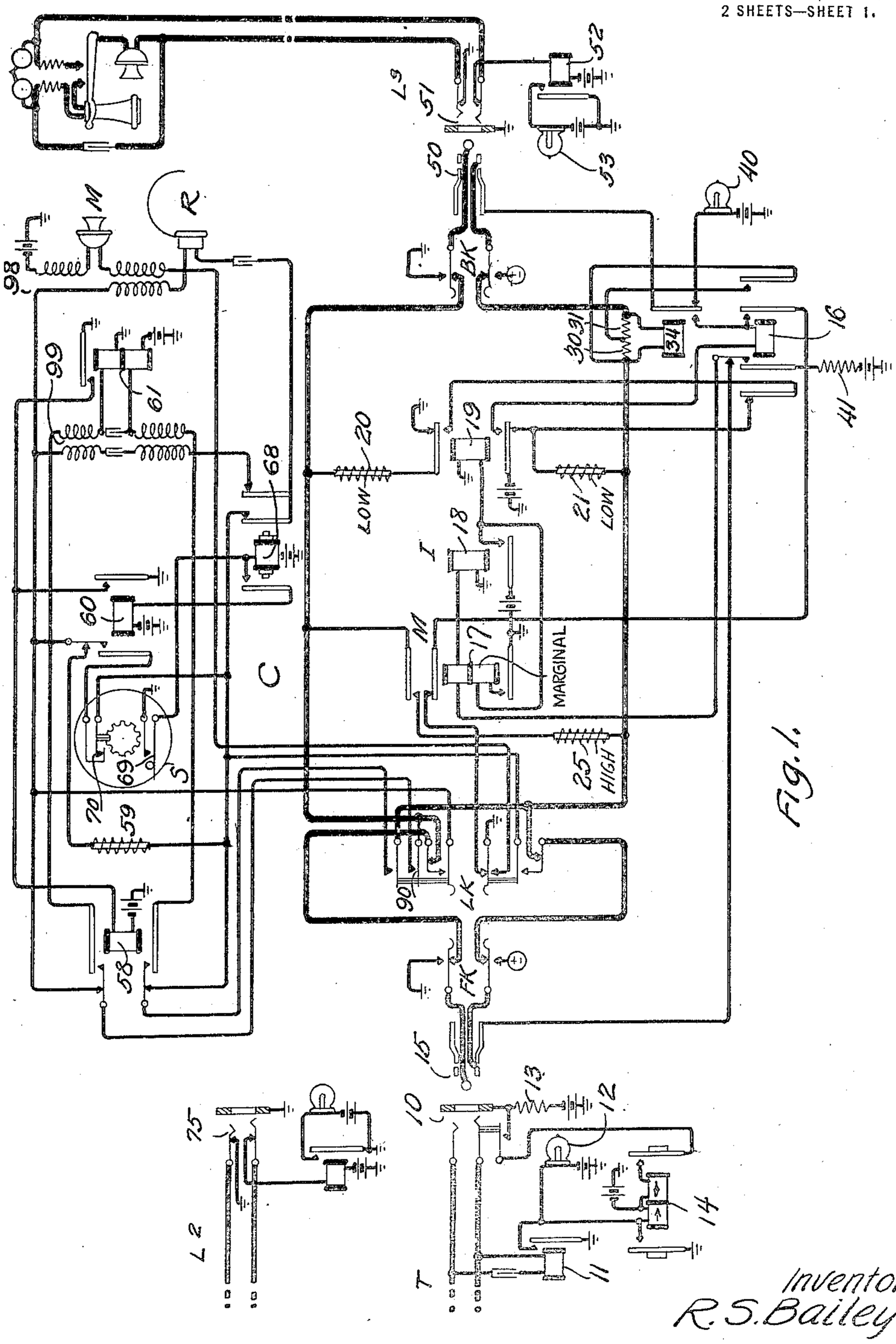

Fig. 1.

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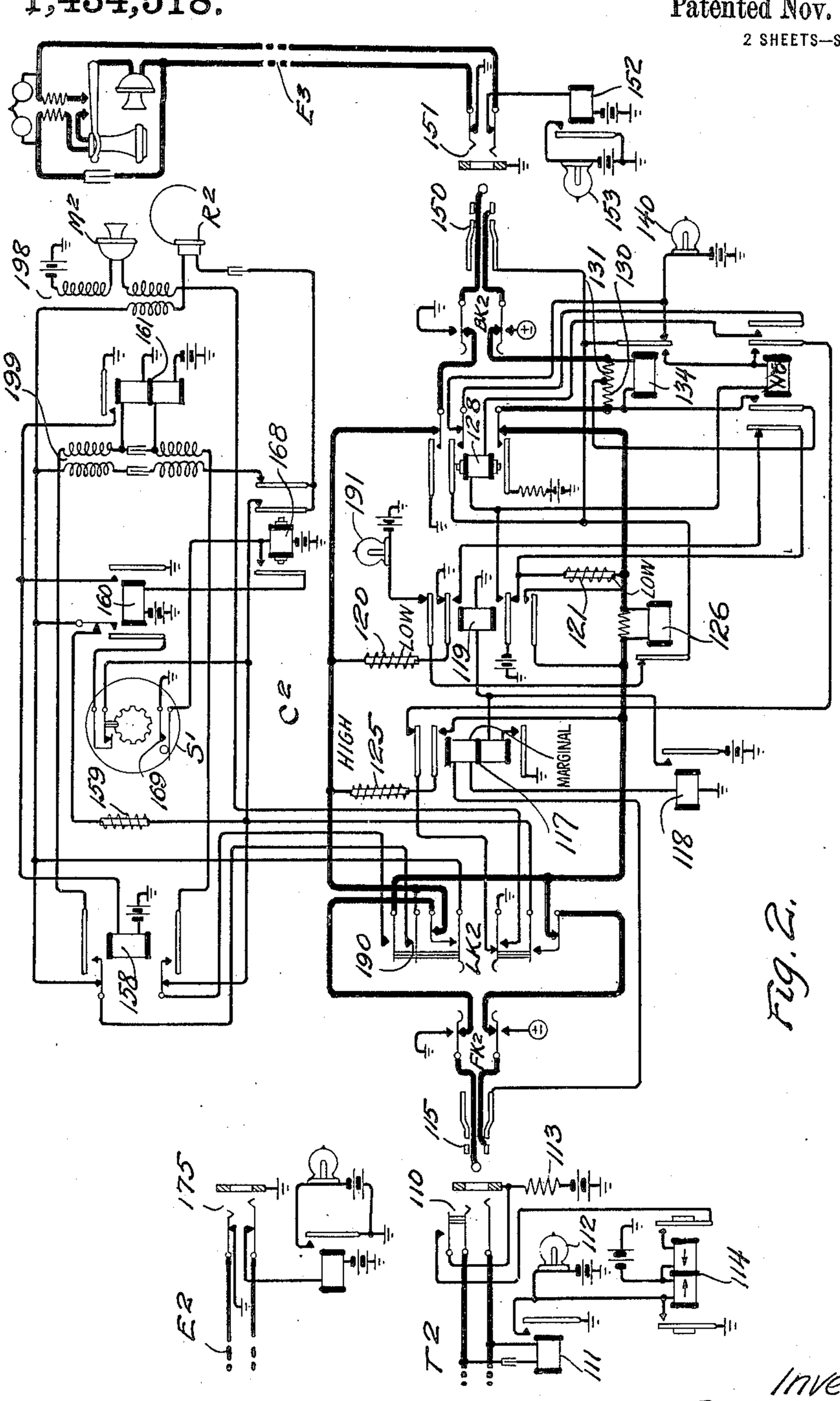

Fig. 2.

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Patented Nov. 7, 1922. 1,434,518

UNITED STATES PATENT OFFICE.

RAND S. BAILEY, OF MONTCLAIR, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

TELEPHONE-EXCHANGE SYSTEM.

Application filed March 22, 1921. Serial No. 454,594.

To all whom it may concern:

Be it known that I, RAND S. BAILEY, residing at Montclair, in the county of Essex and State of New Jersey, have invented certain Improvements in Telephone-Exchange Systems, of which the following is a specification.

This invention relates to telephone exchange systems and more particularly to circuit arrangements for use at a private branch exchange when such an exchange is used in connection with a main central office, which central office may be either of the manual or machine switching type.

An object of the invention is to provide an improved cord circuit for use at a private branch exchange to interconnect subscribers of the private branch exchange and to connect subscribers of the private branch exchange with trunk lines leading to the main central office, wherein through supervision is provided on outgoing calls over the trunk line and non-through supervision is provided on incoming calls over the trunk line.

A feature of the invention consists in automatically converting the cord circuit from one class of supervision to the other by means of apparatus in the cord circuit cooperating with apparatus in the connected trunk circuit.

For a more complete understanding of the invention reference may be had to the accompanying drawings in which Figure 1 illustrates one embodiment of the invention applied to a cord circuit C arranged for single supervision when it is employed for interconnecting lines of the private branch exchange, such as L^3 and L^2, and in which Fig. 2 illustrates another embodiment of the invention applied to a cord circuit C^2 arranged, for double supervision when it is employed for interconnecting extension lines of the private branch exchange, such as E^3 and E^2, and arranged to split the cord circuit and to provide a recall signal when a second call is received over a trunk line T^2 before the operator disconnects.

Referring to Fig. 1 of the drawings and assuming that a subscriber at the main central office desires to be connected to a subscriber at one of the extensions, as, for example, the extension L^3 of the private branch exchange, ringing current will be transmitted over the trunk line T from the main central office, thereby energizing the relay 11 and completing an obvious circuit for the trunk signal 12 and for the relay 14. Relay 14, in energizing, locks up through its left-hand winding, thereby completing an obvious circuit for maintaining the trunk signal 12 actuated. The operator at the private branch exchange, upon observing the trunk signal 12, may insert a plug 15 into the jack 10, whereupon a circuit is completed as follows: ground, winding of relay 18, upper winding of relay 17, inner left-hand normal contacts of relay 16, sleeves of plug 15 and a jack 10 and thence in parallel, one path extending through resistance 13 to grounded battery and the other path extending through the right-hand contacts and winding of relay 14 to grounded battery. Relay 14, is slow-to-operate and slow-to-release and has its windings differentially wound. The flow of current through both windings of the differentially wound relay 14 causes relay 14 to release. Due to the momentary lowered resistance of the sleeve circuit by reason of the path through the right-hand winding of the differential relay 14, when the plug 15 is inserted into jack 10, sufficient current passes through the upper winding of relay 17, which is of the marginal type, to energize said relay 17. As soon as relay 14 releases, the resistance of the sleeve circuit is increased but relay 17 will have operated by this time, and, in operating, locks up over a path extending from ground, lower armature and front contact and lower winding of relay 17, front contact and armature of relay 18 to grounded battery. Relay 17, in operating, also bridges the high impedance coil 25 across the cord circuit. Relay 18, in operating, completes a circuit through its armature and front contact for relay 19. Normally battery is supplied to the tip and ring conductors of the cord circuit C over the upper and lower back contacts of relay 19 and through the windings of the low impedance coils 20 and 21. When the relay 19 is energized, however, the battery supply connections are opened and the tip and ring conductors leading to the plug 15 are connected together through the coils 20 and 21 by a connection extending through the upper alternate contacts of relay 19 and outer left-hand normal contacts of relay 16. A low impedance bridge is thus established across the cord circuit for tripping the machine ringing apparatus at the

main central office, in the manner well known in the art.

The operator may now actuate the key LK in order to connect her set with the cord circuit. When the key LK is in normal condition, the tip conductors of the front and back cords are connected by a path extending from the tip contact of the plug 15, over the upper normal contacts of keys FK, LK and BK to the tip contact of the plug 50. In a similar manner a path extends from the ring contact of the plug 15, lower normal contacts of key FK, lowermost normal contacts of key LK, winding of supervisory relay 34 and the serially connected non-inductive resistances 30 and 31 in parallel, lower normal contacts of key BK to the ring contact of plug 50. When the key LK is actuated, however, the circuit above described is changed so that the tip conductors of the front and back cords are connected over a path extending through the upper innermost contacts of key LK, upper normal contacts of relay 58, and thence through contacts 90 of key LK. Ring connections on the other hand extend through the lowermost alternate contacts of key LK, lower normal contacts of relay 58, and uppermost contacts of key LK. The operator's talking and listening set comprising a transmitter M and a receiver R respectively, and the associated induction coil 98 and repeating coil 99 are bridged across the circuit so that the operator is enabled to converse with the calling subscriber or operator at the distant central office to determine what extension is desired.

The operator, upon obtaining this information and ascertaining that a connection to the extension L^3 is desired, restores the listening key LK to normal and inserts the plug 50 into the jack 51, thereby closing a circuit from ground over the sleeve contacts of the jack 51 and plug 50, armature and back contact of relay 34, and through the supervisory lamp 40 to grounded battery. The lamp 40 is now caused to glow. The operator may then actuate the ringing key BK to transmit ringing current to the desired subscriber.

Upon the response of the called subscriber at the station associated with the extension L^3, current from the main central office flows through the station of the extension L^3 causing the cord circuit supervisory relay 34 to operate and the low impedance bridge to be removed from the cord circuit. This circuit may be traced as follows: from the grounded side of the battery (not shown) at the main central office, over the tip conductor of the trunk line T, tip contacts of jack 10 and plug 15, upper normal contacts of keys FK, LK and BK, tip contacts of plug 50 and jack 51, through the called station loop, ring contacts of jack 51 and plug 50, lower normal contacts of key BK, winding of supervisory relay 34 and the serially connected resistances 31 and 30, in parallel, lowermost normal contacts of key LK, lower normal contacts of key FK, ring contacts of plug 15 and jack 10, and thence over the ring conductor of the trunk line T to battery (not shown) at the main central office. It will be noted that until the called subscriber responds the high and low impedance bridges are both connected across the cord circuit. As soon as the called station responds, however, the low impedance bridge is removed in a manner hereafter described. As is well known the circuit over the trunk line T, if said line leads to a manual office, may include a supervisory relay in a cord circuit (not shown) at the main central office. In case the main central office is of the machine switching type, a relay (not shown) corresponding somewhat in function to the supervisory relay will be included in the machine switching circuit. While the supervisory relay 34, which is energized over the circuit just traced is controlled by the called subscriber, the supervisory relay at the main central office is controlled by the operator so that non-through supervision exists on incoming calls over the trunk line.

The supervisory relay 34, upon being energized, opens the circuit of lamp 40 and completes a circuit for relay 16 over a path extending from grounded battery, lower alternate contacts of relay 19, winding of relay 16, front contact and armature of relay 34, and sleeve contacts of plug 50 and jack 51 to ground. Relay 16, in attracting its outer right-hand armature, short circuits the non-inductive resistance 30, shunted about the supervisory relay 34; in attracting its outer left-hand armature opens the low impedance bridge through the windings of impedance coils 20 and 21; and in attracting its inner left-hand armature substitutes a connection to battery in place of the connection to battery through the sleeve circuit for the purpose of maintaining relay 18 energized. By the opening of the bridge of the low impedance coils 20 and 21, the shunt effect of the battery supply from the main central office of the subscriber's instrument of the extension is obviated and a better transmission circuit is provided.

When the subscriber at the extension L^3 hangs up his receiver, the circuit for relay 34, previously traced, is opened, and, consequently the supervisory relay 34 is deenergized. Relay 34, in retracting its armature, opens the circuit for relay 16, which relay thereupon deenergizes and closes at its outer left-hand contacts the low impedance bridge of the cord circuit. At the inner left-hand contacts of relay 16, the original energizing circuit for relay 18 is again closed. The

relay 34, upon deenergization, also completes a circuit from ground, through the sleeve contacts of jack 51 and plug 50, armature and back contact of relay 34, and through the supervisory lamp 40 to grounded battery, causing said lamp to glow to inform the private branch exchange operator that the connection may be taken down. Due to the maintenance of the high impedance bridge across the cord circuit, the machine switching apparatus at the main central office is prevented from releasing. If, on the other hand, the main central office at which the trunk line T terminates is a manual office, a supervisory relay in the cord circuit at the main central office will be prevented from releasing as well.

The operator at the private branch exchange noting the lighting of lamp 40 may remove plugs 15 and 50 from their respective jacks, thereby removing the bridge from the trunk circuit T and causing the release of the switches at the main central office or the deenergization of the supervisory relay thereat, depending on whether the main central office is of the machine switching or manual type, in the manner well known in the art.

Should a subscriber at an extension line, such as L^3, desire to be connected to a subscriber at the main central office, the operation is as follows: when the subscriber removes his receiver from the switch hook, the line relay 52 is energized to close the circuit of the line lamp 53. The operator in response to the lighting of the line lamp may insert the plug 50 of the cord circuit C into the jack 51, thereby disconnecting the line relay 52 and extinguishing the line lamp 53. As the relay 19 is not now energized, the battery supply may be traced from grounded battery, through the lower normal contacts of relay 19, impedance coil 21, through the winding of supervisory relay 34 and the serially connected resistances 30 and 31, in parallel, lower normal contacts of key BK, ring contacts of plug 50 and jack 51, through the calling substation loop, tip contacts of jack 51 and plug 50, upper normal contacts of key BK, impedance coil 20, and upper normal contacts of relay 19 to ground. The supervisory relay 34 is energized over the circuit just traced and opens the circuit of the supervisory lamp 40, which would otherwise be closed over the sleeve contacts of plug 50 and jack 51.

The operator may now actuate the listening key LK, thereby connecting her set to the cord circuit, in the manner already described, so that she is enabled to converse with the calling subscriber. Upon ascertaining that the subscriber desires a connection through the main central office, the operator may restore her key LK to normal and then insert the plug 15 into the jack 10. A circuit is now completed from grounded battery, through resistance 13, sleeve contacts of jack 10 and plug 15, through the inner left-hand normal contacts of relay 16, upper winding of relay 17, and winding of relay 18 to ground. Relay 17, being of the marginal type, does not operate at this time. Relay 18 operates, however, and completes a circuit, previously traced, for relay 19. Relay 19, in operating, disconnects the battery supply through the impedance coils 20 and 21 so that the battery supply for the calling subscriber's station will now be supplied directly from the main central office. Relay 19, in operating, also completes a circuit for the energization of relay 16 over a path extending from grounded battery, lower alternate contacts of relay 19, winding of relay 16, front contact and armature of relay 34, sleeve contacts of plug 50 and jack 51 to ground. Relay 16, in operating, now locks up over a path extending from grounded battery, lower alternate contacts of relay 19, winding front contact and inner right-hand armature of relay 16, upper inner armature and back contact of relay 17, and inner lower contacts of key LK to ground (provided key LK is in normal position).

Further action upon the part of the private branch exchange operator will now depend on whether or not the main central office is a manual office or an automatic office. In case the main central office is a manual office, the line relay (not shown) associated with the trunk line T at the main central office will be energized as soon as the plug 15 is inserted into the jack 10 by means of the circuit, already traced, including the station of the extension line L^3, if the listening key LK is in normal condition. If the key LK is operated, however, as would normally be the case under the conditions being described, a circuit for said line relay would be completed as follows: from battery (not shown), through said line relay (not shown), over the ring conductor of the line T, ring contacts of jack 10 and plug 15, lower normal contacts of key FK, lowermost alternate contacts of key LK, impedance coil 59, normal contacts of relay 60, upper innermost alternate contacts of key LK, upper normal contacts of key FK, tip contacts of plug 15 and jack 10, and thence over the tip conductor of the trunk line T to ground (not shown) at the main central office. The operator at the distant central office being apprised through the line lamp (not shown) that a call has come in may answer in the usual manner, and the private branch exchange operator through her telephone set, which is connected to the cord circuit C over the contacts of the key LK, is able to converse with the operator at the main central office and inform the op-

erator, of the number desired, so that the operator at the main central office may complete the connection. The private branch exchange operator may then restore the listening key LK to normal so that the talking circuit will be the same as previously traced for a call incoming from the main central office.

In case the main central office is of the machine switching type, the operator at the private branch exchange, after having inserted the plug 15 into the jack 10, and after having actuated the listening key LK, may then actuate the impulse sender S, a number of times corresponding to the number desired at the main central office, for the purpose of setting the machine switching apparatus thereat. Upon the initial movement of the impulse sender or dial S, off normal contacts 69 thereof are closed, thereby completing an obvious circuit for slow-to-release relay 68, which in turn completes an obvious circuit for relay 60. Relay 60, in attracting its right-hand armature, completes an obvious circuit for relay 58, which relay, in operating, opens the conductive connection, which had previously existed between the front and back conductors of the cord, through the operator's set. Battery supply is now furnished to the extension L^3 through the windings of relay 61 over a path which may be traced as follows: from grounded battery, through the lower winding of relay 61, lower right-hand winding of repeating coil 99, lower alternate contacts of relay 58, uppermost contacts of key LK, and thence over the path previously traced through supervisory relay 34, and through the calling substation loop through contacts 90 of key LK, upper alternate contacts of relay 58, upper right-hand winding of repeating coil 99, and upper winding of relay 61 to ground. Supervisory relay 34 is held energized over this circuit during the actuation of the dial and relay 61 is now energized. Relay 61, at its armature and front contact, completes a holding circuit for relay 58 to maintain the connection thus established independently of the relay 60 whose energization depends upon the dial being off normal.

When relay 60 was energized, upon the initial movement of the dial, a dialing circuit was completed to the trunk line T through the tip conductor of said line over the tip contacts of the jack 10 and plug 15, upper normal contacts of key FK, upper alternate contacts of key LK, left-hand alternate contacts of relay 60, interrupting contacts 70 of the dial S, lowermost alternate contacts of key LK, lower normal contacts of key FK, ring contacts of plug 15 and jack 10 to the ring conductor of the trunk line T. The dial operates in the well-known manner to interrupt the dialing circuit just traced and operates the machine switching apparatus at the main central office. The dialing circuit, it will be noted, is independent of the supervisory circuit controlled over the extension L^3. However, at the conclusion of the dialing operation, if the operator for any reason should fail to restore to the listening key LK, a holding circuit for the trunk line T will be provided through the impedance coil 59 in the operator's set, as this coil will be bridged across the tip and ring conductors of the trunk line T. This bridge is closed by the deenergization of the slow-to-release relay 68 which takes place a moment after the dialing operation ceases and which results in the deenergization of relay 60. With the circuit in this condition the calling subscriber is able to converse with the called subscriber, even though the listening key LK has not been restored, by reason of the fact that the left-hand winding of the induction coil 99 is bridged across the tip and ring conductors of the cord circuit in parallel with the impedance coil 59 as soon as the slow-to-release relay 68 is released. The repeating coil 99 serves to inductively couple the front and back conductors through the operator's set so that the subscribers can talk through the repeating coil. It will be noted that the circuit of the left-hand winding of the repeating coil 99 was held opened during the dialing operation by the relay 68, so as to prevent the dialing impulses from being transmitted to the calling subscriber. The operator hearing the conversation of the parties will thus be audibly informed that she has failed to restore the key LK to normal and will thereupon restore said key.

At the completion of conversation, the hanging up of the calling subscriber's receiver causes the release of the supervisory relay 34 and if the trunk line leads to an automatic exchange, the machine switching apparatus by which the connection was set up at the main central office will be released immediately in the manner well known in the art. If on the other hand the main central office at which the line T terminates is a manual office, the opening of the circuit at the station of the extension line L^3, hereinbefore traced, results in the deenergization of a supervisory relay in a cord circuit at the main central office, so that the operator at such office will be informed that the connection is to be taken down. Relay 34, upon deenergization, opens at its armature and front contact, the original energizing circuit for relay 16. Relay 16 remains energized, however, over the locking circuit previously traced and prevents the bridge through coils 20 and 21 from being placed across the cord circuit. Relay 34, in deenergizing, also completes a circuit for su-

pervisory lamp 40 over the path previously traced, causing said lamp to glow to inform the private branch exchange operator that the connection is to be taken down.

In the event of a ringing over the trunk line T with the plug 15 in the jack 10, relay 11 will operate during the ringing intervals, causing relay 14 to operate and lock up, and the lamp 12 to light in the manner previously described. The operator noting the lighting of signal 12 may actuate key LK and inquire the wants of the party calling and then remove plug 50 from jack 51. Actuation of key LK opens the locking circuit for relay 16, whereupon said relay 16 releases. As soon as relay 16 releases and closes its inner left-hand contacts, the cord circuit is in the same condition as when the operator answers an incoming call on the trunk circuit T, whereupon relays 17, 18 and 19 operate, relay 14 releases and signal 12 is extinguished.

If no recall signal, as has been described, has been transmitted, the private branch exchange operator, upon observing the glowing of the lamp 40 in response to the hanging up of the receiver associated with the extension L^3, will withdraw the plugs 15 and 50 from their respective jacks. By withdrawing the plugs 15 and 50 the supervisory lamp 40 will be extinguished and the relays of the cord circuit will be restored to normal position.

In case the subscriber of the extension L^3 should desire to be connected with another extension L^2 of the same private branch exchange, the operator will insert the plug 50 into the jack 51 and actuate the listening key LK as before. Relay 19 of the cord circuit not being operated, current is supplied through the impedance coils 20 and 21 for the calling subscriber's transmitter and to operate the supervisory relay 34. The operator, upon ascertaining the number of the desired subscriber, will insert the plug 15 into the jack 75. The sleeve contact of jack 75 being grounded, the relays 17, 18 and 19 are not energized over the sleeve circuit as in the case previously described, and, consequently, battery is supplied for the called subscriber through the impedance coils 20 and 21. Relay 16 is not energized by the supervisory relay 34 during a connection of this character for the reason that the circuit for relay 16 depends upon the energization of relay 19. After signaling the called subscriber in the well-known manner by the actuation of the key FK and upon the response of the called subscriber conversation may be carried on. The restoration of the receivers to the switch hooks of the calling and called subscribers, causes supervisory lamp 40 to be energized to inform the operator that the conversation has terminated. The operator may remove the plugs from their associated jacks, whereupon all apparatus will be restored to normal position.

Referring to Fig. 2 of the drawings and assuming that the subscriber at the main central office desires to be connected to a subscriber at one of the extensions, as, for example, the extension E^3 of the private branch exchange, ringing current will be transmitted over the trunk line T^2 from the main central office, thereby energizing relay 111. Relay 111, upon energization, completes an obvious circuit for line lamp 112 and through the left-hand winding of differential relay 114. Relay 114 thereupon locks up through its left-hand winding thereby completing a circuit for maintaining line lamp 112 actuated. The operator at the private branch exchange, observing the glowing of the line lamp 112, inserts plug 115 into the jack 110, thereby closing the upper contact of jack 110. A circuit is thereupon completed as follows: ground, winding of relay 118, upper winding of relay 117, sleeve contacts of plug 115 and jack 110, and thence in parallel, one path extending through resistance 113 to grounded battery, and the other path extending through the upper contacts of jack 110, right-hand armature and front contact and right-hand winding of relay 114 to grounded battery. Relay 114, being of the differential type, immediately releases due to the current flowing through its right-hand winding. The momentary lowered resistance of the trunk sleeve circuit, by reason of the path through the right-hand winding of differential relay 114, allows sufficient current to flow through the cord circuit sleeve to energize the marginal relay 117. Relay 118 also energizes in the circuit just traced, thereby completing a locking circuit for relay 117 and an energizing circuit for relay 119 over a path extending from grounded battery, armature and front contact of relay 118, and thence in parallel, one path extending through the lower winding and front contact and lower armature of relay 117 to ground, and the other path extending through the winding of relay 119 to ground. Relay 117, in operating, bridges a high impedance coil 125 across the cord circuit. Normally, battery is supplied to the tip and ring conductors of the cord circuit C^2 over the inner back contacts of relay 119, and through the windings of impedance coils 120 and 121. When the relay 119 is energized, however, the battery supply connections are opened and the tip and ring conductors leading to the plug 115 are connected together over a path extending from the tip conductor of cord circuit C^2, impedance coil 120, upper alternate contacts of relay 119, back contact and outer left-hand armature of relay 116, impedance coil 121 to the ring conductor of the cord circuit C. A second bridge is thus established

across the cord circuit. This bridge which is of low impedance at ringing frequency will trip the machine ringing apparatus at the main central office in the manner well known in the art. The relay 119 also operates to short circuit at its lowermost contacts the winding of the supervisory relay 126, which is connected in the ring conductor of the front cord.

The operator may now actuate the key LK^2 in order to connect her set with the cord circuit. When the key LK^2 is in normal condition the tip conductors of the front and back cords are connected by a path extending from the tip contact of the plug 115, over the upper normal contacts of keys FK^2 and LK^2, upper outer normal contacts of relay 128, upper normal contacts of key BK^2 to the tip contact of the plug 150. In a similar manner a path extends from the ring contact of the plug 115, lower normal contacts of key FK^2, lowermost normal contacts of key LK^2, lowermost contacts of relay 119, lowermost normal contacts of relay 128, through supervisory relay 134 and the serially connected resistances 130 and 131 in parallel, lower normal contacts of key BK^2 to the ring contacts of plug 150. When the key LK^2 is actuated, however, the circuit above described is changed so that the tip conductors of the front and back cords are connected over a path extending from the tip conductor of plug 150, uppermost contacts of key BK^2 and relay 128, contacts 190 of key LK^2, upper normal contacts of relay 158, upper alternate contacts of key LK^2 and upper normal contacts of key FK^2 to the tip of plug 115. The ring connections on the other hand extend from the ring conductor of plug 150, and thence over the path previously traced through the lowermost contacts of relay 119, uppermost contacts of key LK^2, lower normal contacts of relay 158, and lowermost alternate contacts of key LK^2, lower contacts of key FK^2 to the ring contact of plug 115. The operator's talking and listening set, comprising transmitter M^2 and receiver R^2 respectively, and the associated induction coil 198 and repeating coil 199 are bridged across the circuit just described so that the operator is enabled to converse with the calling subscriber or operator at the distant central office to determine what extension line is desired.

The operator, upon obtaining this information and ascertaining the connection to the extension L^3 is desired, restores the listening key LK^2 to normal and inserts the plug 150 into the jack 151, thereby closing a circuit from ground over the sleeve contacts of jack 151 and plug 150, armature and back contact of relay 134 and through the lamp 140 to grounded battery. The lamp 140 is now caused to glow. The operator may then actuate the ringing key BK^2 to transmit ringing current to the desired subscriber.

Upon the response of the subscriber at the station associated with the extension E^3, current from the main central office flows through the station of the extension E^3 causing the cord circuit supervisory relay 134 to operate and the low impedance bridge including coils 120 and 121 to be removed from the cord circuit. The high impedance coil 125, which is of such a value as to maintain the supervisory relay at the central office actuated, after it is energized, remains connected across the cord circuit as hereafter described. The circuit extending through to the station of the extension E^3 may be traced as follows: from the grounded side of the battery (not shown) at the main central office, over the tip conductor of the trunk line T^2, tip contacts of jack 110 and plug 115, upper normal contacts of key FK^2, upper normal contacts of key LK^2, upper normal contacts of relay 128, upper normal contacts of key BK^2, tip contacts of plug 150 and jack 151, through the substation loop, ring contacts of the jack 151 and plug 150, lower normal contacts of key BK^2, the serially connected resistances 131 and 130 and the winding of relay 134 in parallel, lower normal contacts of relay 128, lowermost contacts of relay 119, lowermost normal contacts of key LK^2, lower normal contacts of key FK^2, ring contacts of plug 115 and jack 110, and thence over the ring conductor of the trunk line T^2 to battery (not shown) at the main central office. The supervisory relay 134 will now be under the control of the switch hook at the subscriber's station of the extension E^3, but the supervisory relay (not shown) at the central office will be under the control of the operator so that non-through supervision is provided on incoming calls over the trunk line T^2.

The supervisory relay 134, upon being energized, opens the circuit of lamp 140 and closes a circuit through relay 116. The circuit for the energization of relay 116 may be traced as follows: grounded battery, inner lower alternate contacts of relay 119, winding of relay 116, front contact and armature of relay 134, sleeve contacts of plug 150 and jack 151 to ground. Relay 116, in attracting its inner left-hand armature, short circuits the non-inductive resistance 130 shunted about the supervisory relay 134; and in attracting its outer left-hand armature opens the low impedance bridge, including coils 120 and 121, across the cord circuit. By the opening of the bridge the shunting effect of the battery supply from the main central office to the subscriber's instrument on the extension E^3 is obviated and a better transmission circuit is provided. It will be noted, however, that

the high impedance coil 125 is bridged across the cord circuit as long as relay 117 is energized.

When the subscriber at the extension E^3 hangs up his receiver, the circuit for relay 134, previously traced, is opened, and, consequently, the said relay 134 is deenergized. Relay 134, in retracting its armature, opens the circuit for relay 116, which relay thereupon deenergizes and closes at its outer left-hand contacts the bridge, including coils 120 and 121, across the cord circuit. The relay 134, upon deenergization, also completes a circuit for lamp signal 140, causing said lamp to glow to inform the private branch exchange operator that the connection is to be taken down. Due to the maintenance of the bridge across the cord circuit the machine switching apparatus at the main central office is prevented from releasing. If on the other hand the main central office at which the trunk line T^2 terminates is a manual office, the supervisory relay in the cord circuit at the main central office will be prevented from releasing.

The operator at the private branch exchange, noting the disconnect signal 140, may remove plugs 115 and 150 from their respective jacks, thereby removing the bridge from the trunk circuit T^2 and causing the release of the switches at the main central office or the glowing of the supervisory lamp thereat, depending on whether the main central office is of the machine switching or manual type.

Should a subscriber on an extension line, such as E^3, desire to be connected to a subscriber at the main central office, he will remove his receiver from the switch hook, whereupon the line relay 152 is energized to close the circuit of the line lamp 153. The operator in response to the signal will insert the plug 150 of the cord circuit C^2 into jack 151, thereby disconnecting the line relay 152 and extinguishing the line lamp 153. As relay 119 is not now energized, the battery supply may be traced from grounded battery, over the inner lower normal contacts of relay 119, impedance coil 121, lower normal contacts of relay 128 through the serially connected resistances 130 and 131 and the winding of relay 134 in parallel, lower normal contacts of key BK^2, ring contacts of plug 150 and jack 151, through the substation loop, tip contacts of jack 151 and plug 150, upper normal contacts of key BK^2, uppermost normal contacts of relay 128, impedance coil 120 and upper inner normal contacts of relay 119 to ground. The supervisory relay 134 is energized over the circuit just traced and opens the circuit of the supervisory lamp 140 which would otherwise be closed over the sleeve contacts of plug 150 and jack 151.

The operator may now actuate the listening key LK^2, thereby connecting her set to the cord circuit in the manner already described, so that she is enabled to converse with the calling subscriber. Upon ascertaining that the subscriber desires a connection through the main central office the operator may insert the plug 115 into the jack 110. A circuit is now completed through the winding of relays 117 and 118 over the path previously traced. Relay 118 energizes but relay 117 does not energize due to the high value of the resistance 113. Relay 118, in operating, completes an obvious circuit for relay 119. Relay 119, in operating, disconnects the battery supply through the impedance coils 120 and 121, so that the current for the calling subscriber's station will now be supplied directly from the main central office. Relay 119, as before described, short circuits the supervisory relay 126. Relay 119, in energizing, also connects battery through its lower innermost contacts to the winding of relay 116, causing thereby the energization of relay 116. Relay 116 now locks up over a path extending from ground, lower inner normal contacts of key LK^2 (provided key LK^2 is in normal position), uppermost contacts of relay 117, inner right-hand armature and front contact and winding of relay 116, and front contact and lower inner armature of relay 119 to grounded battery.

Further action on the part of the private branch operator will now depend on whether or not the main central office is a manual office or an automatic office. In case the main central office is a manual office the line relay (not shown) associated with the trunk T^2 at the main central office will be energized as soon as the plug 115 is inserted in the jack 110 by means of the through supervisory circuit, already traced, including the calling station of the extension E^3. If the key LK^2 is operated, however, as would normally be the case under the conditions being described, a circuit for said line relay would be completed in a manner similar to that previously described in connection with the description of Fig. 1 of the drawings. The operator at the distant central office, being apprised by the line lamp (not shown) that a call has arrived, answers the call in the usual manner and the private branch exchange operator, through her telephone set which is connected to the cord circuit C^2 over the contacts of the key LK^2, is able to converse with the operator at the main central office and inform the operator the number desired. The operator of the private branch exchange may then restore the listening key LK^2 to normal so that the talking circuit will be the same as previously traced for a call incoming from the main central office.

In case the main central office is of the machine switching type the operator at the

private branch exchange, after having inserted the plug 115 into the jack 110, and after having actuated the listening key LK², may then actuate the impulse sender S′ a number of times corresponding to the number desired at the main central office for the purpose of setting the machine switching apparatus thereat. Upon the initial movement of the impulse sender or dial S′, the off normal contacts 169 thereof are closed, thereby completing an obvious circuit for slow-to-release relay 168, which in turn completes an obvious circuit for relay 160. Relay 160, in attracting its right-hand armature, completes an obvious circuit for relay 158, which relay in operating opens the conductive connection which had previously existed between the front and back conductors of the cord circuit through the operator's set. Battery supply is now furnished to the extension E³ through the windings of relay 161 over a path similar to that previously traced in connection with the description of Fig. 1 of the drawings. Supervisory relay 134 is held energized over this circuit during the actuation of the dial and relay 161 is now energized. Relay 161, at its armature and front contact, completes a holding circuit for relay 158 to maintain the connection thus established, independently of the relay 160 whose energization depends upon the dial being off normal. When relay 160 was energized, upon the initial movement of the dial, a dialing circuit was completed to the trunk line T² over a path similar to that previously traced in connection with Fig. 1 of the drawings. The dial operates in the well known manner to interrupt the dialing circuit just traced to set the machine switching apparatus at the main central office.

It will be noted that the dialing circuit is independent of the supervisory circuit controlled over the extension E³. However, at the conclusion of the dialing operation, if the operator fails to restore the listening key LK², a holding circuit for the trunk line T² will be provided through the impedance coil 159 in the operator's set as this coil will be bridged across the tip and ring conductors of the trunk line T². This bridge is closed by the deenergization of the slow-to-release relay 168, which takes place a moment after the dialing operation ceases and which causes the deenergization of the relay 160. With the circuit in this condition the calling subscriber is able to converse with the called subscriber even though the listening key has not been restored by reason of the fact that the left-hand winding of induction coil 199 in the operator's set is bridged across the tip and ring conductors of the cord circuit in parallel with impedance coil 159 as soon as slow-to-release relay 168 has released. The repeating coil 199 serves to inductively couple the front and back conductors through the operator's set so that the subscriber can talk through the repeating coil. It will be noted that the circuit of the left-hand winding of the repeating coil 199 was held open during the dialing operation by the relay 168 to prevent the dialing impulses from being transmitted to the calling subscriber. The operator is thus audibly informed that she has failed to restore key LK² to normal, whereupon she restores said key.

At the completion of conversation, the hanging up of the calling subscriber's receiver causes the release of the supervisory relay 134. If the trunk line T² leads to an automatic exchange the machine switching apparatus by which the connection was set up at the main central office will be released in the manner well known in the art. If on the other hand the main central office at which the line T² terminates is a manual office the opening of the supervisory circuit above traced results in the deenergization of a supervisory relay (not shown) in the cord circuit (not shown) at the main central office so that the operator at such office will be informed that the connection is to be taken down. Relay 134, upon deenergization, opens at its armature and front contact the original energizing circuit for relay 116. Relay 116 remains energized, however, over the locking circuit previously traced and thus prevents the low impedance bridge including coils 120 and 121 from being placed across the cord circuit. Relay 134, in deenergizing, also completes a circuit for supervisory lamp 140 causing said lamp to glow to inform the private branch exchange operator that the connection is to be taken down. Another circuit is completed at the same time for relay 128 over a path extending from grounded battery, lower inner alternate contacts of relay 119, winding of relay 128, front contact and outer right-hand armature of relay 116, upper inner normal contacts of relay 128, back contact and armature of relay 134, sleeve contacts of plug 150 and jack 151 to ground. Relay 128 thereupon energizes, thereby disconnecting the front from the back cord and connecting ground and battery to the tip and ring conductors respectively of the back cord. By this opening of the cord circuit, ringing current transmitted over the trunk T² from the main central office will not in the event that the private branch exchange operator delays taking down the connection, be transmitted to the extension E³ with which the cord circuit is still associated to ring the bell at the subscriber's station. The ringing response relay 111 bridged across the trunk circuit will respond to the ringing signal and will cause the lamp signal 112 to light during the intervals that ringing cur-

rent is on the line. Relay 114 will attempt to operate in response to the ringing signals but due to its differential winding being connected to ground in the cord circuit, it cannot lock up and will release as soon as ringing current is removed from the trunk line T^2.

If the subscriber at the extension E^3 should recall by taking the receiver off the hook before the connection has been taken down, a circuit is provided for energizing the supervisory relay 134 due to the operation of relay 128, so that by flashing the switch hook the lamp 140 may be caused to glow to attract the attention of the operator. The supervisory relay 134, when again energized by the subscriber removing his receiver before the private branch exchange operator takes down the connection, opens the circuit of the relay 128. Relay 128 releases and again closes the cord circuit so that the connection extends directly to the main central office and current for supervisory relay 134 is now applied therefrom. With the circuit in this condition, the subscriber may now extend one or more calls to the distant central office without the aid or intervention of the private branch exchange operator.

The operator noting the disconnect signal 140 may withdraw the plugs 115 and 150 from their respective jacks, whereupon all apparatus associated with the cord circuit will be released and the bridge across the trunk line T^2 will be removed, causing thereby the release or restoration to normal of any apparatus which may be associated with the trunk circuit.

In case the subscriber on the extension E^3, for example, should desire to be connected with another extension E^2 of the same private branch exchange, the operator will in response to the lighting of the lamp 153 insert the plug 150 into the jack 151 and then actuate the listening key LK as before. Relay 119 of the cord circuit not being operated, current is supplied through the impedance coils 120 and 121 for the calling subscriber's transmitter and for operating supervisory relay 134. The operator upon ascertaining the number of the desired subscriber will insert the plug 115 into the jack 175. The sleeve contact of the jack 175 being grounded, the relay 118 will not be energized over the sleeve circuit as in the case previously described, and consequently, the current for the called subscriber flows through the impedance coils 120 and 121. Relay 116 is not energized by the supervisory relay 134 during a connection of this character for the reason that the circuit of relay 116 depends upon the energization of relay 119. Lamp 191 now functions as a supervisory lamp for the calling end of the cord circuit, the circuit for said lamp extending from battery through said lamp 191, over the back contact and upper outer armature of relay 119, back contact and armature of relay 126, sleeve contacts of plug 115 and jack 151 to ground. When the called subscriber of the extension E^2 responds, the supervisory relay 126 which is included in the battery supply circuit to the called subscriber and which is not in this instance short-circuited over the lower contacts of relay 119 becomes energized and opens the circuit of the lamp 191. When the two subscribers hang up, the supervisory relays 126 and 134 which are separately controlled by the two subscribers become deenergized and the lamps 191 and 140 are again caused to glow to give the disconnect signals. While as above described the end of the cord circuit terminating in the plug 150 was used as the answering end and the end of the cord circuit terminating in the plug 115 was used as the calling end of the cord circuit, the cord circuit will function equally well for local connections if the plug 115 is used as the answering plug and the plug 150 as the calling plug, since the two ends of the cord circuits are symmetrical so far as local connections are concerned. For local connections, it will also be noted, that the feature of opening the cord circuit by means of the relay 128 in response to the disconnect signal is not present. The operator noting the disconnect signals may remove the plugs 115 and 150 from their respective jacks thereby causing the restoration of all apparatus to normal.

What is claimed is:

1. In a telephone exchange system, a trunk line, a subscriber's line, a cord circuit for interconnecting said lines, and means in the cord circuit and in the connected trunk circuit to provide through supervision if calls are completed in one direction over said trunk line and to provide non-through supervision if calls are completed in another direction over said trunk line.

2. In a telephone exchange system, a trunk line, a subscriber's line, a cord circuit for interconnecting said line arranged to provide through supervision if calls are completed in one direction over said trunk line and to provide non-through supervision if calls are completed in the other direction over said trunk line, and apparatus in the cord and connected trunk circuit cooperating, to convert automatically the cord circuit from one class of supervision to the other.

3. In a telephone exchange system, a trunk line, a subscriber's line, a cord circuit for interconnecting said lines arranged to provide through or non-through supervision, a relay in said cord circuit, and means associated with said trunk circuit for energizing said

relay only when a call is incoming over said trunk line to arrange said cord circuit for non-through supervision.

4. In a telephone exchange system, a two-way trunk line, a subscriber's line, a cord circuit for interconnecting said lines arranged to provide through or non-through supervision, a relay in said cord circuit arranged when energized to adapt the cord circuit for non-through supervision, and a relay associated with the trunk circuit for energizing the relay in the cord circuit only when a call is incoming over the trunk line.

5. In a telephone exchange system, a trunk line, a subscriber's line, a cord circuit for interconnecting said lines arranged to provide through or non-through supervision, a differential relay associated with the trunk line, and a relay in said cord circuit cooperating with said differential relay for converting the cord circuit from one class of supervision to the other.

6. In a telephone exchange system, a trunk line, a subscriber's line, a cord circuit for interconnecting said lines, a bridge for said cord circuit, a relay associated with said cord circuit adapted when actuated to connect said bridge to said cord circuit, and means associated with said trunk line for actuating said relay only when a call is incoming over said trunk line.

7. In a telephone exchange system, a trunk line, a subscriber's line, a cord circuit for interconnecting said lines, a bridge for said cord circuit, a relay, and a differential relay associated with said trunk line for actuating said relay to connect said bridge to said cord circuit only when a call is incoming over said trunk line.

8. In a telephone exchange system, a trunk line, a subscriber's line, a cord circuit for interconnecting said lines arranged to provide through or non-through supervision, signal current responsive means associated with said trunk circuit, a relay associated with said trunk circuit controlled thereby, and means in said cord circuit responsive to the actuation of said relay for converting said cord circuit from one class of supervision to the other.

In testimony whereof, I have signed my name to this specification this 18th day of March, 1921.

RAND S. BAILEY.