

Oct. 18, 1932.

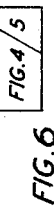
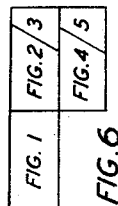
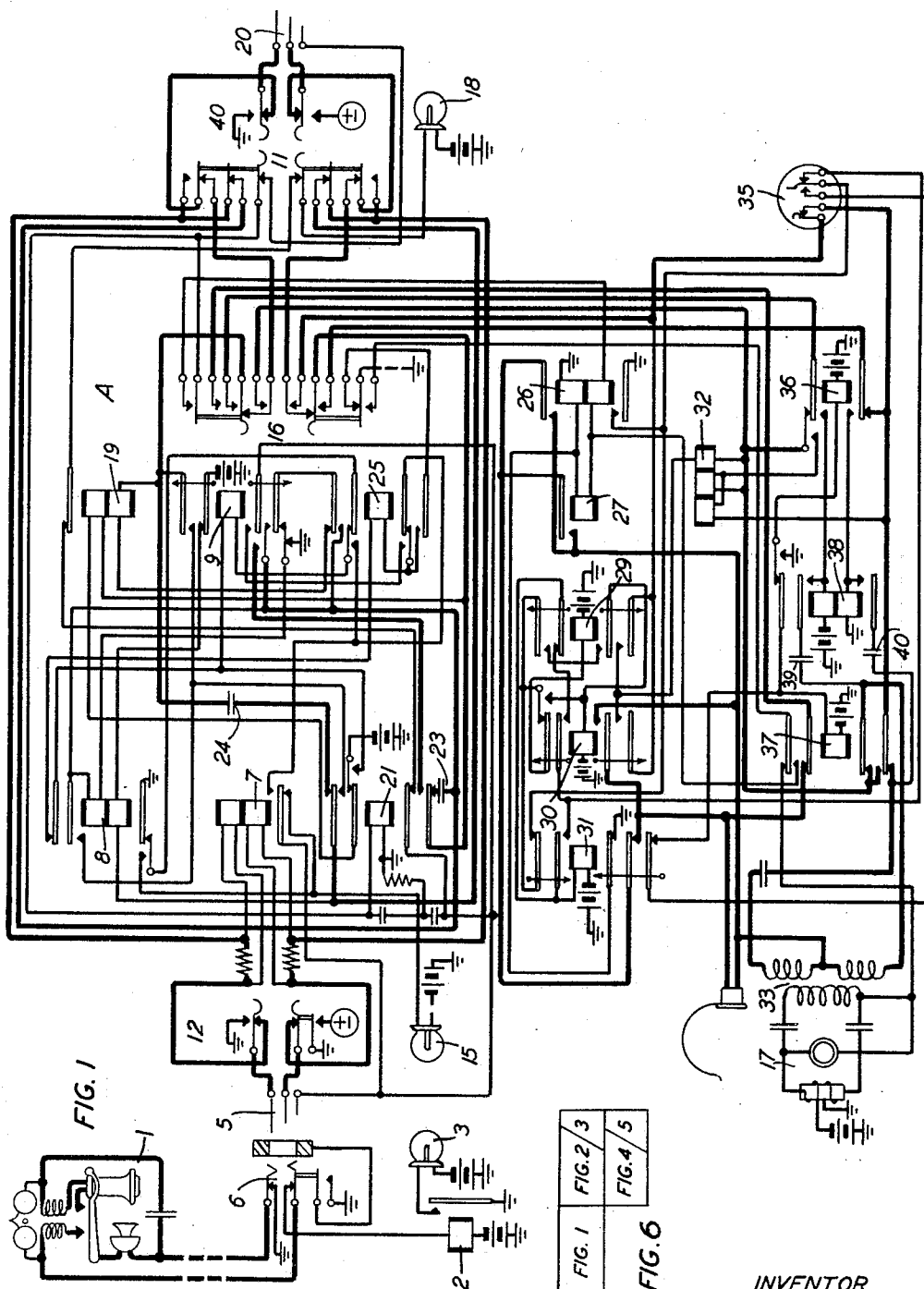
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1,882,753

TELEPHONE SYSTEM

Filed May 29, 1931

3 Sheets-Sheet 1



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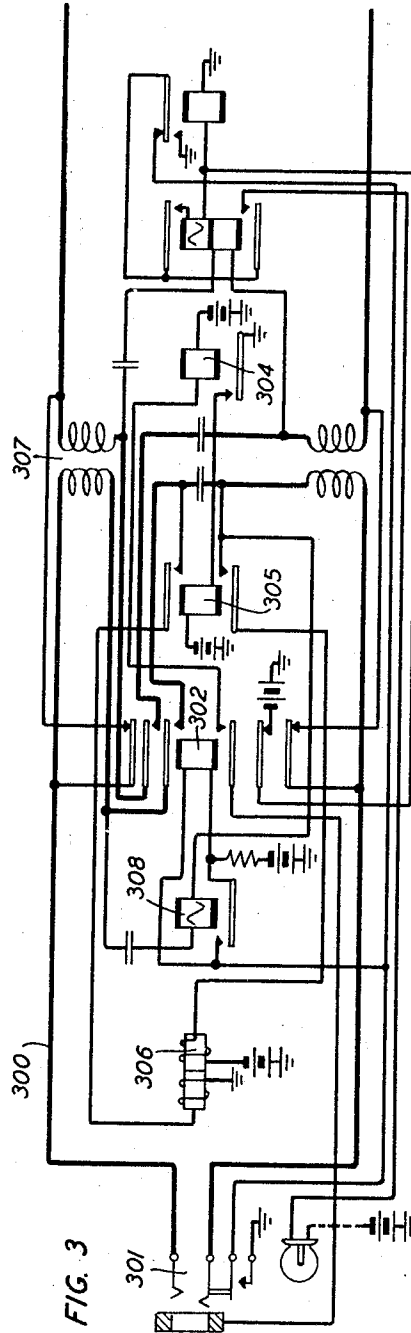
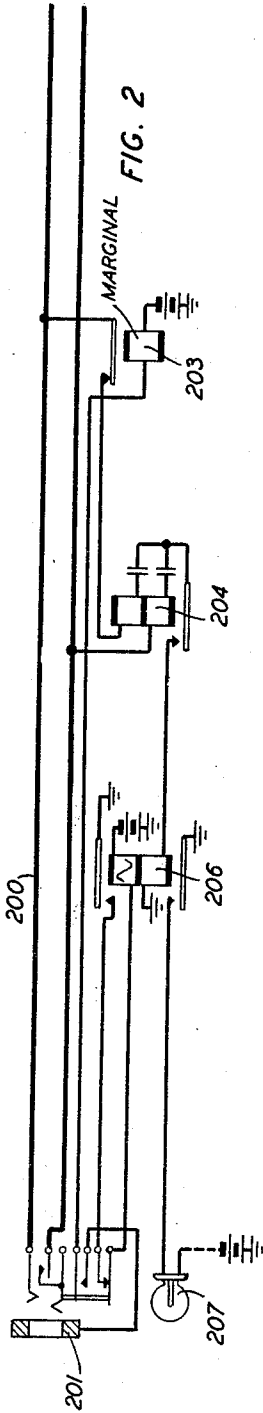
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3 Sheets-Sheet 2



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TELEPHONE SYSTEM

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3 Sheets-Sheet 3

FIG. 4

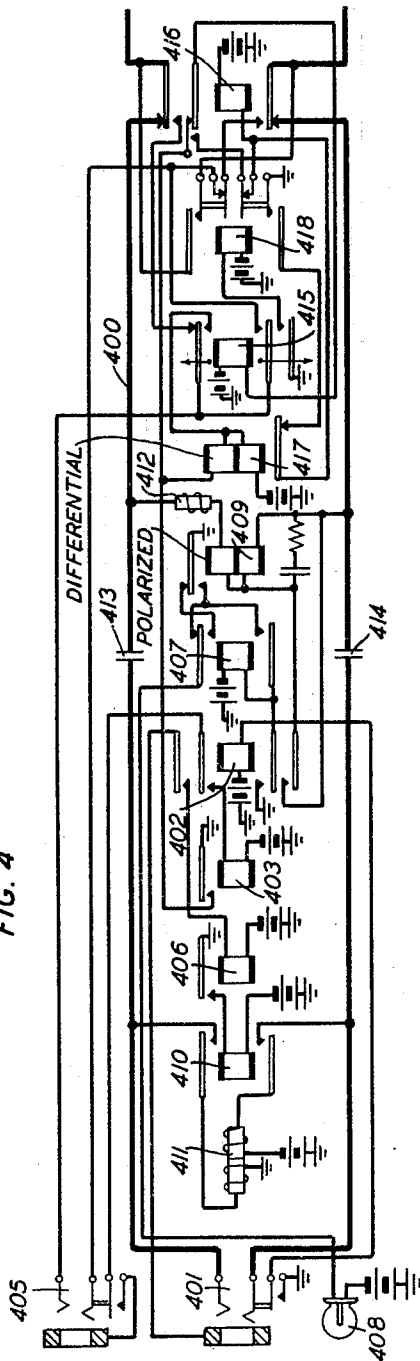
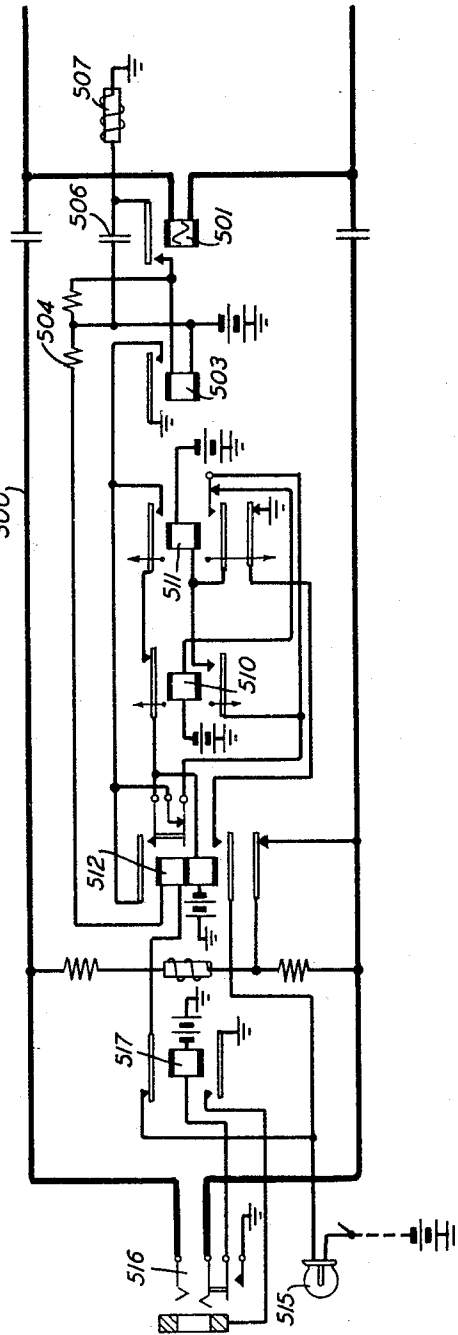


FIG. 5



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TELEPHONE SYSTEM

Application filed May 29, 1931. Serial No. 540,839.

This invention relates to telephone systems and particularly to private branch exchange systems.

The object of this invention is to improve and simplify the handling of telephone connections between subscribers' lines in a private branch exchange, and connections between subscribers' lines in this exchange and lines extending to distant exchanges.

Heretofore, in systems of this kind on connections established by means of a local operator's cord between a local subscriber's line and a line to a distant exchange, when the local subscriber hangs up his receiver on the switchhook to disconnect, the connection through the cord is split. This is for the purpose of preventing the subscriber's station from being signaled in case a call is incoming over the line used in this connection before the operator has removed the cord from the local subscriber's line. Heretofore, this splitting has been done by the operation of a slow-to-operate relay which operated when the subscriber replaced his receiver on the switchhook. The operation of this relay was made slow in order to prevent it from operating during momentary openings of the connection such as occur when the switchhook is flashed by the local subscriber or when supervision occurs from the distant office. In modern telephone practice the talking current has been increased in circuits of this kind which made it more difficult for this slow-to-operate relay to function with a desired uniformity under all conditions of voltage variations which may occur due to the different transmission characteristics of the connected lines.

It is a feature of this invention to overcome such variations in the periods of delay of the splitting of the cord by providing a circuit arrangement whereby a slow-to-release relay is maintained operated while the connection is established and permitted to release when the subscriber replaces his receiver on the switchhook for the release of the connection. The circuit for this slow-to-release relay is controlled by the usual supervisory relay included in the line connection. By this means the periods of delay in splitting of the

cord are made uniform as they are controlled by the slow-to-release characteristic of this relay independently of the voltage variations on the line.

In establishing a connection to a distant exchange over a line the circuit for the above mentioned splitting relay must be put under control of the supervisory relay when the through connection is finally completed and the call is answered by the operator at the distant exchange. This supervisory relay, however, operates as soon as the local operator answers the call from the local subscriber for supervisory purposes, it is then momentarily released, and finally transferred under control of the battery and ground connection established over the tip and ring conductor when the operator at the distant exchange answers the call. It is, therefore, a further feature of this invention in order to prevent the false release of the splitting relay during the transfer period to establish circuit conditions whereby the splitting relay is operated and held by a local battery and ground connection in the cord as soon as the connection to the distant exchange line is established and then transferred to the control by the supervisory relay when this latter relay is finally operated.

When the local subscriber hangs up his receiver on the switchhook to cause the connection to the distant exchange to be split, a battery and ground connection is established from the cord to the subscriber's line for the purpose of permitting the subscriber to make a recall on the connection. Under these circumstances, a surge of current may occur in the circuit due to the battery and ground connection charging the condenser in the subscriber's telephone set. It is a feature of this invention to prevent this surge from disturbing the established circuit conditions in the cord, such as for example, to falsely establish a bridge across the connection to cause a false signal at the central office. To prevent such disturbances a circuit arrangement has been provided for short-circuiting one winding of the battery feed relay that would initiate such false signaling by its operation, due to its being in-

cluded in the battery and ground connection to the subscriber's line. This short circuit prevents the battery feed relay from operating at this time.

5 Another feature of this invention is an arrangement whereby under the above mentioned circumstances if the subscriber removes his receiver to make a recall on the connection, the connection through the cord
10 is reestablished by the splitting relay independently of the supervisory relay in the cord and the splitting relay is not placed under control of the supervisory relay until the supervisory relay is operated in response
15 to current received over the established connection from the distant exchanges. Hence in case of a long line connection where the transmission characteristics may cause the operation of the supervisory relay to be delayed this delay will not interfere with the
20 proper function of the splitting relay in establishing a through connection. This is accomplished by having the special battery feed relay operate when the subscriber lifts
25 his receiver from the switchhook and having this relay shunt the supervisory relay to permit the operation of the splitting relay. When the current is received from the distant exchange the supervisory relay operates
30 and causes the control over the splitting relay to be transferred to the supervisory relay.

Another feature of this invention is an arrangement whereby, when a connection is
35 established to a central office, the subscriber's telephone is shunted while the battery and ground connection for the tip and ring conductors is shifted from a supply in the cord to a supply at the central office. This is to
40 prevent clicks in the subscriber's receiver during this transfer. The arrangement is such that when the cord is extended to the central office trunk a short circuit is placed
45 across the subscriber's line, the current supply at the cord is then removed and a bridge is placed across the tip and ring conductors, whereupon the short circuit is removed and the tip and ring conductors are connected
50 through the cord circuit. Then when the connection is extended in the central office to the current supply thereat the bridge is removed.

It is another feature of this invention to short-circuit the operator's receiver for a short interval while the operator answers a
55 call incoming over a trunk in response to the operation of the talking key in the cord and the insertion of the answering plug of this cord into the trunk jack.

It is another feature of this invention to
60 short-circuit the operator's receiver for a short interval while she answers a call incoming over the trunk to which a cord is already connected. This short circuit is established by the same means, namely, the
65 operation of the talking key and the condi-

tions brought about by the fact that the cord is already connected to the trunk.

It is another feature of the invention to provide an arrangement whereby the same means employed for short-circuiting the receiver is also used as a means for tripping the
70 ringing at the central office when the operator answers the call on a trunk, regardless of whether the call is answered over a trunk to which the cord employed is connected or not, at the time of the call. This is accomplished by the establishing of a bridge across the tip and ring conductors of the trunk for
75 a short interval.

It is another feature of this invention to provide an arrangement whereby the same means that is used for short-circuiting the receiver while answering a call or for tripping the ringing is employed for short-circuiting the receiver during dialing over a
80 central office connection and for maintaining the receiver short-circuited a short interval after dialing to prevent disturbances or clicks in the receiver due to operations at the central office effected by the dialing.
85

Another feature of this invention is an arrangement in tie lines employed in systems of this kind for automatically removing the repeating coil from across tie line conductors when ringing is applied to the line on outgoing calls and thereby remove the drain on the ringing current. This is accomplished
90 by means of an alternating current responsive relay actuated by the ringing current which relay in turn causes another relay to release and open a connection for the repeating coil and establish through connections for the line conductor to permit the ringing current to pass out on the line.
95

Another feature of this invention is an arrangement in tie lines used in systems of this kind that have a separate jack for dialing a distant station, for preventing false impulses or interruptions of the connection through the tie line to the distant station from occurring when the connection is switched from the talking jack to the dialing jack. This is accomplished by means whereby the tip and ring terminals of the dialing jack and the tip and ring conductors of the tie line are short-circuited when a cord circuit is connected to the dialing jack and means whereby when the cord has been prepared for dialing the following functions are caused to take place in the order named: To disconnect the tie line from the talking jack, to remove the short circuit from the dialing jack terminals, to establish a through connection for the tip conductor, to establish a through connection
100 for the ring conductor and to remove the short circuit from the tip and ring conductors of the tie line.
105

Another feature of the invention is an arrangement in outgoing trunks employed in
110

systems of this kind and in the cord circuit whereby a ringing bridge normally connected across the tip and ring conductors of the trunk is automatically removed during dialing. This is accomplished by having a relay in the sleeve circuit of the trunk operate to remove the bridge when the dial is off normal, the off-normal contacts of the dial causing a low resistance shunt around a winding of the usual battery feed relay to be established for the operation of the relay in the trunk circuit.

In tie lines for private branch exchange systems of the above type surges may occur on the line to cause momentary operations of the alternating current responsive relay used for lighting the line lamp. Means has heretofore been provided for delaying the lighting of this lamp. This means usually includes a slow-to-operate relay and a slow-to-release relay.

An arrangement of this kind is satisfactory when the voltage of the battery supply is comparatively low as the slow-to-operate relay will then function properly. In modern telephone service a higher voltage battery is desirable and the slow-to-operate relay will not operate sufficiently slow under these circumstances to delay the operation of the line signal. It is therefore a further feature of this invention to provide an arrangement whereby only slow-to-release relays are employed in the circuit arrangement for delaying the operation of the line signal. The operation of the signal may therefore be delay for the proper interval independent of the characteristics of the voltage of the operation current.

This invention has been illustrated in the accompanying drawings in which,

Fig. 1 shows a cord circuit A and an associated operator's telephone circuit at a private branch exchange embodying features of this invention and a calling subscriber's line in diagrammatic form;

Fig. 2 shows a trunk circuit outgoing from the private branch exchange to a distant exchange and terminating in a jack at the private branch exchange;

Figs. 3, 4 and 5 show various types of tie lines embodying features of this invention and terminating in jacks at the private branch exchange and extending to other private branch exchanges. The figures may be arranged as shown in Fig. 6.

To explain the various features of this invention in connection with these drawings, descriptions will be made as follows: A call from the calling subscriber of line 1 over cord circuit A in Fig. 1 and trunk 200 in Fig. 2 to a distant exchange, the release of such a connection and a recall by the subscriber of line 1 of the operator before this connection has been taken down; second, a call incoming over trunk 200 and answered by the op-

erator; third, an outgoing call from the operator over the tie line shown in Fig. 3; fourth, an outgoing call over the tie line shown in Fig. 4, and fifth, a call incoming over the tie line shown in Fig. 5.

Referring now to the establishing of a connection from the subscriber of line 1 through cord A over trunk 200 to the distant exchange, the calling subscriber by lifting his receiver off the switchhook causes the line relay 2 to be operated to light the line lamp 3 in the usual manner. This call is answered by the operator of cord A by inserting plug 5 into jack 6. Line relay 2 is thereby released to extinguish the line signal 3 and a connection is extended from the subscriber's loop through the tip and ring conductors of jack 6 and plug 5 for the operation of relays 7 and 8 as follows: Battery, upper inner armature and back contact of relay 9, lower winding of relay 8, lower middle normal contacts of dialing key 11, relay 7, lower inner contacts of ringing key 12, ring terminals of plug 5 and jack 6, subscriber's loop, tip terminals of jack 6 and plug 5, upper contacts of ringing key 12, upper winding of relay 7, upper middle normal contacts of dialing key 11, upper winding of relay 8 to ground at lower outer back contacts of relay 9. Relay 8 in operating performs no useful function at this time. Relay 7 opens the circuit for supervisory lamp 15 which was closed in the sleeve circuit to ground on jack 6, when plug 5 was inserted therein. If it is assumed that the talking key 16 has been operated before the call was answered to associate the operator's telephone 17 with the cord circuit, the supervisory lamp 18 will not operate in the above mentioned sleeve circuit as the circuit therefor will be opened due to the operation of relay 19, as will hereinafter be described.

With the operator's telephone set connected through plug 5 and jack 6 to the calling subscriber's line the operator will now ascertain the desired number and if a connection to a distant exchange is desired the operator will insert plug 20 into the jack 201 of the trunk 200 leading to this distant exchange. The immediate effect of this operation will be the operation of relay 21 from battery, winding of relay 203, contacts of jack 201, the sleeve terminals of this jack and plug 20, upper inner normal contacts of dialing key 11, winding of relay 21 to ground. Relay 203 being marginal in character will not operate in this circuit. Relay 21 in operating disconnects the calling subscriber's line from the talking connection through condensers 23 and 24 to the operator's set 17. The ring conductor is connected at the upper outer armature and front contact of relay 21 to the contact of the upper inner armature of relay 8 and the front contact of the upper outer armature of relay 9. Relay 21 also disconnects

battery at its upper inner armature and back contact from the upper winding of relay 19 and connects it to the winding of relay 9. Finally, relay 21 opens the sleeve circuit for lamp 18 at the lower inner armature and back contact. The operation of relay 21 closes a short circuit around the windings of relay 7 to cause it to release while relay 8 is maintained operated. This short circuit may be traced from battery, upper inner armature and back contact of relay 9, lower winding of relay 8, upper outer armature and front contact of relay 21, upper inner armature and front contact of relay 8, upper winding of this relay to ground at the lower outer armature and back contact of relay 9. The purpose of this short circuit across the tip and ring conductors is to prevent a click through the calling subscriber's receiver which occurs when battery and ground is removed later by the operation of relay 9, and to prevent this relay from operating until relay 7 has released. When relay 7 releases it closes a circuit for relay 9 as follows: Battery, upper make-before-break contact of relay 21, winding of relay 9, upper inner armature and back contact of relay 25, lower make-before-break contact of relay 8, lower armature and back contact of relay 7, sleeve terminals of plug 5 and jack 6 to ground at the lower made contacts of jack 6. Relay 9 in operating disconnects battery at its upper armature and back contact from the ring conductor of the calling subscriber's line and ground at its lower outer armature and back contact from the tip conductor. This relay in operating also connects the lower winding of relay 19 across the tip and ring conductors as connected to the normal inner upper and lower contacts of talking key 16 to the tip and ring conductors of the plug 20. This will serve as a holding bridge after the connection has been established. Relay 9 also connects the tip and ring conductors from plug 5 to plug 20; at its upper outer armature and front contact for the tip conductor and at its middle lower make-before-break contacts for the ring conductor. When relay 9 operates the above mentioned short circuit for relay 7 and the holding circuit for relay 8 is opened and this relay now releases. When relay 8 releases it permits relay 7 to operate over the loop extending through plug 20 and jack 201 to the battery and ground at the distant exchange over trunk 200. As relay 8 is now released relay 25 is operated over a circuit as follows: Battery, upper make-before-break contact of relay 21, upper outer armature and back contact of relay 8, winding of relay 25, lower inner armature and back contact of this relay, armature and front contact of relay 7, sleeve terminals of plug 5 and jack 6 to ground on jack 6. Relay 25 in operating provides a locking circuit for itself through its lower make-before-break contact and lower

armature and front contact of relay 9 to the ground on jack 6 under control of relay 9. Relay 25 in operating opened at its upper outer armature and back contact the holding bridge through the lower winding of relay 19 and by closing its upper make-before-break contacts transfers the control of relay 9 to the sleeve circuit closed by relay 7.

If the call is to be extended to a dial central office the operator will dial the desired subscriber's line as follows: As the talking and dial key 16 is operated the immediate effect will be the operation of relays 26 and 27 over a circuit from battery, winding of relay 203, the sleeve circuit of jack 201 and plug 20, upper inner normal contacts of key 11, upper outer made contacts of key 16, lower winding of relay 26, winding of relay 27, lower inner armature and back contact of relay 31 to ground. The relay 27 operates first and short-circuits the receiver of the operator's set 17 at its armature and front contact. Relay 26 in operating also short-circuits the receiver at its upper armature and front contact. The purpose of this will be described hereinafter. Relay 26 closes a circuit for the operation of relay 29 from battery, winding of relay 29, upper outer armature and back contact of relay 30, upper outer armature and back contact of relay 31 to ground at the lower armature and front contact of relay 26. Relay 29 in operating opens at its upper inner armature and front contact a circuit for relay 31 and closes a ringing tripping bridge across the tip and ring conductors of the cord circuit at its lower outer armature and front contact through the right hand winding or retardation coil 32 and across the left hand winding of repeating coil 33. This bridge performs no useful function at this time but on incoming calls over trunk 200 it trips the ringing. Relay 29 in operating also closes a circuit for relay 30 from battery, winding of relay 30, lower inner armature and front contact and upper outer armature and front contact of relay 29, upper outer armature and back contact of relay 30 to ground at relay 26. Relay 30 in operating provides a locking circuit for itself to this ground at relay 20 through its upper make-before-break contacts. Relay 30 also closes a second connection for the above mentioned tripping bridge through its lower outer armature and front contact. Relay 30 also short-circuits the receiver at the lower inner armature and front contact in multiple with the upper armature and front contacts of relays 26 and 27. Relay 30 also opens the circuit for relay 29 at its upper outer armature and back contact and closes a circuit for the operation of relay 31. Relay 29 is slow in releasing so that this circuit will not be closed until relay 29 releases. This circuit may be traced from battery, winding of relay 31, upper inner

armature and back contact of relay 29, upper inner armature and front contact of relay 30, off-normal contacts of dial 35, lower armature and front contact of relay 26 to ground. Relay 31 in operating closes a locking circuit for itself at its upper inner armature and front contact directly to the ground at relay 26. When relay 31 operates it opens the short circuit for the receiver established by relays 26 and 27 at its lower outer armature and back contact and opens the locking circuit for relay 30 at its upper outer armature and back contact. Relay 31 is slow to operate and relay 30 is slow in releasing. Relay 30 in releasing opens the tripping bridge closed at its lower outer armature and front contact, as well as the short circuit for the receiver through its lower inner armature and front contact. The operating times of relays 26, 27 and 31 and the releasing times of relays 29 and 30 are such as to allow the tripping bridge to cause tripping functions at the distant exchange to take place before the operator's receiver is connected to the telephone circuit in order to prevent the operator hearing clicks which may occur due to these operations. Due to the operation of relay 31 and release of relay 30 the operator's receiver will now be connected to the talking key 16 over the tip and ring conductors over the trunk 200 and a dial tone will then be heard by the operator when the central office equipment is ready to receive dial pulses.

When, now, the operator actuates the dial 35 the off-normal contacts of the dial open the circuit for relay 31. This relay in releasing again short-circuits the receiver. Relay 27 may be released at this time due to the high resistance of the upper winding of relay 26. At the release of relay 31 the upper high resistance winding of relay 26 is shunted by the establishing of the connection to ground at the lower inner armature and back contact of relay 31 and relay 27 reoperated. When relay 31 releases relays 29 and 30 are again operated to maintain the short circuit for the receiver independent of relays 26 and 31. Relay 31 in releasing also closes the circuit for the operation of relays 36 and 37. Relay 36 is operated by a circuit from battery, winding of relay 36, upper outer armature and back contact of relay 38, lower outer armature and back contact of relay 31, off-normal contacts of dial 35 to ground at the lower armature and front contact of relay 26. The circuit for relay 37 may be traced from battery, winding of this relay over the same circuit to ground at relay 26. Relay 37 in operating short-circuits the middle and left hand windings of the retardation coil 32 by closing the connection through its lower outer armature and front contact and opens the connection to ground from the transmitter circuit applied at the lower outer make contact of key 16 through the upper outer armature and back contact of relay 37. Relay 37 connects this ground through this armature and the corresponding front contact to the connection between the lower winding of relay 26 and the winding of relay 27. Relay 27 is thereby short-circuited which causes the operation of the marginal relay 203 in the trunk circuit 200. Relay 203 in operating opens the bridge through the ringing relay 204 to prevent this bridge from interfering with the impulses outgoing over the trunk 200 when dialing again. It will be noted that the relays 30 and 31 while placing a short circuit on the receiver at this time prevent the operator hearing any clicks due to the operation of relays 36 and 37. Relay 36 in operating connects a short circuit across the middle winding of the retardation coil 32 to prepare a low resistance bridge across the trunk circuit when the dial returns to normal. This bridge will extend between the tip and ring conductors through the upper make-before-break contacts of relay 36 and the left hand winding of retardation coil 32. Relay 36 also in operating opens the connection between the plugs 5 and 20 to the tip and ring conductors at the upper and lower armatures and back contacts. This relay also connects the tip and ring conductors from plug 5 through these armatures and the corresponding front contacts through the winding of relay 38 to battery and ground. Relay 38 now operates over the loop to the calling station if the receiver is still off the hook or through the bridge in the cord circuit established by the operation of relay 9, as hereinbefore mentioned. Relay 38 in operating opens a circuit at its upper outer armature and back contact for relay 36 from the off-normal contact of the dial 35 and locks up this relay through the upper make-before-break contacts to ground.

The dial may now return to normal opening and closing the impulse contact according to the digit selected. The line connection through to the distant exchange closed by relay 37 is thereby interrupted to begin the selection of the desired subscriber's line in the usual manner. It should be noted that this connection is free from all encumbrances as the bridge in the trunk circuit is removed from across the line and the repeating coil 33 and retardation coil 32 are short-circuited by the operation of relay 37 and the calling subscriber's circuit is removed by the operation of relay 36. When the dial is restored to normal the off-normal springs open the circuit for relay 37 which now releases and removes a short circuit from the left and middle windings of retardation coil 32 and connects a ground to the transmitter circuit at its upper outer armature and back contact. The normally closed off-normal springs of the dial 35 now close the circuit through the

contacts of relays 30 and 29 for relay 31 which operates and opens the short circuit for the receiver applied by relay 26. A short-circuit however is still maintained by relay 30. Relay 31 in operating closes the same locking circuit for itself and opens the circuit for relay 30 which releases slowly and removes the short circuit from the receiver. The slow-to-operate characteristic of relay 31 and slow-to-release characteristic of relay 30 prevent the operator hearing clicks due to the dialing operations. Relays 36 and 38 remain operated under control of the key 16. The calling subscriber may now talk to the operator and to the central office when relay 30 releases, this connection being established to condensers 39 and 40. The central office circuit is held operated by the bridge through the left hand winding of the retardation coil 32.

When the operator has completed dialing the talking and dialing key 16 is restored to normal and the calling subscriber's line is connected to the central office as hereinbefore described. If the calling subscriber replaces his receiver on the switchhook before the operator has completed dialing, the operator is informed of the action by the lighting of supervisory lamp 15 and the operator may then either rering the calling station on the completion of dialing or when the called subscriber answers. Under these conditions relay 25 releases as relay 7 is released and dialing key 16 is operated. When the subscriber at the calling station again removes the receiver from the switchhook lamp 15 is extinguished and the call proceeds in the usual manner.

At the end of a conversation when the lamp 15 is lighted indicating that the calling subscriber has hung up his receiver the operator may remove the plug 20 from the trunk and restore the circuits to normal. When relay 7 releases to light lamp 15 the connection through the tip and ring conductors from plugs 5 to 20 is split and local battery and ground are connected to the tip and ring conductors leading to the calling subscriber over plug 5 and jack 6 while a bridge is connected across the tip and ring conductors leading to the distant exchanges through plug 20. This is to prevent the calling subscriber's station from being signaled on incoming calls from the central office in case the connection has not been taken down immediately after disconnection by the calling subscriber. The local battery and ground is supplied to the calling subscriber's line to permit this subscriber to originate a new call after disconnection. When both cords are removed from the jack all relays restore to normal. The operations are as follows: When the calling subscriber hangs up his receiver relay 7 releases causing the release of relay 9. This splits the cord at the upper outer armature

and front contact for the tip conductor and at the lower middle front contacts for the ring conductor. Relay 9 in releasing also connects battery at its upper inner armature and back contact to the tip conductor and ground to the ring conductor at its lower outer armature and back contacts through the windings of relays 8 and 7. It should be noted however that the upper winding of relay 8 is short-circuited through the upper outer armature and front contact of relay 25 by the above mentioned ground to prevent the false operation of relay 8 when relay 9 is released. At this time a surge of current may occur due to this battery and ground connection charging the usual condenser in the subscriber's set at the calling station. This surge of current, which would pass through the lower winding of relay 8, would have the tendency to cause the relay 8 to operate and thereby cause the release of relay 25 but is prevented from so doing by the short circuit around the upper winding of relay 8. In other words, this short circuit of the upper winding caused by the operated condition of relay 25 prevents the normal circuit through the two windings of relay 8 from being completed on the release of relay 9, while the circuit from battery to ground through the lower winding of relay 8 is not sufficient to operate this relay.

If now the calling subscriber removes his receiver from the switchhook under this condition relays 8 and 7 will both be operated. Relay 8 is operated in this case by the current passing through the lower winding of relay 8. Relay 8 in operating opens the circuit for relay 25 which now releases. Relay 8 in operating also short-circuits as hereinbefore described the calling subscriber's line and relay 7. Relay 9 is then operated, due to release of relays 7 and 25 and operation of relay 8, from battery, upper inner make-before-break contacts of relay 21, winding of relay 9, upper inner armature and back contact of relay 25, lower make-before-break contacts of relay 8, armature and back contact of relay 7 to ground over the sleeve terminals of plug 5 and jack 6 to ground. Relay 9 in operating connects the central office battery and ground through the windings of relay 7 and the calling subscriber's loop causing relay 7 to operate and relay 8 to release. Relay 7 in operating extinguishes the lamp 15 and closes a circuit for the reoperation of relay 25 as hereinbefore described. Relay 25 in operating provides the usual locking circuit for itself under control of relay 9 and relay 7 and places relay 9 under control of relay 7. Under these circumstances therefore it is evident that any delay of the operation of relay 7 from the central office source will not interfere with the proper functioning of relay 9 in establishing the through connection.

If the call is incoming over trunk 200 the ringing relay 204 will be operated. This relay in turn closes a circuit for the operation of the alternating current responsive relay 206. This relay in operating provides a locking circuit for itself through its upper winding and upper armature and front contact and a normal contact of the jack 201. Relay 206 in operating lights a signal 207. In response to this signal the operator inserts plug 20 into jack 201. This opens the locking circuit for relay 206 which releases and extinguishes signal 207. When relay 21 is operated over the sleeve circuit as hereinbefore traced this relay opens the tip and ring conductor connection between plugs 20 and 5 through condensers 23 and 24. Relay 9 is now also operated from battery, upper make-before-break contacts of relay 21, winding of relay 9, upper inner armature and back contact of relay 25 to ground at the lower armature and front contact of relay 8. Relay 9 in operating disconnects at the lower make-before-break contacts ground for the tip conductor and battery from the ring conductor leading to plug 5. It also connects the lower winding of relay 19 across the tip and ring conductors leading to the plug 20 as a holding bridge and connects the tip and ring conductors from plug 20 to plug 5. It will be noted that in order to prevent the operator from receiving clicks while answering, this call her telephone receiver will be momentarily short-circuited due to the operations of the relays 26, 27, 29, 30 and 31 as hereinbefore described. That is, it will be maintained short-circuited between the operation of relays 26 and 31. These relays operate the same regardless of whether the key 16 is operated to answer the call before or after the plug 20 is inserted in jack 201. In either case the ringing will be tripped by the bridge established as hereinbefore described through the right hand winding of retardation coil 32 by the operation of relay 29 and the receiver will be short-circuited to prevent the operator from hearing clicks incident to the answering of the call. When the key 16 is restored to normal the connection is cut through and when plug 5 is inserted into the jack of the desired line, lamp 15 is lighted. When the desired subscriber answers relay 7 is operated to extinguish it and cause the operation of relay 25 as hereinbefore described. Relay 25 in operating provides a locking circuit for itself under control of key 16, and opens the holding bridge consisting of the primary winding of relay 19 from across the trunk 200 and places relay 9 under control of relay 7.

If a connection is established to another private branch exchange over the tie line 300 shown in Fig. 3 from a subscriber through cord circuit A the following operations will take place: The operations in the cord cir-

cuit are the same as hereinbefore described for the extending of a connection over trunk 200. When plug 20 is inserted into jack 301 relay 302 operates over a circuit from battery, winding of this relay to ground at the lower contacts closed by jack 301. Relay 302 in operating disconnects the jack from the trunk 300 and establishes a circuit for relay 304 from battery, winding of this relay, lower inner armature and front contact of relay 302 over the sleeve circuits of jack 301 and plug 20 to ground through the winding of relay 21 as hereinbefore described. Relay 304 in operating closes an obvious circuit for the operation of relay 305. This relay connects battery and ground through the retardation coil 306 for the tip and ring conductors and the left hand windings of repeating coil 307. When now the ringing key 40 is operated to ring the distant end of the tie line, the ringing responsive relay 308 bridged across the tip and ring conductors is operated by ringing current applied by key 40. Relay 308 in operating short-circuits relay 302 at its lower armature and front contact and relay 302 in releasing causes the release of relays 304 and 305. Relay 302 in releasing also disconnects the windings of the repeating coil 307 from the line at the upper inner and middle armatures and front contacts and connects the tip and ring conductors through past the repeating coil 307 at the upper and lower outer armatures and back contacts. The tie line is now cleared from all encumbrances so that ringing will pass through the tip and ring conductors directly out over the tie line. When ringing ceases relay 308 is released and relays 302, 304 and 305 reoperated to reconnect the repeating coil 307 in the line for speech transmission.

The operation of the tie line 400 shown in Fig. 4 will now be described in connection with an outgoing call. The operation of the cord circuit A is the same as hereinbefore described in connection with an outgoing call over trunk 200. When the plug 20 is inserted in the talking jack 401, relay 402 is operated over an obvious circuit closed by jack 401. Relay 402 in operating connects the relay 403 at the upper inner armature and front contact to the open sleeve contacts of the dial jack 405. Relay 406 is connected through the upper outer armature and front contact of relay 402 to the sleeve of jack 401 and relay 407 is operated by an obvious circuit closed through the lower inner armature and front contact to ground. The operation of relay 407 closes a circuit for the lighting of line lamp 408 from battery, lamp 408, upper armature and front contact of relay 409, upper armature and back contact of relay 407 to ground. Relay 406 now operates over the sleeve circuit in series with relay 21 and closes the circuit for the operation of relay 410. Relay 410 in operating connects

battery and ground through the retardation coil 411 to the tip and ring conductors of the jack 401 to supply talking and supervisory battery for the cord circuit.

Relay 402 also closes at its lower outer armature and front contact a bridge across the tip and ring conductors of line 400 outgoing to the distant exchange, through the upper winding of relay 409 and retardation coil 412 to prepare the circuit at a distant exchange for dialing. When the distant exchange is ready for reception of dial pulses a dialing tone will be transmitted through the condensers 413 and 414 over jack 403 to the operator's telephone set in cord A. The operator will then insert a plug corresponding to plug 20 of another cord circuit into the dial jack 405 for the purpose of dialing the distant exchange. Relay 403 is thereby operated over the connection established by relay 402 in series with the relay 21 in the second cord circuit. Relay 403 in operating closes a circuit for the operation of relay 415 from battery, winding of this relay, upper inner armature and back contact of relay 416, armature and front contact of relay 403 to ground. This circuit is also completed through the windings of relay 417 but this relay does not operate at this time as its windings are connected in series-opposing relation to each other. Relay 415 in operating connects a short circuit across the tip and ring conductors of the dial jack at its lower inner armature and front contact and connects the midpoint between the two windings of relay 417 at its upper armature and front contact to the tip conductor of the dial jack. If now relay 21 in the cord circuit has not operated at this time relay 417 will operate as the battery and ground over the tip and ring conductors from the cord circuit causes a difference in potential between the two windings of relay 417. Relay 417 in operating opens at one point the circuit for relay 416 at its lower armature and back contact to prevent this relay from operating when relay 418 operates to close another point of this circuit. Relay 418 will operate over an obvious circuit closed by the operation of relay 415. Relay 418 in operating prepares this operating path for relay 416 at its lower outer armature and front contact and opens a locking circuit for relay 416 at its lower inner contacts. Relay 418 also connects a short circuit across the tip and ring conductors of the tie line at its upper armature and front contact, the purpose of which will be described hereinafter. Relay 418 further opens the ring conductor of the dial jack from the lower armature and front contact of relay 416 at its upper inner contacts.

These relays now remain operated until both battery and ground connections are removed from the cord circuit on the operation of the relay 21 when relay 417 releases closing

the circuit for relay 416 at its lower armature and front contact. Relay 416 operates and prepares a dialing circuit through the tip and ring conductors of the dial jack as follows: As relay 416 in operating opens the operating circuit for relay 415 at its upper inner armature and back contact relay 415 releases, but as it is slow in releasing the locking circuit for relay 416 controlled by relay 418 is prevented from closing in case relay 416 should be operated momentarily when ground is removed from the tip conductor in the cord circuit before the battery is removed which causes relay 417 to release and reoperate due to the change of potential across its winding. When relay 415 releases fully it removes the short circuit from the tip and ring conductors of the dial jack 405 at its lower inner armature and front contact and disconnects relay 417 from the dial jack tip and ring conductors. Relay 415 also opens the circuit for relay 418 and connects the tip conductor of the dial jack to the tip conductor of the line 400 through its upper armature and back contact and the upper outer armature and front contact of relay 416. Relay 418 in releasing closes the locking circuit for relay 416 to the ground at relay 403 before it opens the operating circuit for relay 416 and closes the ring conductor from the dial jack to the line 400 through its inner upper contacts and the lower armature and front contact of relay 416 before it opens the short circuit across the tip and ring conductors of the line. The action of relay 415 in closing the tip conductor through to the line and the relay 418 in closing the ring conductor through to the line before relay 418 removes the short circuit from the line is to prevent the possibility of an open circuit appearing at this time and causing a false impulse to be sent to the distant tie line circuit. Dial tone may now be heard by the operator provided the talking dial key is operated on the cord circuit connected to the dial jack. The operator now dials the desired number at the distant private branch exchange.

After dialing is completed the operator removes the plug of the cord circuit used for dialing from jack 405 causing relay 403 to release which in turn opens the locking circuit for relay 416. Relay 416 in releasing reestablishes the talking connection over the trunk 400 to jack 401 through the cord circuit connected to this jack. When the called subscriber answers the call the direction of the current flowing from the distant private branch exchange is reversed causing the operation of polarized relay 409 to extinguish the lamp 408. Relay 407 now locks under control of relay 409 by the circuit established at the upper armature and front contact of relay 409 to prevent lamp 408 from lighting falsely on disconnection at this exchange.

When the called subscriber disconnects the current from the distant exchange it is returned to the original direction causing the release of relay 409. If this occurs while the plug is still inserted in the jack 401, the line lamp 408 will light as a disconnect signal. If the plug is removed from this jack before the distant exchange disconnects the short circuit is removed from the lower winding of relay 409 by the release of relay 402 to cause an increase in the resistance of the line and thereby in the usual manner release the connection at the distant exchange. Relays 409 and 407 remain operated to prevent the lighting of the line lamp 408 at this time.

A description will now be made of a call incoming over tie line 500 shown in Fig. 5 to a subscriber in the private branch exchange over cord A. When the distant private branch operator applies ringing current to this tie line relay 501 is operated. This relay closes a circuit for relay 503. Relay 501 vibrates in response to the ringing current and opens and closes the circuit for relay 503 but this relay remains operated steadily because of the shunting resistance 504 and capacity 506. The retardation coil 507 and capacity 506 are used to prevent the buzzing circuit from causing noise on the usual battery feeding system. Relay 503 in operating closes a circuit for the operation of relay 510 from battery, winding of relay 510, lower make-before-break contacts of relay 511, upper inner contacts of relay 512 to ground at the armature and front contact of relay 503. Relay 510 closes a circuit for relay 511 from battery, winding of relay 511, lower armature and front contact of relay 510, inner upper contacts of relay 512 to ground at the armature and front contact of relay 503. Relay 511 in operating provides a locking circuit independent of relay 510, the circuit of which is opened by relay 511. Relay 510 is slow in releasing and therefore delays the closing of a circuit for the operation of relay 512 from battery, lower winding of relay 512, upper armature and back contact of relay 510, upper armature and front contact of relay 511 to ground at relay 503. Relay 511 also closes a momentary locking circuit for itself through its lower armature and front contact to ground at relay 503. This circuit is opened on the operation of relay 512 and as relay 510 opened the original energizing circuit relay 511 will now release. Relay 511 completes the obvious circuit for lighting signal 515 closed by relay 512. Relay 511 is slow in releasing. The purpose of the slow-to-release characteristics of relays 510 and 511 is to hold the circuit for signal 515 open long enough to prevent the false lighting of this signal in case relay 501 operates on surges such as may occur upon disconnection. Relay 512 in operating closes a locking circuit for itself from battery, resistance 504, upper

winding of relay 512, upper armature and back contact of relay 517, lower inner armature and front contact of relay 512 to ground at the lower outer armature and back contact of relay 511. This is to maintain relay 512 operated after the original energizing circuit therefor is opened by the release of relay 511. The relay 512 is held operated between the opening of the original circuit and the closing of the locking circuit by the circuit established by its upper armature and front contact for the lower winding to ground at relay 503. In other words, the period of delay in the operation of lamp 550 depends solely on the slow-to-release characteristics of relays 510 and 511 independent of the voltage conditions on the line.

To answer this call plug 20 is inserted into jack 516. This causes the operation of relay 517 over a circuit closed by the jack 516. Relay 517 in operating opens the locking circuit for relay 512 and this relay in releasing opens the circuit for lamp 515. Relay 517 also establishes a connection from ground for the sleeve circuit to provide the usual supervision on the cord circuit. The establishing of a connection to the desired subscriber's line in the private branch exchange may now proceed in the usual manner through the cord circuit A.

Although this invention has been disclosed in connection with but a single system, it should be understood that this is merely illustrative of the invention and that it may readily be applied to other systems without departing from the spirit thereof.

What is claimed is:

1. In a telephone system, subscribers' lines, a cord circuit, a relay for controlling the continuity of said cord circuit, means responsive to the establishing of a connection between two lines through said cord circuit for operating said relay to establish continuity in the cord circuit, and means responsive to the hanging up of the receiver of the telephone set of one line for releasing said relay to break the continuity of said cord circuit.

2. In a telephone system, subscribers' lines, a cord circuit, a slow-to-release relay for controlling the continuity of said cord circuit, means responsive to the establishing of a connection between two lines through said cord circuit for operating said relay to establish continuity in the said cord circuit, and means responsive to the hanging up of the receiver of the telephone set of one line for permitting the release of said relay in accordance with its slow-to-release characteristics.

3. In a telephone system, subscribers' lines, a cord circuit, a relay for controlling the continuity of said cord circuit, a supervisory relay having its windings included in the tip and ring conductors of the cord circuit, means

responsive to the establishing of a connection between two lines through said cord circuit for operating said relays independently, means for transferring the control over the first mentioned relay to the supervisory relay to maintain it operated when the supervisory relay is operated, and means responsive to the hanging up of the receiver of the telephone set of one line for releasing the supervisory relay to release the first mentioned relay to break the continuity in the cord circuit.

4. In a telephone system, lines, trunks, a cord circuit, a relay for controlling the continuity of said cord circuit, a supervisory relay in said cord circuit, means for operating said supervisory relay on the connection of the cord circuit to a line, means for operating said first mentioned relay on the connection of the cord circuit to a trunk, means responsive to the operation of said first mentioned relay for releasing the supervisory relay and for establishing the continuity of said cord circuit, means for reoperating said supervisory relay, and means for transferring the control of said first mentioned relay to said supervisory relay responsive to the reoperation of said supervisory relay.

5. In a telephone system, lines, a cord circuit, a relay for controlling the continuity of said cord circuit, means responsive to the establishing of a connection between two lines through said cord circuit for operating said relay to establish continuity in said cord circuit, a supervisory relay in said cord circuit, means for transferring the control over said first mentioned relay to said supervisory relay, a current supply in said cord circuit, a current supply in one of said lines, means for transferring the control over said supervisory relay from the current supply in the cord circuit to the current supply in said line, and means for preventing the first mentioned relay from releasing during the transfer of control of said supervisory relay from one current supply to the other.

6. In a telephone system, a subscriber's line terminating in a telephone set including a condenser, a trunk, means for connecting said line and trunk, a first relay, a current supply, a second relay having two windings normally connected in circuit between said current supply and line, means for releasing said first relay when said subscriber hangs up his receiver to disconnect said trunk from said line and connecting the current supply to the subscriber's line through the windings of said second relay, a third relay, means for actuating said third relay in response to the establishing of a connection, means for holding said third relay under control of said second relay, and means for short-circuiting one winding of said second relay under control of said third relay for preventing said second relay from operating

on the charging of the condenser in the subscriber's telephone set at the connection of the current supply to the subscriber's line.

7. In a telephone system, a subscriber's line, a cord circuit, a trunk, a supervisory relay, means for establishing a connection between said subscriber's line and trunk through said cord circuit under control of said supervisory relay, means responsive to the subscriber replacing his receiver on the switchhook for splitting the connection through the cord circuit under the control of said supervisory relay, and means responsive to the subscriber again removing his receiver from the switchhook for reestablishing a connection through the cord circuit independent of the supervisory relay.

8. In a telephone system, a subscriber's line, a cord circuit, a trunk, means for establishing a connection between said subscriber's line and trunk through the cord circuit, a supervisory relay, means for releasing said relay in response to the subscriber replacing his receiver on the switchhook, a splitting relay, means for releasing said splitting relay to split the connection through the cord circuit in response to the release of the supervisory relay, and means thereafter responsive to the removing of the receiver from the switchhook for reestablishing a connection through the cord by the reoperation of the splitting relay independent of the supervisory relay.

9. In a telephone system, a subscriber's line, a cord circuit, a trunk, a supervisory relay, means for establishing a connection between said subscriber's line and trunk through said cord circuit under control of said supervisory relay, means responsive to the subscriber replacing his receiver on the switchhook for splitting the connection through the cord circuit under the control of said supervisory relay, means responsive to the subscriber again removing his receiver from the switchhook for reestablishing the connection through the cord circuit independent of the supervisory relay, a current supply in the trunk circuit, means for connecting this current supply to the cord circuit after the reestablishing of the connection through the cord circuit, means responsive to this connection of the current supply for operating the supervisory relay, and means responsive to this operation of the supervisory relay for placing the splitting means under control of said supervisory relay.

10. In a telephone system, a line, trunks, a cord circuit for connecting a line and a trunk, a current supply in said cord circuit, means responsive to the connection of the cord circuit to a subscriber's line for connecting said supply to a subscriber's line, means responsive to the connecting of the cord circuit to a trunk for short-circuiting said sub-

scriber's line, for removing said supply from said cord circuit, for establishing a bridge across the tip and ring conductors of said cord circuit for removing said short circuit, and for connecting the tip and ring conductors of the cord circuit through from the subscriber's line to the trunk, a current supply in said connected trunk, and means responsive to the removal of the short circuit and the connection of the tip and ring conductors through the cord circuit for the passage of current therethrough from said supply in the trunk for removing the bridge.

11. In a telephone system, lines, trunks, a cord circuit for connecting a line and a trunk, a battery and ground connection, means responsive to the establishing of a connection between the cord and the subscriber's line for connecting said battery and ground connection to the tip and ring conductors of the subscriber's line, means responsive to the establishing of a connection between the cord circuit and the trunk for short-circuiting the line, for removing the battery and ground connection from the cord circuit, for applying a bridge across the tip and ring conductors, for removing the short circuit, and for connecting the tip and ring conductors through to the trunk, a battery and ground connection in the trunk, and a relay means responsive to current from said last mentioned battery and ground connection for removing the bridge.

12. In a telephone system, subscriber's lines, trunks, a cord circuit for connecting subscribers' lines with trunks, an operated telephone set, means for associating said telephone set with a cord circuit, means responsive to the connection of a cord circuit to a trunk and the association of the telephone set to said cord circuit for short-circuiting the receiver in said set, for establishing a bridge across the tip and ring conductors of the cord circuit and for maintaining said short circuit and bridge for a short interval.

13. In a telephone system, a calling line, a trunk, a cord circuit for connecting said line to said trunk, an operator's telephone set, means for opening the connection through the tip and ring conductors of the cord circuit when the subscriber hangs up the receiver on the switchhook to release a connection, means for connecting the operator's telephone set to the part of the cord circuit connected to the trunk, means for short-circuiting the operator's receiver in response to the connection of the operator's telephone set to said cord, means for establishing a bridge across the tip and ring conductors of the part of the cord circuit connected to the trunk, and means for maintaining said short circuit and said bridge for a short interval thereafter.

14. In a telephone system, a cord circuit, a trunk, means for connecting the cord circuit

to the trunk, an operator's telephone set, means for connecting said telephone set to the cord circuit, means responsive to the connection of the cord circuit to the trunk and the operator's telephone set to the cord circuit for establishing a short circuit for the operator's receiver, a bridge across the tip and ring conductors of the cord, and means operative a short interval thereafter for opening the bridge and for shortly thereafter opening the short circuit.

15. In a telephone system, a trunk, a cord circuit, a ringing trip relay in the trunk, an operator's telephone set, means for connecting the telephone set to the cord circuit, means for connecting the cord circuit to the trunk, means responsive to the connection of the cord circuit to the trunk and the set to the cord circuit, for short-circuiting the receiver and for establishing a bridge across the tip and ring conductors of the trunk to operate said ringing trip relay, and means for removing said bridge and opening the short circuit a short interval thereafter.

16. In a telephone system, a cord circuit, a trunk, means for connecting the cord circuit to the trunk, an operator's telephone set, a dial, means for connecting said set and dial to the cord circuit, and means thereafter responsive to the operation of the dial for short-circuiting the receiver during the dialing and for a short interval thereafter.

17. In a telephone system, a cord circuit, a trunk, means for connecting the cord circuit to the trunk, an operator's telephone set, a dial, means for connecting said set and dial to the cord circuit, means responsive to said connection of the set and dial to the cord circuit for short-circuiting the receiver and establishing a bridge across the tip and ring conductors of the cord circuit for a short interval, and means thereafter responsive to the operation of the dial for short-circuiting the receiver during the dialing and for a short interval thereafter.

18. In a telephone system, a trunk, a cord circuit, means for connecting said cord circuit to said trunk, a repeating coil in said trunk, means responsive to the establishing of a connection between the cord and the trunk for connecting said repeating coil across the conductors of said trunk, a ringing responsive relay in said trunk, means for applying ringing current to said trunk for operating said relay, and means responsive to the operation of said relay for removing the repeating coil from across the conductors of said trunk.

19. In a telephone system, a tie line having a talking connection and a dialing connection, means for establishing the talking connection to the tie line and means for establishing the dialing connection to the tie line, means responsive to the establishing of the

5 dialing connection for short-circuiting it and
for short-circuiting the tie line, a dial, means
for connecting said dial to the dialing con-
nection, and means responsive to said connec-
10 tion of the dial for opening the talking con-
nection, for removing the short circuit from
the dialing connection, for connecting the
tip conductor through from the dialing con-
nection to the tie line, for connecting the ring
15 conductor through from the dialing connec-
tion to the tie line, and for removing the
short circuit from the tie line.

20. In a telephone system, a trunk, a cord
circuit, a ringing bridge across the conduc-
tors of said trunk, a dial associated with said
15 cord, means responsive to the moving of the
dial off normal for removing said ringing
bridge from across the conductors of said
trunk.

21. In a telephone system, a tie line, a
20 relay in said tie line, a signal, and means
responsive to the operation of said relay for
actuating said signal a short interval after
the operation of the relay, said means includ-
25 ing only slow-to-release relays.

In witness whereof, I hereunto subscribe
my name this 27th day of May, 1931.

LANGFORD J. BOWNE.

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