

Sept. 26, 1939.

J. F. TOOMEY

2,173,924

TELEPHONE SYSTEM

Filed Dec. 16, 1937

4 Sheets-Sheet 1

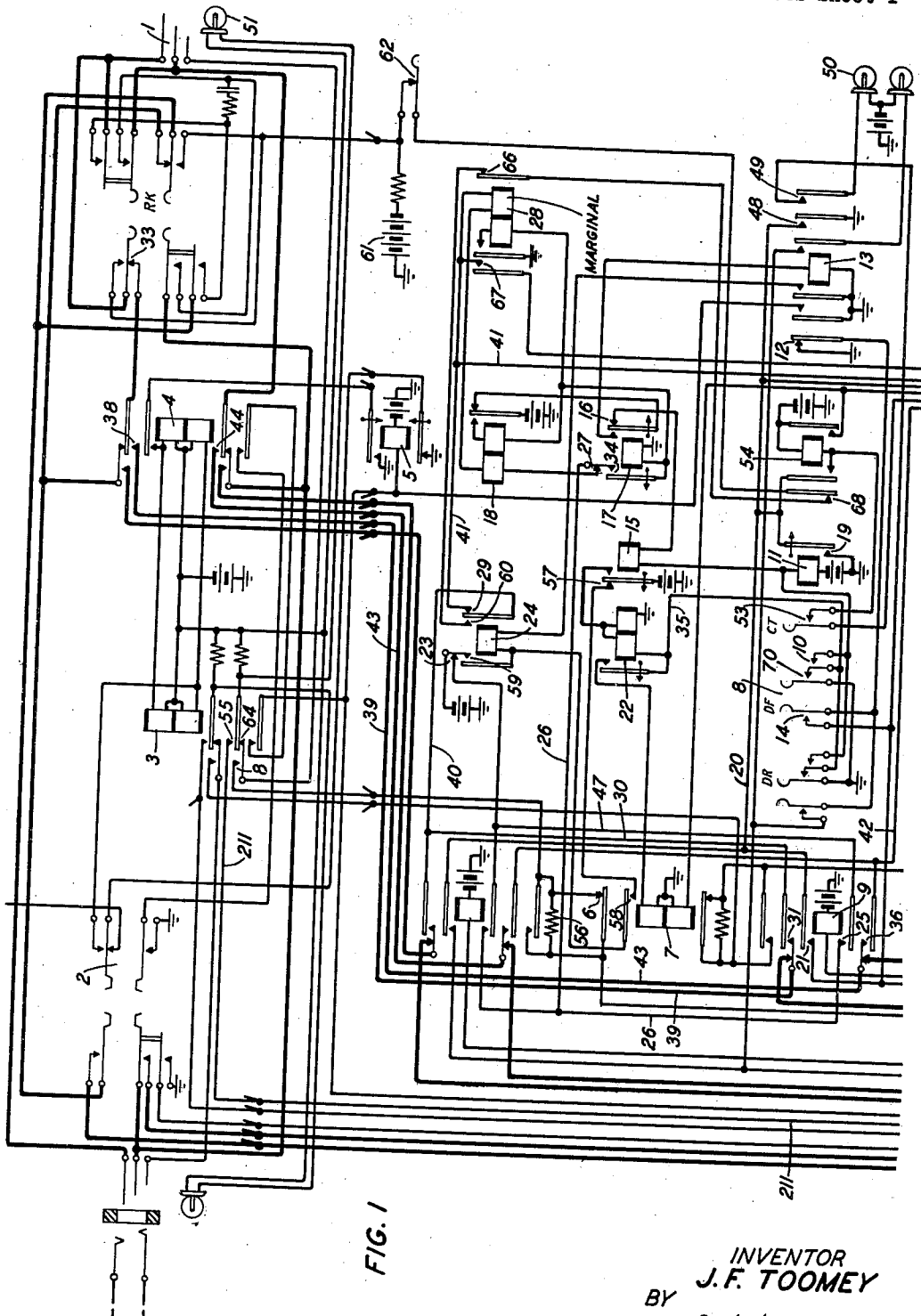


FIG. 1

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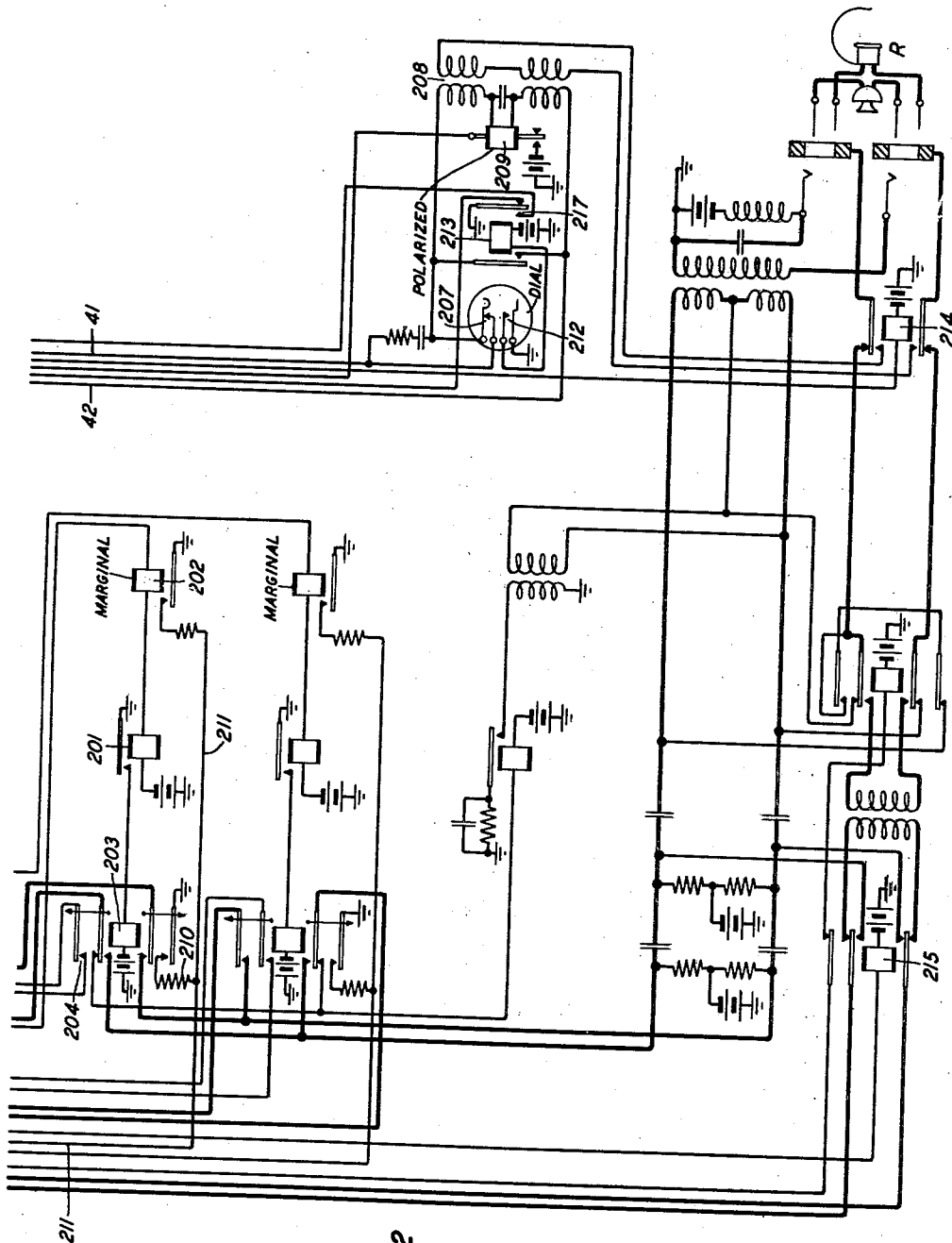


FIG. 2

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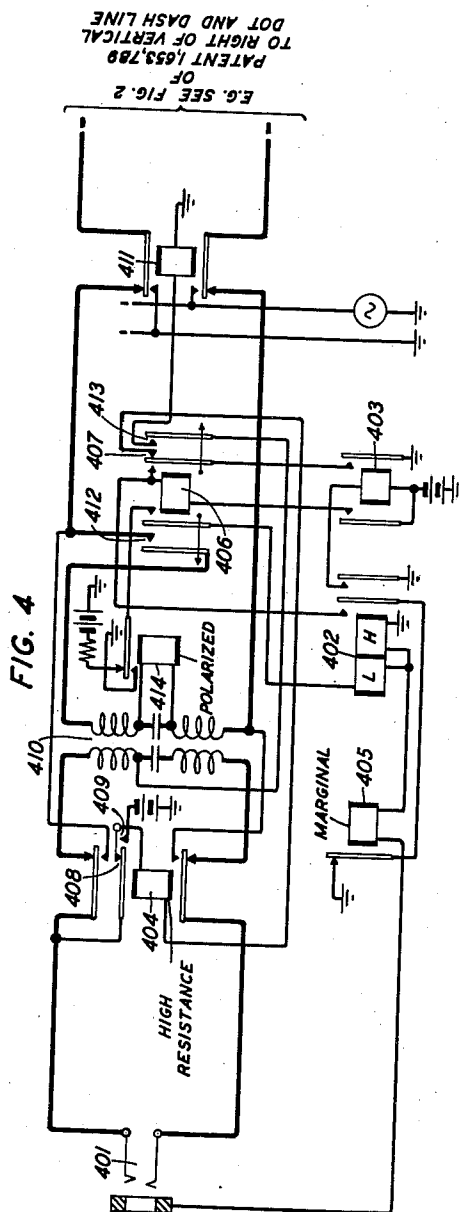
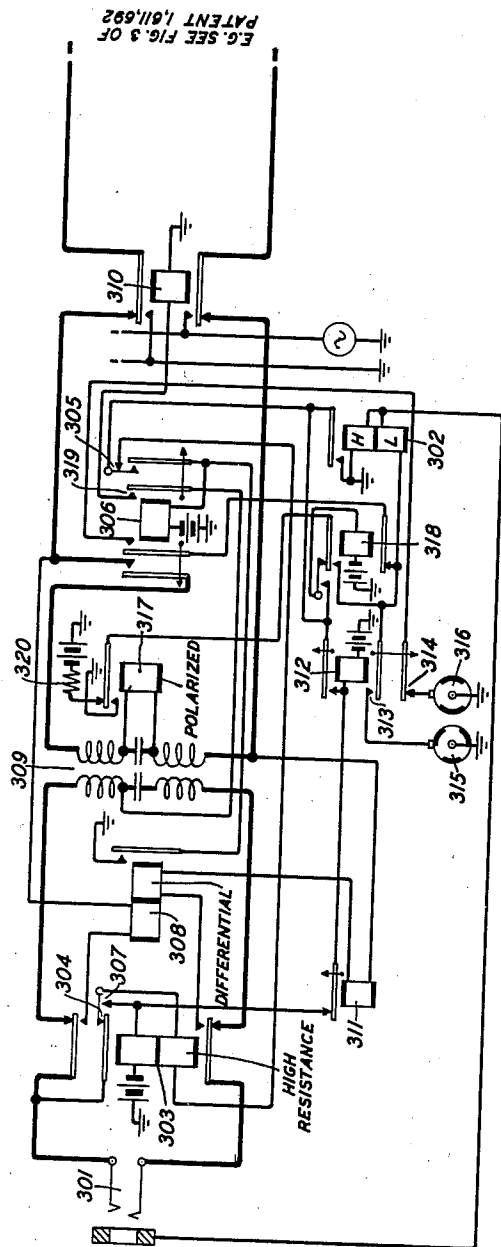
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Sept. 26, 1939.

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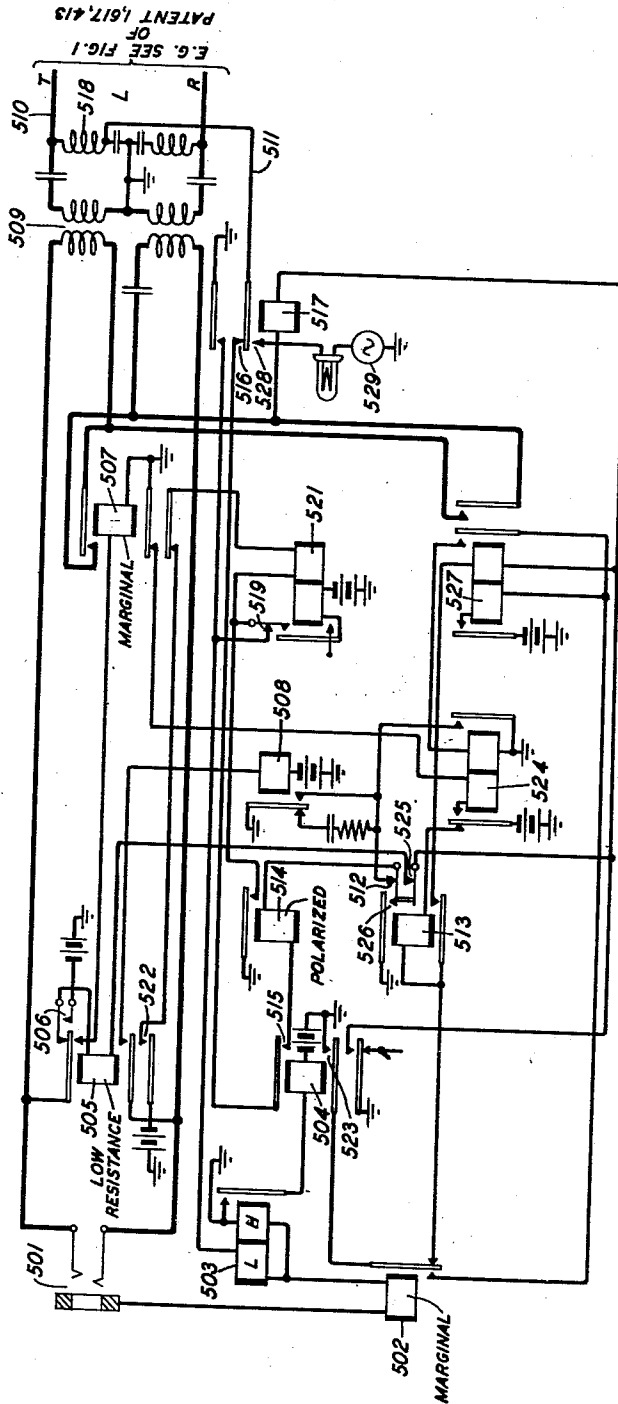
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4 Sheets-Sheet 4

FIG. 5



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2,173,924

TELEPHONE SYSTEM

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Application December 16, 1937, Serial No. 180,069

12 Claims. (Cl. 179—27)

This invention relates to improvements in telephone systems and more particularly to improvements in circuit arrangements for enabling toll operators to extend toll connections to subscribers' lines in automatic exchanges.

At the present time there are several so-called "dialling trains" which provide circuit facilities between a toll switchboard and an automatic subscriber's exchange which are identified by such names as "loop dialing toll trains", "repeated dialing toll trains", "AB toll trains", "local trains", "community dial office trunks" and "dial toll lines".

As an example of the loop dialing toll trains reference may be had to United States Patent 1,653,789 which shows a toll operator's cord, position, and dial circuit and a trunk circuit extending from a toll switchboard to a distant automatic exchange in which arrangement seizure of the out trunk jack by the operator and operation of a so-called "dial key" associates the operator's dial circuit with the cord whereupon the contacts of the dial are serially connected in a loop circuit extending from the operator's position, over the trunk and through the so-called line or pulsing relay at the automatic office and wherein, at the conclusion of the dialing operation when the selector switch at the automatic office seizes the called line, a reversal of current in the line is effected which causes the dial to be automatically disconnected from the cord.

An example of the so-called repeated dial toll trains is disclosed in United States Patent 1,474,008 to Stokely, which differs from the arrangement of Patent 1,653,789 in that the dial when connected to the cord controls a repeating relay in the outgoing end of the trunk which follows the interruptions of the dial contacts and repeats or relays these interruptions or impulses over the line, hence the designation "repeated dialing toll train". In this arrangement the dial is disconnected from the cord as soon as the dial key is released without waiting for a current reversal when the called line is seized.

An example of a so-called dial toll line is disclosed in United States Patent 1,617,413 to L. A. Mortimer, which shows a toll line outgoing from a toll operator's position to a distant automatic exchange, which line is arranged to simultaneously transmit telephone and telegraph signals, i. e., is composited.

Due to the fact that it is necessary in some instances to terminate two or more kinds of dial lines in the same switchboard, additional equipment has heretofore been required for each line,

which differs from the type of line for which the switchboard, position and dial circuits are equipped to function. For example, in the case of a toll board arranged with position and dial circuits to work with repeated dial toll trains, if it became desirable to terminate trunk circuits therein arranged for loop dialing, it has been necessary to provide additional equipment (dial jack circuit) at the outward end of each loop dial trunk in order that the switchboard cord circuit will properly function therewith.

An object of the present invention is therefore to so arrange the circuits of the operator's position, and the outgoing end of the various types of lines above mentioned, that the operator can operatively connect any one of her cord circuits to any of the above-described lines appearing at her position.

Features of the invention in accordance with the above object are as follows:

1. Means for connecting and locking the dial circuit to either end of the cord in response to the operation of a non-locking dial key. By this arrangement the dial key need only be held operated long enough for a group of relays to operate whereupon the dial is locked to the cord under control of either a polarized relay in the dial circuit, which is operated when the distant exchange equipment transmits a current reversal to cause the trunk to cut-through into the talking position and to release the dial circuit from the cord, or, in the absence of such reversal, under control of a release key at the operator's position.

2. Means for selectively associating the dial circuit with either end of the cord.

3. Means for preventing the operator from connecting the dial circuit with both cords of a pair simultaneously.

4. Means for insuring that the tip of the cord is in contact with the tip of the outgoing line jack and the line circuit is in condition to receive pulses before a dial pilot lamp at the operator's position is lighted, to signal to the operator to commence dialing.

5. Means for transmitting tone, ringing induction, etc. to the operator, when they are applied to the distant end of the line, as soon as the dial returns to normal.

6. Means for preventing the release of the dial from the cord, while the dial is "off normal".

7. Means for transmitting a signal to cause the line circuit to be cut-through into the talking condition before the dial circuit is released from the cord.

8. Means for automatically starting machine

ringing in response to a line reversal on either loop or repeated dialing toll trains.

9. Means LR to prevent the start of automatic ringing on dial toll lines which transmit a reversal during establishment of a connection.

10. Means for reassociating the dial with the cord, at will, on connections to dial toll lines.

The invention will be understood from the following description and the accompanying drawings, Figs. 1 and 2 of which when placed together with Fig. 1 above Fig. 2, represent a toll operator's cord and position and dial circuits arranged in accordance with the present invention, and Figs. 3, 4 and 5 represent the outgoing end of trunk circuits adapted to function with either end of the cord circuit shown at the top of Fig. 1.

Fig. 3 is an outgoing trunk circuit for use with a line extending to a step-by-step automatic exchange and terminating thereat in a so-called repeated dial toll train, the trunk circuit in this figure being provided with a differential relay in series with the trunk conductors during dialing for causing the trunk to be "cut through" in condition for conversation when the called line in the distant exchange has been seized.

Fig. 4 is an outgoing trunk circuit for use with so-called loop dial toll trains and is provided with a marginal relay in the sleeve circuit to effect the "cut through" operation when the called line is seized.

Fig. 5 is an outgoing trunk circuit for use with a toll line arranged to transmit dial pulses and other signals over a composite circuit.

Call extended over a repeated dial train

The invention will first be described in connection with a call from the toll office, Figs. 1, 2 and 3, to a subscriber in a distant automatic step-by-step exchange over a line terminating in the distant exchange in a so-called repeated dial toll train which functions in the following well-known manner:

(a) During the progress of establishing the connection, the pulsing circuit is opened if an "all trunks busy" condition is encountered.

(b) If the called line is busy the pulsing circuit is not opened but a distinctive tone is connected to the tip conductor of the line leading back to the toll office.

(c) If the called line is idle and is seized by the connector switch the tip and ring conductors are reversed thereby connecting the negative pole of the central office battery to the tip of the line and ground to the ring which causes current to flow in an opposite direction in the line leading back to the toll office.

(d) When the called subscriber answers by removing his receiver from the switchhook battery and ground is removed from the line.

Repeated dial toll trains employing circuit arrangements which function in the above manner are well known and further description of such circuits is deemed unnecessary.

When the toll operator receives a call for a subscriber in a distant automatic exchange which is reached over a line extending through a repeated dial toll train which functions in the manner described, she inserts either end of her cord circuit, the right-hand end for example, terminating in plug 1, into jack 301 of the trunk (Fig. 3) and operates her talk key 2 whereupon relays 3 and 4 operate in parallel in a circuit which can be traced from ground, lower contacts of relay 5, upper contacts of key 2 and the lower winding of relays 3 and 4 in parallel to battery.

The operation of relays 3 and 4 completes a circuit to operate relay 5 which can be traced from ground, lower contacts of key 2, lowermost contacts of relays 4 and 3 and the winding of relay 5 to battery. Relay 5 in operating opens at its lower contact the initial circuit for operating relays 3 and 4 but closes an obvious substitute circuit, at its upper contacts, to hold these relays over their upper windings in parallel.

With plug 1 in jack 301 the operation of relay 3 completes a circuit to operate relay 302 in the trunk which can be traced from battery, windings of relays 201 and 202 of Fig. 2, contact 6 of relay 7, contacts 8 of relay 3, sleeve conductor of plug 1 and jack 301 and upper winding of relay 302 in the trunk to ground.

Relay 202 is marginal and does not operate due to the resistance value of the upper winding of relay 302 but relay 201 does operate thereby closing an obvious circuit to operate relay 203.

The next act of the operator is to actuate the dial key 8 thereby causing operation of relay 9 in a circuit which can be traced from ground, contacts 12 of relay 13, contacts 14 of key 8, contacts 204 of relay 203 and winding of relay 9 to battery.

Operation of key 8 and the closing of its contacts 14 and 18 also operates relays 11 and 15 in parallel, the circuit for relay 11 being obvious and that for relay 15 extending over contacts 16 of relay 17 to battery at the outer right contacts of relay 18. Relay 11 in operating closes its contacts 19 thereby closing a holding ground for relay 9 which can be traced from ground, contacts 15 of relay 11, conductor 20, contacts 21 of relay 9, contacts 264 of relay 203 and winding of relay 9 to battery.

Relay 9 in operating closes its contacts 31 and 36 thereby connecting the dial contacts 207 across the tip and ring of the cord in a circuit which can be traced from the tip of the plug 1, contacts 33 of the ringing key RK, contacts 38 of relay 4, conductor 39, contacts 31 of relay 9, conductors 30 and 40, contacts 29 of relay 24, conductor 41, normally closed contacts 207 of the dial, upper left winding of transformer 208, winding of polarized relay 209, lower left winding of transformer 208, conductor 42, contacts 36 of relay 9, conductor 43, contacts 44 of relay 4 to the ring conductor of the plug 1.

Relay 15 in operating operates relay 22, over its right-hand winding. Relay 22 closes a circuit from battery through its left-hand winding and front contact to ground through the upper winding of relay 7 but this relay not operate as it is short-circuited by ground over conductor 35 from the key 8. With relays 9 in the cord circuit and 302 in the trunk circuit operated a circuit is completed to operate relay 18 in the cord circuit and relay 303 in the trunk, which can be traced from battery, contacts 23 of relay 24, conductor 47, contacts 25 of relay 9, conductor 26, contacts 27 of relay 17, left-hand winding of relay 18, right-hand winding of relay 28, contacts 29 of relay 24, conductors 40 and 30, contacts 31 of relay 9, conductor 39, contacts 38 of relay 4, contacts 33 of the ringing key RK, tip conductor of the plug 1 and jack 301, contacts 304 and lower winding of relay 303, contacts 305 of relay 306 to ground at the upper contacts of the sleeve relay 302.

Relay 18 of the cord circuit and relay 303 in the trunk circuit operate in this circuit but relay 28 is marginal and does not operate due to the circuit resistance.

Relay 18 in operating closes a circuit including

its front contact and right-hand winding and the winding of relay 17, which latter relay now operates. The operation of relay 17 first closes its contacts 34 which completes a locking circuit for itself which can be traced from battery, contacts 23 of relay 24, conductor 47, contacts 25 of relay 9, conductor 26 and contacts 34 and winding of relay 17 to ground, and later opens its contacts 27 thereby opening the operating circuit previously traced for relay 18 which latter relay thereupon releases and closes its back contacts thereby connecting battery to operate relay 13 over the right-hand front contacts of relay 17.

Relay 13 in operating closes at its contacts 48 and 49 a circuit to light the dial pilot lamp 50 to indicate that the dial is now connected to the front plug 1 of the cord circuit. This circuit can be traced from ground, contacts 48 of relay 13, conductor 20, contacts 21 of relay 9, contacts 49 of relay 13 and lamp 50 to battery. The same ground supplied over contacts 48 of relay 13 operates relay 214, thereby connecting the operator's receiver R across the right-hand winding of repeating coil 208 to enable the operator to hear tones which may be transmitted back over the trunk during the process of building up the connection, and provides a locking circuit for relay 9 to hold this relay operated after the dial key 8 is released. This locking circuit can be traced from ground, contacts 48 of relay 13, conductor 20, contacts 21 of relay 9, contacts 204 of relay 203 and winding of relay 9 to battery.

The dial key need be held operated only momentarily, just long enough for relay 11 to operate, after which it can be released, thereby opening the circuit of relay 11. This relay is slow to release, however, and holds operated long enough so that relay 13 operates to lock relay 9 before relay 11 opens the previously traced holding circuit of relay 9. In case relay 13 fails to operate for any reason, the release of relay 11 will release relay 9 which disconnects the dial from the cord and returns the circuit to normal.

The operation of relay 13 opens its contacts 12, thereby removing ground from the contacts of the dial key thus preventing the operator from connecting the dial circuit with a second cord before it is released from the first cord. Relay 13 also closes its contacts 65 thereby connecting a holding ground for relays 5 and 215 thus preventing release of these relays before the dial is released in case the talk key 2 is released.

When relay 303 in the trunk operates in response to the joint operation of relays 302 and 9 it opens its contacts 304 and closes contact 307 thereby disconnecting it from the tip conductor of the trunk and completing a locking circuit for itself which can be traced from battery, upper winding, contact 307, and lower winding of this relay, contact 305 of relay 306 and the upper contacts of relay 302 to ground. Relay 303 also opens its upper and lower normal contacts thereby disconnecting the tip and ring of the jack from the repeating coil 309 and closes the upper and lower alternate contacts thereby extending the tip and ring conductors through the windings of differential relay 308, around the repeating coil 309 and over back contacts of ringing relay 310 to the tip and ring trunk conductors extending from the right-hand side of the drawing which are connected to the line extending to the distant exchange. Relay 311 is also included in series with the right-hand winding of relay 308 in the ring conductor of the trunk.

When the trunk is extended through to bat-

tery in the distant office, by operation of relay 303, the impulse relay in the first selector thereat operates together with relay 311 of Fig. 3. Relay 308 is differentially connected and therefore as current flows in both windings in opposition to each other the relay does not operate.

The foregoing circuit can be traced from negative battery on the ring conductor of the line, lower back contact of relay 310, winding of relay 311, right-hand winding of relay 308, lower alternate contact of relay 303, ring contacts of the jack 301, and plug 1 of Fig. 1, contacts 44 of relay 4, conductor 43, contacts 36 of relay 9, conductor 42, lower left winding of repeating coil 208 (Fig. 2), polarized relay 209, upper left winding of repeating coil 208, contacts 207 of the dial, conductor 41, contacts 29 of relay 24, conductors 40 and 30, contacts 31 of relay 9, conductor 39, contacts 38 of relay 4, contacts 33 of the ringing key RK, tip of the plug 1, and jack 301, upper alternate contact of relay 303, left-hand winding of relay 308, upper normal contacts of relay 310 to ground on the tip conductor of the line to the distant office.

Polarized relay 209 of the dial circuit (Fig. 2) does not operate on the direction of the current flowing at this time in the circuit just traced.

The circuit is now in readiness to receive dial pulses which are initiated by rotating the dial (Fig. 2). When the dial is moved off normal, contacts 212 are closed thereby connecting ground to operate relay 213 which removes ground from the contacts of the cut-through key 53 and prevents its accidental operation, before the dial returns to normal, from operating release relay 54 and causing the dial circuit to be disconnected from the cord. Operation of relay 213 also short-circuits the left-hand windings of repeating coil 208 thereby preventing the impedance of the coils, including relay 209, from distorting the pulses.

Return of the dial to normal opens and closes its contacts 207 in a well-known manner, thereby alternately releasing and operating the impulse relay in the distant office the number of times corresponding to the first digit of the called subscriber's number. Relay 311, (Fig. 3) however, is slow to release and remains operated during the pulsing interval.

The extension of the call from this point as controlled by the operation of the impulse relay in the distant office is accomplished in the usual manner well known in the art.

In case an "all trunks busy" condition is encountered by the selector at the automatic office, the foregoing pulsing circuit is opened by the operation of a switch at that point, which operates when the selector makes its eleventh rotary step and relay 311 releases thereby closing a circuit to operate relay 312 which can be traced from ground, contacts of relay 302, contacts 305 of relay 306, lower winding and contacts 307 of relay 303, back contacts of relay 311 and winding of relay 312 to battery. Relay 312 closes its upper contacts and locks itself operated to ground at the contacts of relay 302. Relay 312 also closes its lower contacts 313 thereby connecting ground through the fast interrupter 315 (120 I. P. M.) to the sleeve of the trunk and cord through the lower (low resistance) winding of relay 302, thereby short-circuiting the upper or high resistance winding of this relay, and lowering the resistance in the sleeve circuit sufficiently that the supervisory lamp 51 in the cord will flash in step with the interrupter as an indi-

cation to the operator that all trunks are busy whereupon she removes the plug 1 of jack 301 and the circuit restores to normal.

Prior to this time the joint resistance of the upper and lower windings of the sleeve relay 302 in the trunk was sufficiently high to prevent operation of marginal relay 202 in the position circuit (Fig. 2), but when the upper high resistance winding of relay 302 is short-circuited, the resistance in the sleeve circuit is lowered to the point at which relay 202 operates in step with the interrupter 315. Relay 202 closes its contacts thereby connecting ground to conductor 211, over contacts 55 of relay 3, and through the supervisory lamp 51 to battery.

If, however, an idle trunk is found by the selector the extension of the call is continued, following the second operation of the dial, in the usual and well-known manner.

If an "all trunks busy" condition is encountered by the toll transmission selector in the distant office another switch operates on the eleventh rotary step of the selector switch and again causes relay 311 to release thus causing the cord supervisory lamp 51 to flash under control of interrupter 315 as previously described.

If an idle trunk is found leading to the connector at the distant office, the operator will not receive any signal and the third and fourth series of impulse (tens and units digits) may be transmitted by again rotating the dial which steps the connector into engagement with the called line.

If the called line is busy no battery reversal occurs at the distant office, but a tone is applied to the tip of the line which is transmitted back over the trunk and, when the dial is normal, through the left-hand winding of repeating coil 208. Due to the fact that the operator's receiver is connected across the right-hand winding of the coil at this time the tone is heard in the operator's receiver as an indication that the called line is busy whereupon the operator will remove the plug from the jack thereby restoring the circuit to normal.

If, however, the called line is idle the tip and ring of the trunk are reversed at the distant office and polarized relay 209 in the dial circuit operates to disconnect the dial circuit from the cord and cause the cut-through relay 306 in the trunk to operate thereby introducing the repeating coil 309 into the trunk and conditioning it for speech transmission. The steps whereby this is accomplished will now be described.

When relay 209 operated it closed an obvious circuit to operate relay 7, which relay completed a circuit to operate relay 24 which circuit can be traced from battery, contacts 57 of relay 15, contacts 58 of relay 7, winding of relay 24 and ground at the inner left contacts of relay 13. Relay 24 operated and locked itself, over its contacts 59, to battery under control of relay 13, which relay, however, will soon release. Relay 24 also connects, at its contacts 60, 45-volt battery 61 through a resistance and key 62, contacts 63 of relay 54, right-hand back contacts 66 of relay 28, to conductors 40 and 30, contacts 31 of relay 9, conductor 39, contacts 38 of relay 4 and contacts 33 of the ringing key RK to the tip of the plug and jack.

Due to the fact that the battery at the central office is reversed at this time so that the 24-volt central office battery is now connected to the tip, it will be noted that, with the dial circuit previously traced open at contacts 29 of relay 24 and the ground connected to the ring in the dial circuit,

no current flows in the right-hand winding of differential relay 308 and consequently current, due to the difference of potential between the 24-volt battery at the distant central office and the 45-volt battery in the position circuit, flows in the left-hand winding of relay 308 which causes it to operate.

Relay 308 in operating closes an obvious circuit to operate the cut-through relay 306 which connects the right-hand winding of repeating coil 309 to the trunk conductors extending to the distant office. Operation of relay 306 also opens its contacts 305 thereby releasing relay 303 which, in releasing reconnects the tip and ring of the jack to the left-hand winding of repeating coil 309 and disconnects the previously traced pulsing circuit, including relay 308. When the line is cut through by the operation of relay 306, polarized relay 317 will operate due to the fact that negative battery at the distant office is connected to the tip of the trunk and ground or positive battery to the ring. Operation of relay 317 operates relay 318 which locks up to ground at the contacts of relay 302. With relays 317 and 318 operated, ground is connected to the lower winding of sleeve relay 302 thereby reducing the sleeve circuit resistance to a point where the marginal relay 202 in the position circuit operates thereby lighting supervisory lamp 51 as an indication to the operator that the called line has been found idle and seized.

Further, release of relay 303 and the connection of the tip conductor to the upper left-hand winding of the repeating coil 309 connects the 45-volt battery 61, now connected to the tip of the cord, by operation of relay 24, through to the ringing relay 310 which can be traced from the tip of the trunk jack, upper normal contacts of relay 303, upper left-hand winding of repeating coil 309, contacts 319 of relay 306, and winding of relay 310 to ground. Operation of relay 310 connects ringing current at its inner contacts to the line extending to the distant office where it operates a relay which initiates ringing on the subscriber's line, in a well-known manner. Relay 310 is only operated momentarily as it releases as soon as relays 24 and 9 in the position circuit release as explained below.

Returning now to the cord, position and dial circuit, when relay 24 operated and attracted its left armature it opened contact 23 and thereby disconnected battery from conductor 47 which up to this time has held relay 17 operated. Relay 17 now, therefore, releases slowly and after an interval opens the circuit for relay 13 which in turn releases thereby opening its contacts 48 and 49 and extinguishing pilot lamp 50. Removal of ground, at contacts 48 of relay 13, from conductor 20 also opens the locking circuit of relay 9 which relay then releases and disconnects the dial circuit from the cord. Release of relay 13 also opens the circuit for relay 24 which now releases to disconnect the battery 61 from the tip of the cord. Relay 13 also releases relay 5 which unlocks relays 3 and 4 which release provided the talk key 2 has been released. Due to the slow release of relay 17 relays 9 and 24 do not release until after relay 310 has operated. The dial circuit is now disconnected from the cord. When relay 3 releases it opens its contacts 8 and closes contacts 64 thereby establishing a direct connection between supervisory lamp 51 and the sleeve of the plug 1, independent of relay 202 in the position circuit.

When the called subscriber answers by removing his receiver from the switchhook, the ringing

current is disconnected from his line and battery is disconnected from the line leading back to the toll office, whereupon relay 317 releases and substitutes battery, through a resistance 320 for the ground which was connected to the sleeve through the lower winding of sleeve relay 302. Under this condition, the sleeve resistance is once more increased to a point which extinguishes supervisory lamp 51. Connection of battery to relay 302 prevents this relay from releasing and breaking down the connection in case the operator should remove plug 1 from jack 301 for any reason, as, for example, to change cords.

When the called subscriber hangs up relay 317 again operates and reconnects ground to the lower winding of relay 302 which reduces the resistance of the sleeve circuit and relights the supervisory lamp 51 as a signal to the operator that the conversation is ended.

Call extended over a loop dial train

We will next assume that the called subscriber is in a distant automatic exchange reached over a line connected to the trunk circuit shown in Fig. 4, which line terminates in a so-called loop dial toll train at the automatic exchange which functions as follows:

(a) During the progress of establishing the connection an all-trunk busy condition is encountered, the tip and ring conductors are reversed thereby connecting the negative pole of the central office battery to the tip of the line and ground to the ring conductor and this reversed battery supply is interrupted 120 times a minute.

(b) If the called line is busy the central office battery is reversed with respect to the line in the same manner as in the case of an all-trunks busy condition the only difference being that this circuit is interrupted at a different rate, usually slower, i. e., 60 times a minute.

(c) When the called line, if idle, is seized battery is reversed as before but in this case no interruption of the circuit occurs.

(d) When the called subscriber answers, battery is disconnected from the line leading back to the toll office.

When the toll operator receives a call for a subscriber reached as above described she inserts plug 1, for example, into jack 401 of the outgoing trunk and operates her talk key 2 and dial key 8 whereupon relays 3, 4, 5, 201, 203, 9, 18, 17 and 13, in the position circuit, operate as previously described in connection with Fig. 3 and relays 402, 403, 404 and 405 operate in the trunk, relays 402 and 405 operating from battery in series with relays 201 and 202 in the position circuit over the sleeve of the cord and trunk. Dial pilot lamp 50 also lights to indicate that the dial circuit is connected to the cord. Relay 402 operates relay 403 and these two relays, jointly operated, prepare a circuit to operate the "cut-through" relay 406 when marginal relay 45 releases due to an increase in the resistance of the sleeve circuit when relay 7 operates, at the conclusion of dialing, to include resistance 56 therein.

Relay 404 operates in response to operation of relay 403 in a circuit from ground, right-hand contacts of relay 403, contact 407 of relay 406, winding of relay 404, contacts 408 of relay 404, tip of the trunk and cord to battery at contacts 23 of relay 24 as before traced in connection with the description of operation for Fig. 3. The cord supervisory lamp 51 does not light at this time due to the high resistance of the sleeve circuit which includes the high resistance (right-hand) wind-

ing of relay 402 which prevents relay 202 from operating.

When relay 404 operated it opened its contacts 408 and closed contacts 409 thereby establishing a locking circuit for itself to battery independent of the battery supplied over the tip of the cord.

Operation of relay 404 disconnects the tip and ring from the repeating coil 410 and connects them directly to the line conductors extending to the distant exchange over the back contacts of ringing relay 411 whereupon the impulse relay in the distant office operates thus conditioning the circuit for reception of dial pulses.

The operator now actuates the dial, as before described, thereby causing the switches at the distant exchange to first select idle trunks and finally the called subscriber's line in the well-known manner.

In case an all-trunk busy condition is encountered, reversed and interrupted battery is supplied back over the trunk to the toll position which causes polarized relay 209 in the dial circuit to operate to disconnect the dial circuit from the cord. Operation of relay 209 operates relay 7 in the position circuit which opens its contact 6 thereby including resistance 55 in the previously traced sleeve circuit which includes the marginal relay 405 in the sleeve circuit of the trunk. Relay 405 being marginal is unable to hold operated in this high resistance circuit and it therefore releases thus closing a circuit to operate the "cut-through" relay 406 which can be traced from ground, back contact of relay 405, inner front contact of sleeve relay 402, winding of relay 406 to battery at the left-hand front contacts of relay 403. Relay 406 in operating locks itself operated under control of relay 403 which will be held operated as long as the sleeve relay 402 remains operated. Operation of relay 406 connects, at its contact 412, the right-hand winding of repeating coil 410 to the line over the back contacts of ringing relay 411 and at its contact 413 connects ringing relay 411 to the tip of the trunk at the middle of the left-hand winding of repeating coil 410.

Due to the fact that reversed battery interrupted 120 times a minute is coming back over the line from the automatic office at this time, relay 414, which is polarized in the proper direction to respond to this reversed battery, alternately operates and releases thereby alternately connecting and disconnecting ground at its front contact to shunt the right-hand high resistance winding of sleeve relay 402, which, in turn, alternately operates and releases the marginal relay 202 in the position circuit which causes supervisory lamp 51 in the toll cord to flash at the interrupted rate which indicates to the operator that an all-trunks busy condition has been encountered whereupon she withdraws plug 1 from jack 401 and the circuit restores to normal.

In case idle trunks are found, the dialing proceeds until the connection is finally advanced to the terminals of the called line.

If the line is busy the central office battery at the automatic exchange is reversed and interrupted in the same manner as when a busy group of trunks was found with this difference that the rate of interruption is different, usually 60 times a minute.

If the called line is idle a battery reversal, without interruption, takes place at the distant office whereupon polarized relay 209 in the dial circuit operates as before described thereby causing the operation of relays 7 and 24 and the release

shortly thereafter of relay 17 which is slow to release, this being followed by release of relays 13, 5, 9, 24, 3 and 4.

When relay 7 operated it opened its contact 6 thereby including resistance 56 in the previously traced sleeve circuit which includes marginal relay 495 of the trunk circuit. This relay as before described in connection with an all-trunks and line-busy condition now release and closes the circuit to operate the cut-through relay 406 which operates, locks up under control of 403 and conditions the trunk for conversation. As soon as the trunk is cut through, by the operation of relay 495, polarized relay 414 operates and shunts out the high resistance right-hand winding of sleeve relay 402 thereby decreasing the resistance of the sleeve circuit and causing supervisory lamp 51 to light as an indication that the called line has been seized, but the subscriber's receiver is still on the switchhook.

Due to the fact that relay 17 in the position circuit is slow in releasing, the release of relay 24 is delayed a short interval after relay 404 releases thereby causing the ringing relay 411 to operate momentarily to send a short impulse of ringing current over the line to initiate the automatic ringing of the subscriber's bell.

When the called subscriber answers the line becomes dry, i. e., battery is disconnected at the distant office and relay 414 in the trunk circuit releases thereby increasing the resistance in the sleeve circuit once more to extinguish the supervisory lamp 51 as a signal that the subscriber has removed his receiver from the hook.

When the called subscriber hangs up the reversed battery is again connected to the line and back into the trunk circuit which reoperates relay 414 which again shunts the high resistance winding of sleeve relay 402 which decreases the sleeve resistance and relights the supervisory lamp 51 as a signal to the toll operator that the connection can be taken down.

The removal of plug 1 from jack 401 permits the circuit to restore to normal in readiness for another call.

Call extended over a dial toll line

We will next assume that the called subscriber is located in an automatic exchange reaching over a so-called dial toll line which is connected to a trunk circuit at the toll office as shown in Fig. 5.

A toll line adapted to transmit pulses and other signals over a composite circuit to control automatic switches at the distant end is shown in United States Patent 1,617,413 to L. A. Mortimer and will serve to describe the operation of the automatic switches in response to dial pulses transmitted over the tip conductor thereof.

It will therefore be assumed that the conductors extending from the right-hand side of Fig. 5 are connected to the conductors of the line L shown in Fig. 1 of the patent mentioned, at the point where the toll line and conductors are shown by a dotted line.

When the toll operator receive a call for a subscriber reached over a dial toll line, which toll line terminates in the toll office in the circuit shown in Fig. 5, the operator inserts plug 1 in the outgoing jack 501 and operates the talk key 2 whereupon relays 345, 201 and 203 in the cord and position circuit as previously described in connection with Fig. 3 and relays 502, 503 and 504 in the trunk circuit also operate. Relays 502 and 503 operate over the sleeve circuit in series with relays 201 and 202 in the position circuit to bat-

tery. Relay 504 operates in an obvious circuit from relay 503.

The operator then operates the dial key 3 which causes relays 9, 11, 15, 18, 17, 13, 22 and 214 in the position circuit and relay 505 in the trunk circuit to operate. Marginal relay 28 in the position circuit also operates in the present case due to the low resistance of relay 505 which was not the case in connection with Figs. 3 and 4 as the trunk relays 303 and 405 of these figures are of a higher resistance than 505 and hence do not permit sufficient current to flow in the right-hand winding of relay 23 to cause its operation. Relay 28 in operating locks to contacts 34 of relay 17 and opens its right-hand contact 66 thereby preventing battery 61 from being connected to the toll line when relay 24 operates at the completion of dialing. Relay 28 also closes its contacts 69.

The operation of relay 28 also closes contacts 67 so that when off-normal relay 213 operates and closes its contacts 217, ground will be connected to conductor 41 and thence to the tip of the line to give a dial off-normal signal to the toll line which short-circuits and releases relay 507 in the trunk circuit while the dial is "off normal", to be later referred to.

Relay 505 in operating locks itself at its contacts 506 under control of the sleeve circuit and connects relays 507 and 508 to the tip and ring conductors, respectively, of the trunk whereupon both these relays operate in series with the closed contacts 207 of the position dial.

At its upper contact relay 507 closes the left-hand side of the repeating coil. Relay 508 in operating connects ground to the tip conductor 510 of the toll line L over conductor 511 which corresponds to lead 129 of Fig. 1 of Patent 1,617,413. This causes operation of the pulsing relay in the distant automatic exchange which corresponds to relay 200 of Fig. 2 of the above-noted patent. This pulsing circuit may be traced from ground, front contacts of relay 508, contacts 512 of relay 513, winding of polarized relay 514, contacts 515 of relay 504, contacts 516 of relay 517, conductor 511 and winding 518 of the coil 509 to the tip of the line L from which point it is extended over the line to the distant exchange and passing through the pulsing relay to negative battery.

Relay 514 is polarized and does not operate on the direction of current flowing in the circuit at this time. Operation of the pulsing relay at the distant exchange causes the apparatus thereat to function to select an idle sender as described in Patent 1,670,413 beginning with line 17 on page 3 and when such a sender is ready to receive pulses positive battery is substituted for the negative battery previously connected to the pulsing circuit as described beginning with line 7 on page 4 of the patent, which causes a current reversal and operation of polarized relay 514 at the toll office.

Operation of relay 514 connects ground at its closed contacts over contacts 519 of relay 520, to the left-hand low resistance winding of relay 503 thereby short-circuiting the right-hand, high resistance, winding and lowering the resistance of the sleeve circuit to cause operation of marginal relay 202 in the position circuit which in turn lights supervisory lamp 51 as a signal to the operator that the sender is ready to receive dial pulses whereupon she proceeds to transmit the proper code of the called subscriber. Relay 508 follows the alternate opening and closing of the dial contacts and repeats these pulses over the tip of the line to the distant exchange.

Relay 507 releases when the dial is off normal as previously mentioned thereby increasing the sleeve circuit resistance and extinguishing the supervisory lamp 51 as follows: Release of relay 507 closes its lowermost contacts thereby operating relay 521 from ground at relay 514 to battery at the lowermost contacts of relay 505. Relay 521 operates and opens its contacts 519 which removes the short circuit from the right-hand winding of relay 503. Relay 521 locks up over its left-hand winding and front contacts to ground at relay 514 thereby keeping lamp 51 extinguished during the remainder of the dialing.

The release of relay 507 also opens the left-hand winding of repeating coil 509 thereby preventing this coil from interfering with the pulsing. When the dial restores to normal, relay 507 re-operates, closes the repeating coil and permits any tone signal which may be transmitted back over the toll line to pass into the cord and position circuit where they will be repeated through repeating coil 268 to the operator's receiver over the front contact of relay 214.

Assuming no busy condition is encountered during the progress of the call, when the dialing is completed, the operator presses the cut-through key 53 which serves to release the dial circuit from the cord as follows:

Operation of key 53 completes a circuit to operate release relay 54 which extends from ground at the right-hand normal contacts of relay 213 in the dial circuit over contacts of key 53 to battery through the winding of relay 54.

Relay 54 operates and locks up at its left contact to ground at contacts 48 of relay 13 and at its right-hand contacts connects battery to operate relay 7 which relay completes a circuit to operate relay 24 which may be traced from battery, contacts 57 of relay 15, contacts 58 of relay 17, winding of relay 24 and ground at the inner left contacts of relay 13. Relay 24 operating locks itself, over its contacts 59, to battery under control of relay 13. This relay, however, will soon release. The closure of contacts 60 of relay 24 has no effect in the present case as relay 26 is operated as previously described. Hence, battery 61 is not connected to the tip of the line, Fig. 5, as was the case described in connection with Fig. 3.

Relay 24 in operating further opens its contacts 23 thereby disconnecting battery from conductor 47 which up to this time has held relay 17 operated. Relay 17 now releases slowly and after an interval opens the circuit of relay 13 which in turn releases opening its contacts 48 and 49 and extinguishing pilot lamp 50. The removal of ground at contacts 48 of relay 13 from conductor 26 also opens the locking circuit of relay 9, which relay releases to disconnect the dial circuit from the cord. Release of relay 13 also opens the circuit of relay 24 which now releases. Relay 13 also releases relay 5 which unlocks relays 3 and 4 thus permitting these relays to release when the talk key 2 is released.

Returning to the operation of relay 7, previously mentioned, when this relay operated it opened its contacts 6 thereby including resistance 56 in the sleeve circuit which includes marginal relay 502, which relay now releases and causes operation of relay 513 in a circuit which can be traced from ground, contacts 523 of relay 524, back contacts of relay 502 and winding of relay 513 to battery at the left-hand back contact of relay 524. Operation of relay 513 opens at its contacts 525 the circuit of relay 505 which releases. Relay 513 also connects ground at its contacts 526 to

relay 514 in substitution for the ground originally supplied from the front contacts of relay 508 over contacts 512 thereby maintaining the continuity of the line pulsing circuit after relay 508 releases. Release of relay 505 also disconnects relays 507 and 508 from the trunk which now release.

When the dial circuit (Fig. 2) has been disconnected from the cord by the release of relays 9 and 7 resistance 56 is short-circuited thereby again lowering the resistance of the sleeve circuit and causing marginal relay 502 in the trunk to reoperate which now permits relay 527 to operate in a circuit which can be traced from ground at the lowermost contacts of relay 504, right-hand winding of relay 527, lower contacts and winding of relay 513 to battery at the left-hand contacts of relay 524. Relay 513 is thus held operated in series with relay 527 under control of relays 504 and 524. Relay 527 in operating recloses the repeating coil circuit which was opened when relay 507 released.

Relay 514 being operated at this time, relay 521 remains locked thereby maintaining the sleeve circuit resistance high and the supervisory lamp 51 in the cord circuit extinguished.

As soon as the sender at the distant exchange has completed its work it is released in the usual manner causing the reversal of the pulsing circuit current which permits relay 514 to release which in turn opens the locking circuit of relay 521 which slowly releases and connects the left-hand, low resistance winding of relay 503 to the now open contacts of relay 514. No change, however, is effected in the sleeve circuit resistance at this time.

In the event that all-trunks-busy or line-busy condition is encountered by the automatic switches, the pulsing circuit current will again be reversed under control of an interrupter to alternately operate and release relay 514 which alternately shunts the right-hand high resistance winding of relay 503 which lights the cord supervisory lamp 51, the rate of flashing depending on whether a "trunk-busy" or "line-busy" condition is encountered as is well understood.

If the called line is idle it will be seized and the pulsing circuit current will be reversed, without interruption, causing relay 514 to operate and steadily light lamp 501 which indicates to the operator that the called line has been connected too.

In case the automatic exchange is arranged to automatically ring the called subscriber as soon as his line is released, no action is required on the part of the toll operator.

When the subscriber answers the pulsing circuit current will be again reversed in a direction to release relay 514 which will extinguish lamp 51.

In case the connection is to be extended to a toll position, for example, by the automatic switches and the originating toll operator desires to rering, she will operate her ringing key RK thereby connecting battery 61 to the tip of the trunk causing relay 517 to operate in a circuit which can be traced from the tip of the trunk, upper left-hand winding of repeating coil 509, outer right contact of relay 527, winding of relay 517 to ground at the lowermost contact of relay 504. Relay 517 in operating opens the pulsing circuit at contact 516 thereby disconnecting ground therefrom and substituting, at contact 528, the source of ringing current 529 which flows over the tip conductor 510 of the toll line L to cause the apparatus at the automatic exchange to function to light the distant operator's cord

supervisory lamp. Operation of relay 517 also connects ground at its upper contact to relight the supervisory lamp 51 during the ringing interval.

- 5 In the event the toll operator desires to send additional pulses after the dial circuit has been disconnected from the cord and the trunk cuts through to the toll line, the procedure is the same as in originating a new call except that the cord is already plugged into the trunk.

When the dial key 8 is operated, relay 9 operates and connects battery to the tip of the line through the left-hand winding of relay 18 and the right-hand winding of relay 28, but due to the fact that the toll line is in the talking condition and relay 513 is operated, no ground is present on the tip of the trunk and hence relay 18 does not operate. However, the following circuit is established under this condition when dial key 8 is operated as follows: Ground, contacts 14 and 10 of the dial key, winding of relay 15, contacts 16 of relay 17 to battery at the back contacts of relay 18. Relay 15 operates and closes an obvious circuit to operate relay 22. Relay 22 connects battery to the upper winding of relay 7 as follows: Battery, from contacts of relay 15, left-hand winding and front contacts of relay 22 and upper winding of relay 7 to ground, but relay 7 does not operate as it is short-circuited by ground over conductor 35 from the dial key. When the dial key is restored, however, the circuit of relay 15 is opened which releases relay 22, but as both of these relays are slow to release, relay 22 remains operated long enough after the dial key is restored to permit relay 7 to operate. Operation of relay 7 opens its contacts 6 thereby including resistance 56 in the sleeve circuit and causing relay 502 in the trunk to release which disconnects ground from the left-hand winding of relay 527 thereby permitting this relay to operate from battery over its left-hand contacts and winding and its right-hand inner contact and the right-hand winding of relay 524 to ground, which latter relay thereupon operates.

Operation of relay 524 locks up over its left winding, releases relay 513 and connects ground at its right-hand contact to maintain the pulsing circuit closed when relay 513 releases and opens its contact 526.

The release of relay 513 causes the reoperation of relay 505 in a circuit which may be traced from ground, lowermost contact of relay 504, contact 525 of relay 513, winding of relay 505, upper normal contact of this relay to the tip of the trunk and cord and to battery at relay 24 through relays 28 and 18. Relays 28 and 18 again operate in this circuit and cause the dial circuit to be locked to the cord as before. The operation of relay 505 also reconnects relays 507 and 508 to the trunk under control of the dial contacts. Operation of relay 507 releases relay 524. Operation of relay 508 again connects ground to the pulsing circuit in substitution for the holding ground previously supplied by relay 524 until it released.

The circuit is now ready to transmit any further pulses desired and the operation from this point is the same as previously described.

What is claimed is:

- 70 1. In a telephone system, an operator's position, a circuit arrangement including a dial thereat, a trunk circuit extending from said position to and terminating in an automatic switch, a cord circuit at said position adapted to be connected to said trunk, non-locking switching

means at said position effective, when said cord is connected to the trunk, to cause said dial circuit to be connected to the cord, means for locking the dial circuit to the cord independent of the switching means, and means in the trunk, operated when said dial circuit is connected to the cord, to operate said locking means.

2. In a telephone system, an operator's position, a circuit arrangement including a dial thereat, a trunk circuit extending from said position to and terminating in an automatic switch, a cord circuit at said position adapted to be connected to said trunk, non-locking switching means at said position effective when said cord is connected to the trunk to cause said dial circuit to be connected to the cord, means for locking the dial circuit to the cord independent of the switching means, means in the trunk, operated when said dial circuit is connected to the cord, to operate said locking means, and means in said dial circuit responsive to a current reversal in the trunk to release said locking means.

3. In a telephone system, an operator's position, a circuit arrangement including a dial thereat, a trunk circuit extending from said position to and terminating in an automatic switch, a cord circuit at said position adapted to be connected to said trunk, a non-locking dial key for causing said dial circuit to be connected to one end of the cord, means for locking said dial circuit to the cord independent of the dial key, means in the dial circuit for operating said locking means, said means being conditioned for operation responsive to connection of the dial circuit to the cord, and means in the trunk operated when the cord is connected with the trunk to operate said conditioned means.

4. In a telephone system, an operator's position, a circuit arrangement including a dial thereat, a trunk circuit extending from said position to and terminating in an automatic exchange, a cord circuit at said position adapted to cooperate with said trunk, means including a manually operable switch for connecting said dial circuit to the cord when the cord is connected to the trunk, means for locking said dial circuit to the cord independent of the manual means, and means jointly responsive to connection of said cord to the trunk and connection of said dial circuit to the cord for actuating said locking means.

5. In a telephone system, an operator's position, a circuit arrangement including a dial thereat, a trunk circuit extending from said position to and terminating in an automatic exchange, normally open circuit speech transmission means interposed in said trunk, a cord circuit at said position adapted to cooperate with said trunk, means including a non-locking manually operable switch for causing said dial circuit to be connected to the cord when the cord is connected to the trunk, means for locking the dial circuit to the cord independent of the manual means, means jointly responsive to connection of said cord to the trunk and connection of the dial circuit to the cord for actuating said locking means, cut-through means for completing the circuit of the speech transmission means to condition the trunk for conversation, and means in the dial circuit automatically responsive to a current reversal in the trunk for causing actuation of said cut-through means in the trunk and the subsequent release of said locking means in the dial circuit.

6. In a telephone system, an operator's position, a circuit arrangement including a dial there-

at, a trunk circuit extending from said position to and terminating in an automatic exchange, normally open circuit speech transmission means interposed in said trunk, a cord circuit at said position adapted to cooperate with said trunk, means including a manually operable switch for causing said dial circuit to be connected to the cord when the cord is connected to the trunk, means for locking the dial circuit to the cord independent of the manual means, means jointly responsive to connection of said cord to the trunk and connection of the dial circuit to the cord for actuating said locking means, cut-through means for completing the circuit of the speech transmission means to condition the trunk for conversation, a source of ringing current, means for connecting said source to the trunk extending to the automatic exchange, means in the dial circuit automatically responsive to a current reversal in the trunk for causing actuation of said cut-through means and the subsequent release of said locking means, said cut-through means being adapted when actuated to cause the operation of said ringing current connecting means and to maintain it operated under control of said locking means.

7. In a telephone system, an operator's position, a circuit arrangement including a dial thereat, a trunk circuit extending from said position to and terminating in an automatic exchange, a cord circuit at said position adapted to cooperate with said trunk, means including a manually operable non-locking dial key for connecting said dial circuit to the cord when the cord is connected to the trunk, means for locking said dial circuit to the cord independent of the dial switch, means jointly responsive to connection of said cord to the trunk and connection of said dial circuit to the cord for actuating said locking means, a normally disabled speech transmission path interposed in said trunk, cut-through means for enabling the trunk for speech transmission and a manually operable release key in the dial circuit, operatively effective when the dial is in its normal position for causing operation of said cut-through means, the subsequent release of said locking means and to hold the dial circuit connected to the cord until said release key is restored to normal.

8. In a telephone system, an operator's position, a circuit arrangement including a dial thereat, a trunk circuit extending from said position to and terminating in an automatic exchange, a cord circuit at said position adapted to cooperate with said trunk, means including a manually operable non-locking dial key for connecting said dial circuit to the cord when the cord is connected to the trunk, means for locking said dial circuit to the cord independent of the dial key, means jointly responsive to connection of said cord to the trunk and connection of said dial circuit to the cord for actuating said locking means, a normally disabled speech transmission path interposed in said trunk, cut-through means for enabling the trunk for speech transmission, a source of ringing current, means for connecting said source to the trunk extending to the automatic exchange, a manually operable release key in the dial circuit operatively effective when the dial is in its normal position for causing operation of said cut-through means, the subsequent release of said locking means and to hold the dial circuit connected to the cord until said release key is restored to normal, said cut-through means being adapted when actuated to cause the operation of said ringing means and to maintain it operated under control of said release key.

tion of said ringing means and to maintain it operated under control of said release key.

9. In a telephone system, an operator's position, a circuit arrangement including a dial thereat, lines terminating at said position, a cord circuit at said position either end of which is adapted to be connected to any of said lines, an individual non-locking switch for each end of the cord effective when its respective end of the cord is connected to one of the lines to cause said dial circuit to be connected to that end of the cord, means for locking the dial circuit to the cord independent of the switch, means in the connected line, operative when said dial circuit is connected to the cord, to operate said locking means, and means responsive to operation of said locking means to disable the switch corresponding to the other end of the cord to prevent its operation from connecting the dial circuit to both ends of the cord simultaneously.

10. In a telephone system, an operator's position, a circuit including a dial thereat, a trunk extending from said position and terminating in an automatic exchange, a cord circuit adapted to be connected to said trunk, means including a non-locking dial key for causing the dial circuit to be connected to the cord when the cord is connected to the trunk, means for locking the dial circuit to the cord independent of the dial key, a pulsing relay, means responsive to connection of said cord to the trunk and connection of the dial circuit to the cord to connect said pulsing relay to the trunk, a circuit for said pulsing relay adapted to be controlled by said dial, means automatically actuated at a certain stage in the building-up of a connection for reversing the direction of the current flow in said pulsing circuit, means actuated thereby for disconnecting said pulsing relay from the trunk and releasing the dial circuit from the cord, and means responsive to the reoperation of said dial key to reconnect said dial circuit to the cord and means responsive to the release of said dial key to reconnect said pulsing relay to the trunk.

11. In a telephone system, an operator's position, a circuit arrangement including a dial thereat, a trunk circuit extending from said position to and terminating in an automatic exchange, normally open circuit speech transmission means interposed in said trunk, a cord circuit at said position adapted to cooperate with said trunk, means including a non-locking dial key for causing said dial circuit to be connected to the cord when the cord is connected to the trunk, means for locking the dial circuit to the cord independent of the dial key, means jointly responsive to connection of said cord to the trunk and connection of the dial circuit to the cord for actuating said locking means and to condition the trunk for dialing, cut-through means for completing the circuit of the speech transmission means, means in the dial circuit responsive to a reversal of current flowing in the trunk to release said locking means to cause disconnection of said dial circuit from the cord and to release said means in the trunk to disable the dialing condition, means in the trunk SM—(CT) responsive to release of said locking means to prepare said cut-through means for operation and responsive to the reoperation of the dial key and the subsequent release thereof to actuate said cut-through means.

12. In a telephone system, an operator's cord and position circuit, a circuit arrangement including a dial associated with said cord and position

tion circuit, a trunk circuit accessible to said cord and extending to a distant automatic exchange, a non-locking dial key effective when said cord is connected to the trunk to cause the dial circuit to be connected to the cord, means for locking the dial circuit to the cord independent of the dial key, means in the trunk operated when the dial circuit is connected to the cord to cause operation of said locking means, means in said dial circuit responsive to a current reversal in the trunk to release said locking means, a source of ringing current, a ringing means in said trunk controlled over a conductor thereof for connecting said source to the trunk to transmit ringing current to the automatic exchange, a direct current source associated with said dial circuit, means in said dial circuit responsive to said current reversal to partially close the circuit to connect said direct current source to said trunk conductor, and means in the dial circuit responsive to connection of said cord to the trunk and connection of said dial circuit to the cord for preventing completion of the circuit between said direct current source and said trunk conductor.

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