March 25, 1941. R. E. KING ET AL 2,235,890

TELEPHONE SYSTEM

Filed Oct. 24, 1939 7 Sheets-Sheet 1

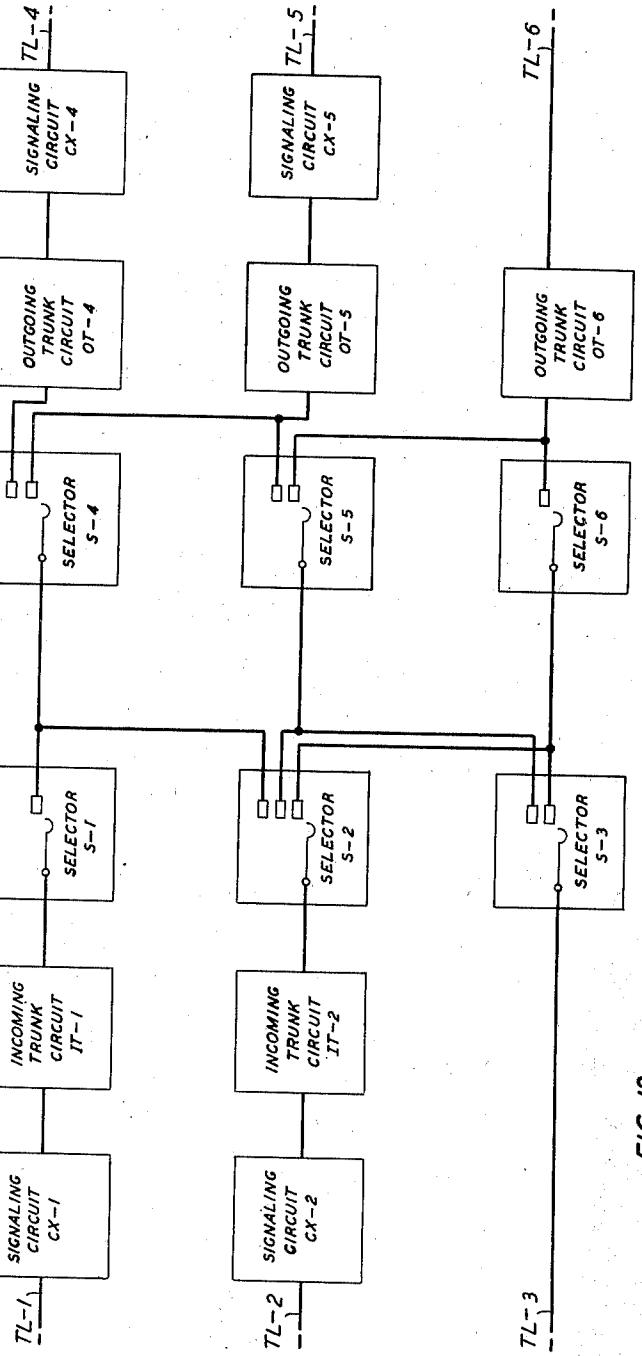
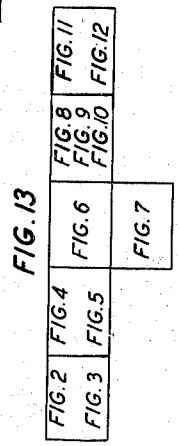


FIG. 1



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TELEPHONE SYSTEM

Filed Oct. 24, 1939 7 Sheets-Sheet 2

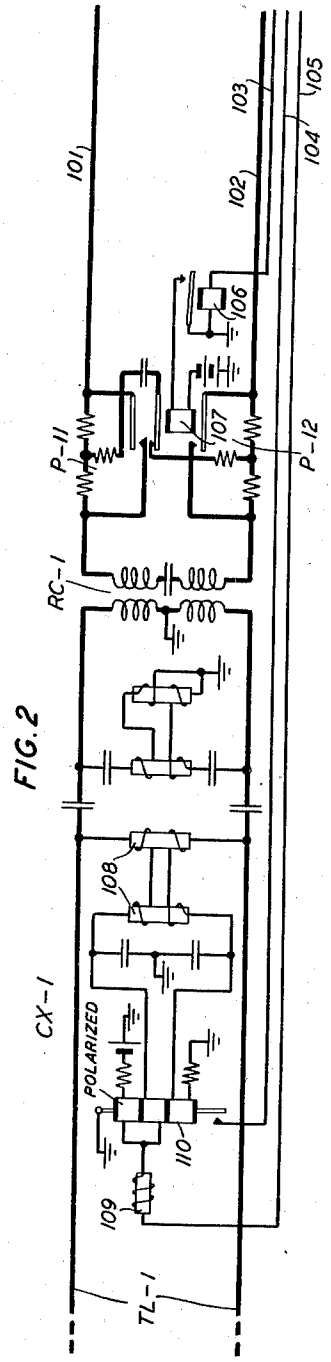

FIG. 2

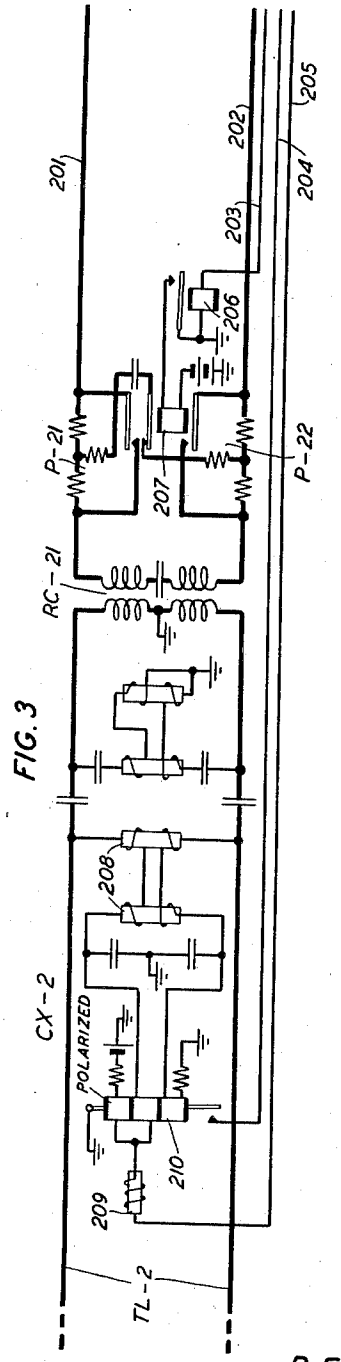

FIG. 3

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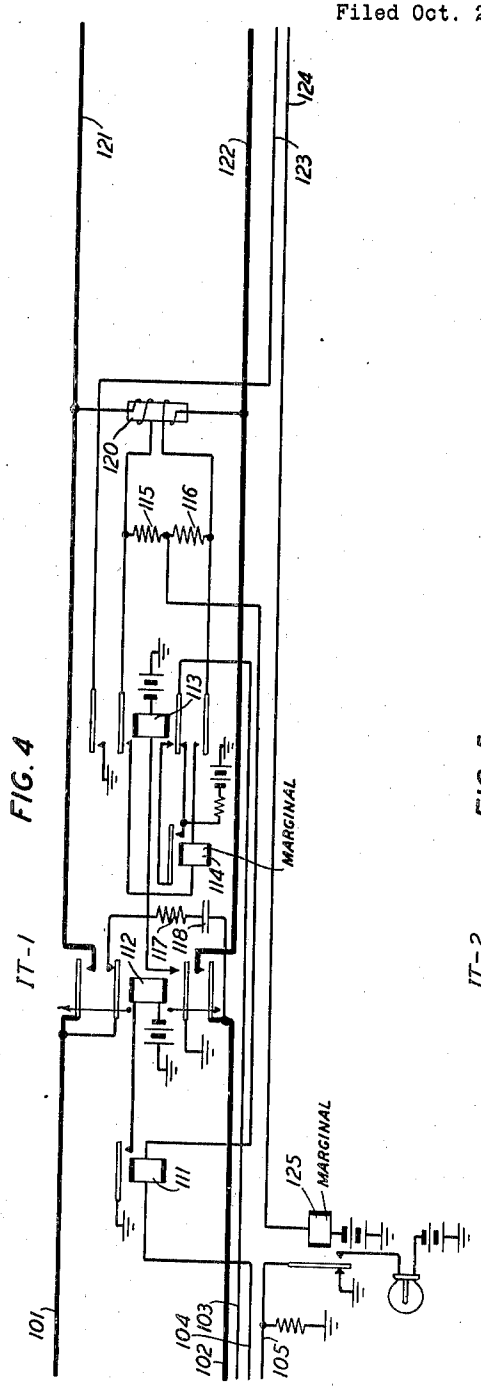

FIG. 4

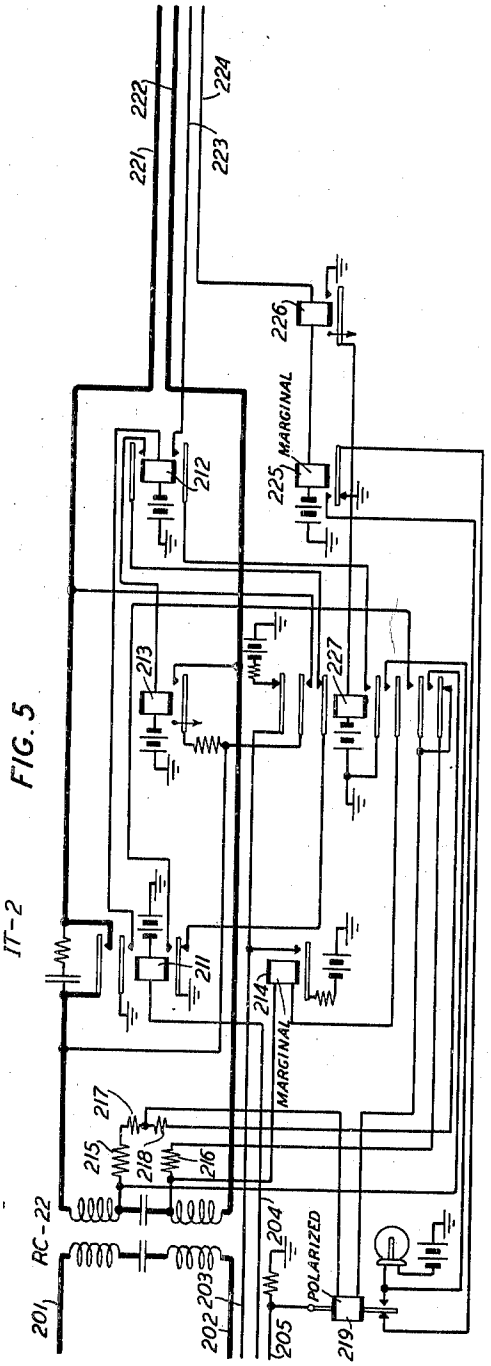

FIG. 5

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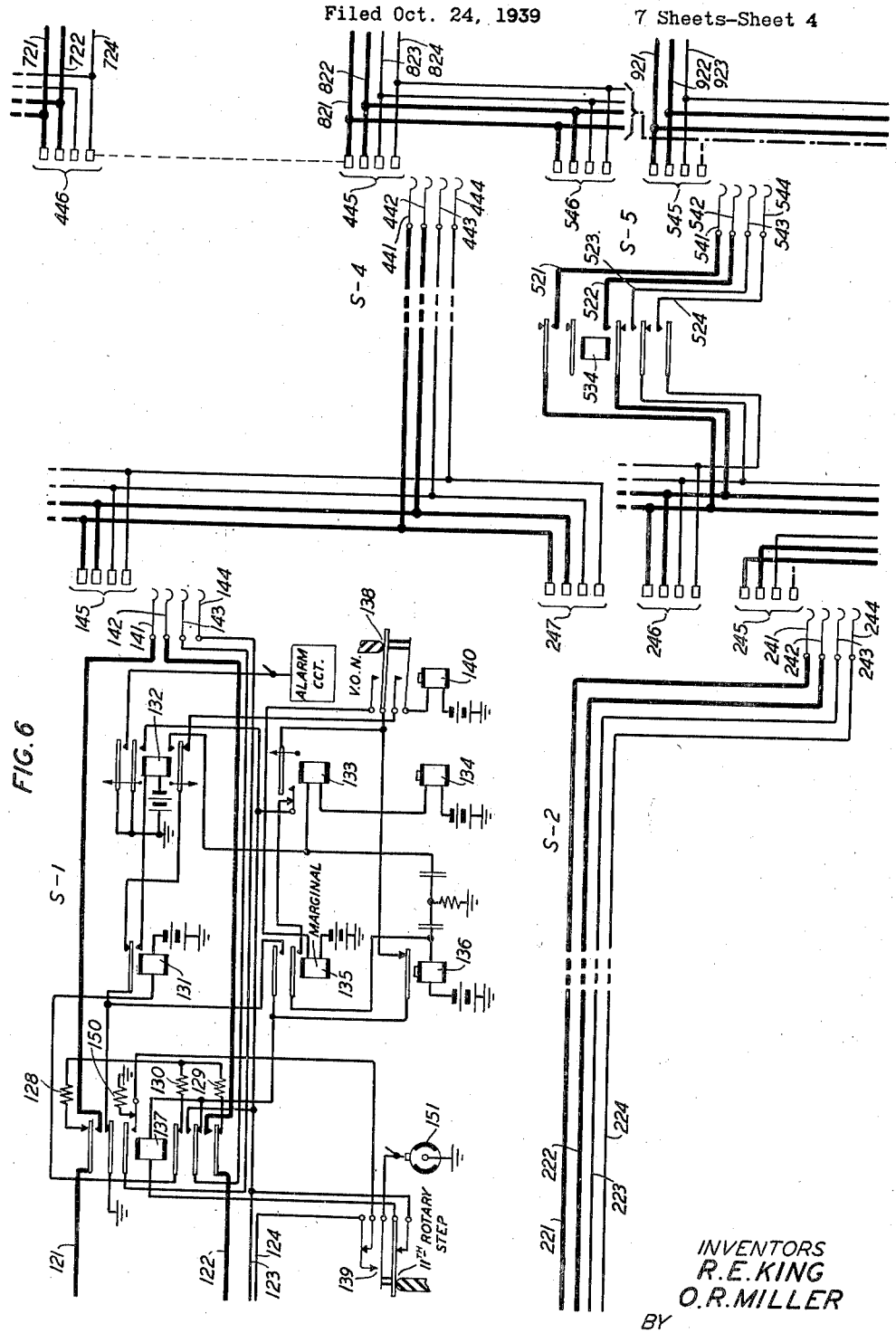

FIG. 6

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TELEPHONE SYSTEM

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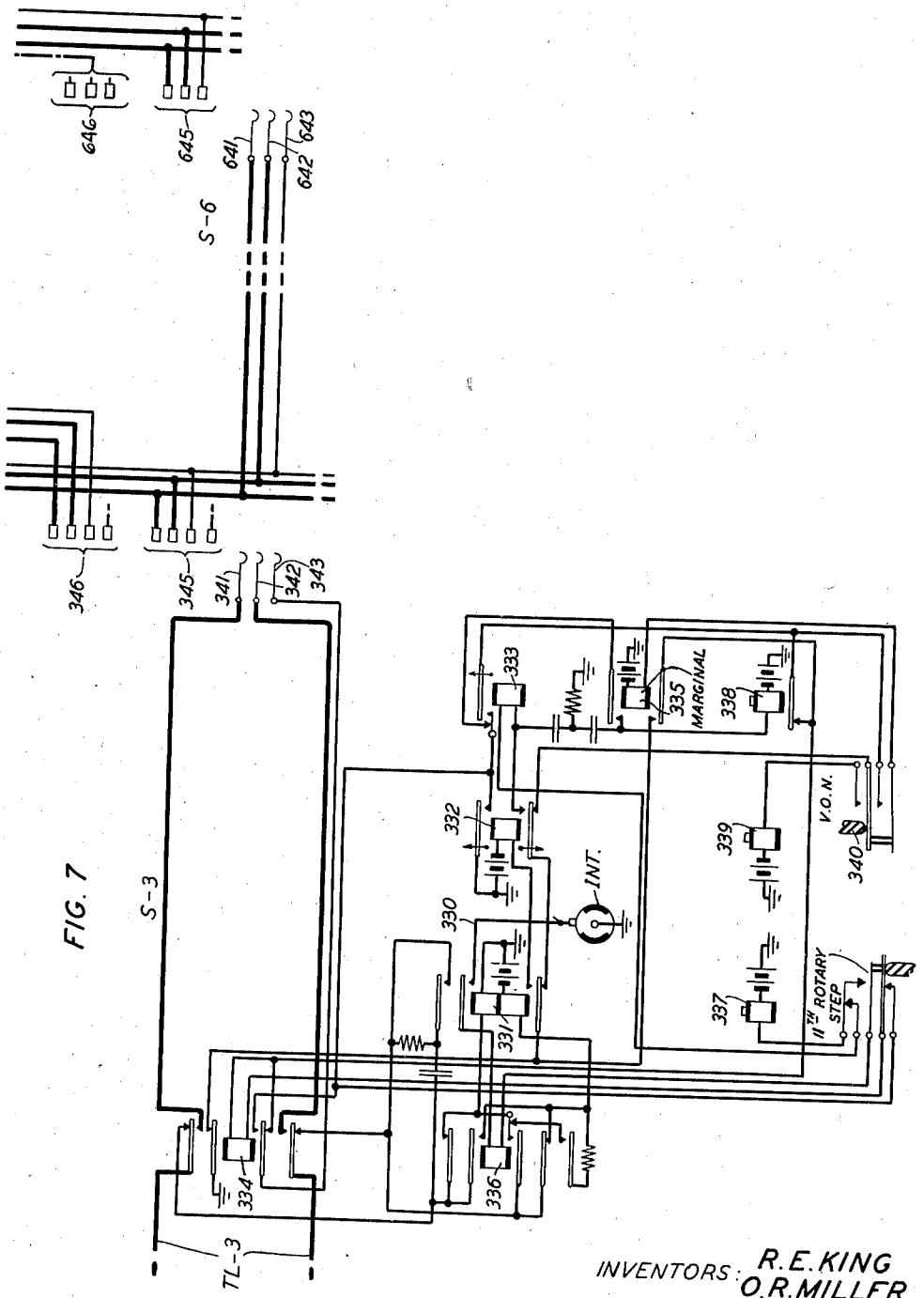

FIG. 7

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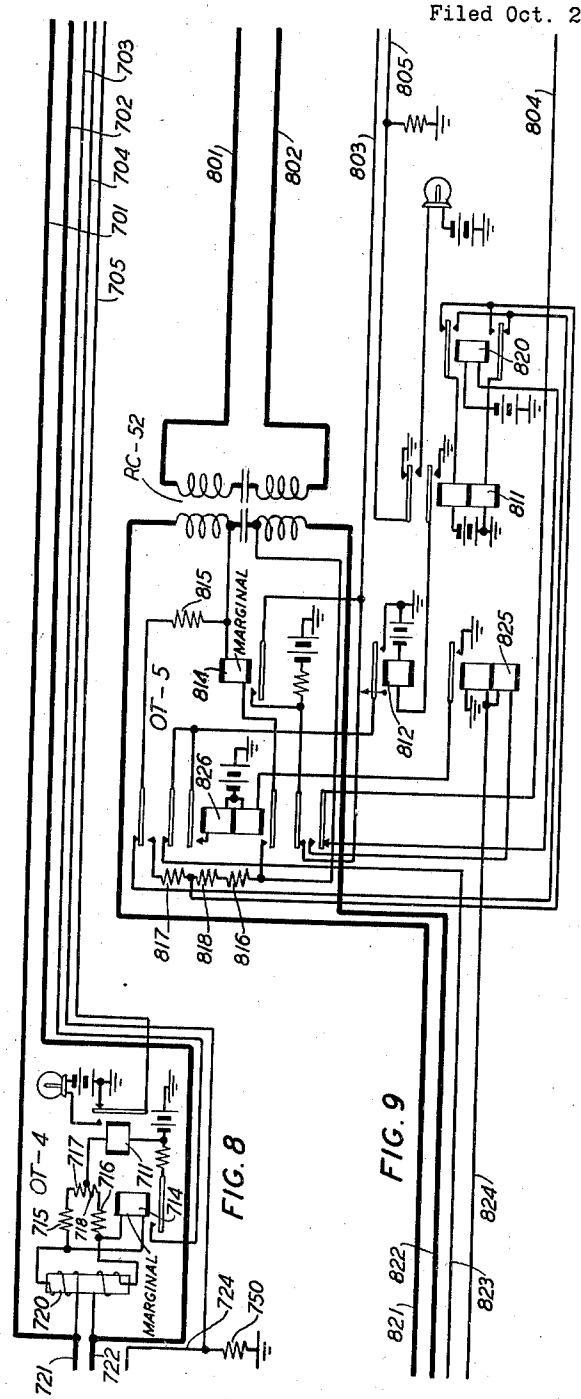

FIG. 8

FIG. 9

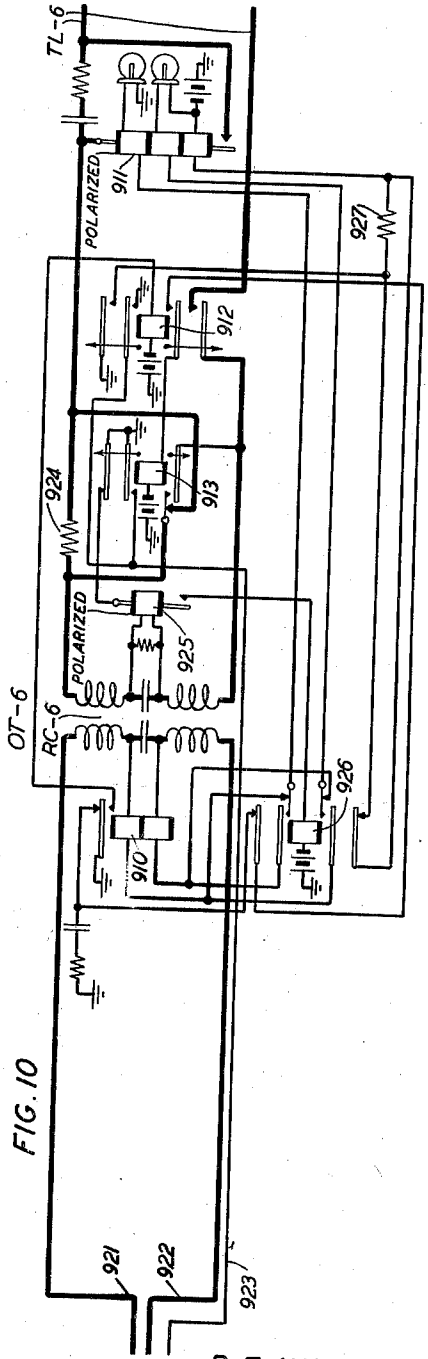

FIG. 10

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TELEPHONE SYSTEM

Filed Oct. 24, 1939 7 Sheets-Sheet 7

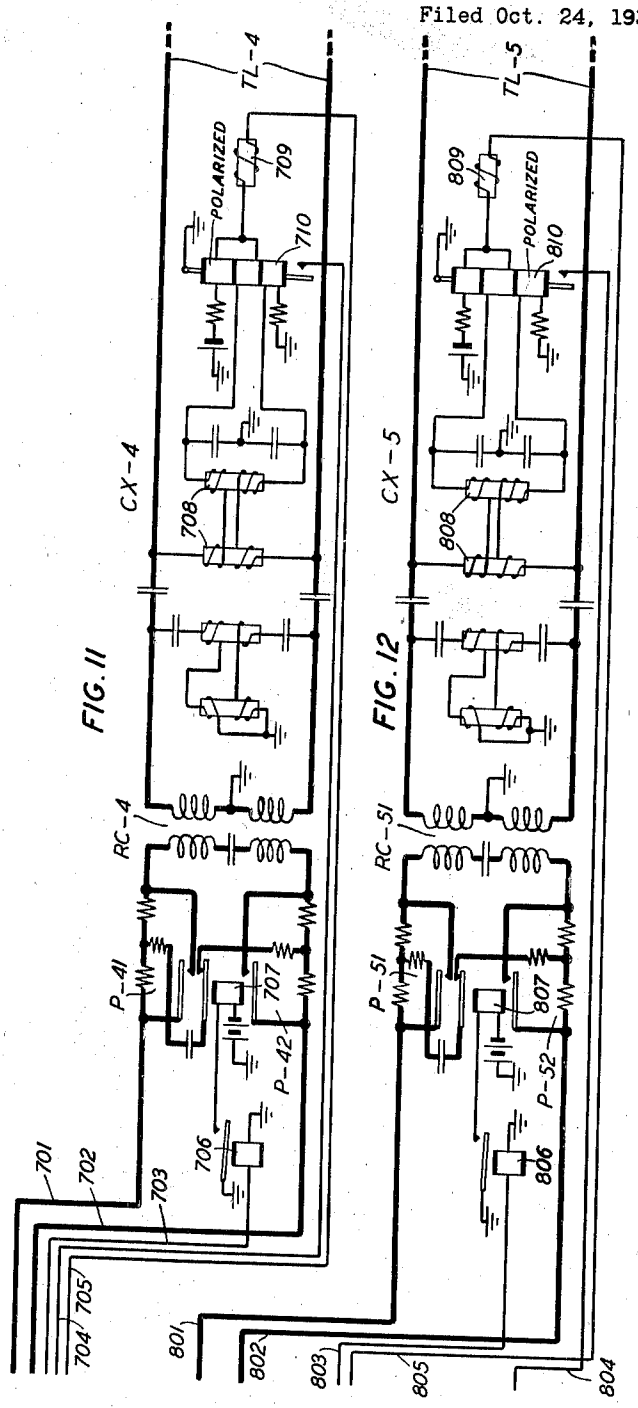

FIG. 11

FIG. 12

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Patented Mar. 25, 1941 2,235,890

UNITED STATES PATENT OFFICE

2,235,890

TELEPHONE SYSTEM

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Application October 24, 1939, Serial No. 300,936

8 Claims. (Cl. 179—16)

This invention relates to signaling systems and particularly to systems comprising impulse controlled switches.

It is the object of this invention to enable the interconnection of trunks and switches arranged for different types of signaling and to increase the efficiency of such signaling systems.

This invention is a signaling system comprising toll lines arranged for loop and composite signaling, trunks and selectors arranged for simplex signaling, trunks and selectors arranged for loop signaling, and comprising trunks arranged for either simplex or loop signaling and for determining which type of signaling is to be used.

A feature of the invention is an incoming trunk circuit which is arranged to transmit signals to and receive signals from an interconnected outgoing trunk in a loop signaling circuit if the outgoing trunk is arranged only for loop signaling and which is arranged to transmit signals to and receive signals from an interconnected outgoing trunk in a simplex signaling circuit if the outgoing trunk circuit is arranged only for simplex signaling or is arranged for either loop or simplex signaling.

Another feature of the invention is an outgoing trunk circuit which is arranged to receive signals from and transmit signals to an interconnected incoming trunk in a loop signaling circuit if the incoming trunk is arranged only for loop signaling and which is arranged to receive signals from and transmit signals to an interconnected incoming trunk in a simplex signaling circuit if the incoming trunk is arranged only for simplex signaling or is arranged for either loop or simplex signaling.

A telephone system arranged in accordance with this invention is represented schematically in the drawings which form a part of this specification. The invention is, of course, not limited in its application to the particular system disclosed in the drawings but is applicable to any signaling system comprising lines or trunks some of which are arranged for loop signaling and others for simplex signaling and comprising automatic switches of any known type for interconnecting incoming and outgoing and two-way trunks.

Referring to the drawings:

Fig. 1 represents schematically a toll office comprising two toll lines TL—1 and TL—2 arranged for composite signaling, toll line TL—3 arranged for loop signaling, incoming selectors S—1 and S—2 arranged for control by a simplex impulse receiving circuit, incoming selector S—3 arranged for control by a loop impulse receiving circuit, incoming trunk circuits IT—1 and IT—2 interconnecting the toll lines TL—1 and TL—2 with the incoming selectors S—1 and S—2, intermediate selector S—4 arranged for control by a simplex impulse receiving circuit, intermediate selectors S—5 and S—6 arranged for control by loop impulse receiving circuits, toll lines TL—4 and TL—5 arranged for composite signaling, toll line TL—6 arranged for loop signaling, and outgoing trunk circuits OT—4, OT—5 and OT—6 connecting toll lines TL—4, TL—5 and TL—6 to terminals in the banks of selectors S—4, S—5 and S—6;

Fig. 2 shows composite signaling circuit CX—1 and other equipment associated with toll line TL—1;

Fig. 3 shows composite signaling circuit CX—2 and other equipment associated with toll line TL—2;

Fig. 4 shows incoming trunk circuit IT—1 associated with signaling circuit CX—1;

Fig. 5 shows incoming trunk circuit IT—2 associated with signaling circuit CX—2;

Fig. 6 shows in coming selectors S—1 and S—2 associated with trunk circuits IT—1 and IT—2, intermediate selector S—4 connected to terminals in the banks of incoming selectors S—1 and S—2 and intermediate selector S—5 connected to terminals in the banks of selector S—2;

Fig. 7 shows incoming selector S—3 associated with toll line TL—3, and shows intermediate selector S—6 connected to terminals in the banks of selectors S—2 and S—3;

Fig. 8 shows outgoing trunk circuit OT—4 connected to terminals in the bank of selector S—4;

Fig. 9 shows outgoing trunk circuit OT—5 connected to terminals in the banks of selectors S—4 and S—5;

Fig. 10 shows outgoing trunk circuit OT—6 connecting a toll line TL—6 to terminals in the banks of selectors S—5 and S—6;

Fig. 11 shows composite signaling circuit CX—4 connecting the outgoing trunk circuit OT—4 to toll line TL—4; and

Fig. 12 shows composite signaling circuit CX—5 connecting the outgoing trunk circuit OT—5 to toll line TL—5.

The selector switches S—1, S—2, S—3, S—4, S—5 and S—6 are of the well-known two-motion step-by-step type comprising a set of brushes, a ten-level terminal bank, and vertical and rotary stepping magnets. Reference may be had to "Automatic Telephony" by Smith and Campbell, 2nd edition, pages 53 to 56, for a de-

scription of the structure of such switches. The bank of each of these switches is represented in the drawings by one, two or three sets of terminals. The relays and other apparatus associated with the selector switches S—1 and S—3 are shown but the relays and other apparatus associated with selectors S—2, S—4, S—5 and S—6 are omitted. Each of selectors S—2 and S—4 is similar to the selector S—1; and each of the selectors S—5 and S—6 is similar to the selector S—3. Selectors S—1, S—2 and S—4 are arranged for receiving dial impulses in a simplex circuit. Selectors S—3, S—5 and S—6 are arranged for receiving impulses in a loop circuit.

The composite signaling circuits CX—1, CX—2, CX—4 and CX—5 are similar to the composite signaling circuits disclosed in applicants' Patent No. 2,208,765 of July 23, 1940, to which reference may be had for a detailed explanation of the operation of these signaling circuits.

The operation of the various trunk circuits and selectors will be more readily described and understood by assuming calls incoming over toll lines TL—1, TL—2 and TL—3 and outgoing over toll lines TL—4, TL—5 and TL—6.

Call from toll line TL—1 to toll line TL—4

Assume first a call involving the interconnection of toll lines TL—1 and TL—4. Upon seizure of toll line TL—1 at its distant end, the connection of signaling battery to the upper conductor of toll line TL—1 effects the operative energization of the signal receiving relay 110 of signaling circuit CX—1. Relay 110 closes a circuit for operating relay 111 of the associated incoming trunk circuit IT—1 and relay 131 of the associated incoming selector S—1. This circuit is traced from ground through the front contact of relay 110, conductor 104, winding of relay 111, thence in simplex through resistors 115 and 116, windings of retard coil 120, conductors 121 and 122, outer back contacts of relay 137 of selector S—1, resistors 128 and 129, then through resistor 130, the inner lower back contact of relay 137 and the winding of relay 131 to battery. Relay 111 closes a circuit for operating relay 112 and relay 131 closes a circuit for operating relay 132. Relay 112 opens the normally closed repeater termination comprising resistor 117 and capacitor 118 and closes the talking path from trunk TL—1, through repeating coil RC—1 and conductors 101 and 102, to conductors 121 and 122 leading to selector S—1. Relay 112 also closes a circuit for operating relay 113. Relay 113 connects the winding of pad control relay 114 across one end of the simplex circuit path above traced. The resistance of the two sides of the simplex circuit being balanced at this time, relay 114 does not operate and the normally operated pad control relay 106 releases, thereby effecting the operation of relay 107. Relay 107 short-circuits the transmission pads P—11 and P—12. Relay 113 connects ground to conductor 123 to hold selector S—1 and the selected intermediate selector after these selectors have completed their selective operations as hereinafter described. At its outer upper front contact, relay 132 closes a circuit for causing the operation of a permanent signal alarm in case dial impulses are not received over toll line TL—1 within a predetermined interval of time. Relay 132 also connects ground to conductor 123.

When a first train of dial impulses is received over toll line TL—1 by relay 110, relays 111 and 131 alternately release and reoperate in response to each impulse. Being slow in releasing, relays 112 and 132 do not release during the response of relays 111 and 131 to dial impulses. The release of relay 131 in response to the first dial impulse closes a circuit for operating relay 133 and vertical-stepping magnet 134, from ground at the middle upper back contact of relay 137, through the back contact of relay 131, lower front contact of relay 132, winding of relay 133, and through the winding of the vertical-stepping magnet 134 to battery. The operation of the vertical-stepping magnet 134 steps the brushes 141 to 144, inclusive, up to the first level of the terminal bank. The vertical off-normal springs 138 are actuated as soon as the shaft and brushes of the selector are moved out of normal position thereby closing a circuit, including the upper contacts of springs 138 and the front contact of relay 133, for operating relay 135. Relay 135 closes a locking circuit which is independent of relay 133 and includes the back contact of the rotary-stepping magnet 136 and the middle upper back contact of relay 137. When relay 131 reoperates at the end of the first impulse, the stepping magnet 134 releases. Relay 133 is slow in releasing and remains operated until all of the impulses in the train have been received and vertical stepping completed. The release of relay 131 in response to each succeeding impulse of the train effects the reoperation of magnet 134 to raise the brushes step by step to the level corresponding to the digit represented by the train of impulses.

When relay 133 releases after the last impulse of the train has been received, it closes a circuit including the inner front contact of relay 135 for operating the rotary-stepping magnet 136. The operation of magnet 136 causes the release of relay 135 and rotates the brushes 141 to 144, inclusive, into engagement with the first set of terminals in the selected level. The release of relay 135 causes the release of magnet 136. If the intermediate selector connected to the first set of terminals is busy, the brush 143 encounters ground potential which causes the reoperation of relay 135; in which case relay 135 closes the circuit for operating the rotary-stepping magnet 136 and the brushes are advanced to the next set of terminals. Relay 135 and magnet 136 are in this manner effective to advance the brushes, step by step, until an idle intermediate selector is found or until the eleventh rotary position is reached due to all of the switches in the selected group being busy. If the brushes are advanced to the eleventh rotary position, the springs 139 are actuated connecting the interrupter 151 through conductor 124 to the winding of relay 125. Relay 125 is marginal and although its winding is normally connected in series with resistor 150 of selector S—1, the current is not sufficient to operate relay 125. With springs 139 actuated, relay 125 is operated to intermittently connect signaling battery to the upper conductor of toll line TL—1 as an all-trunks-busy signal. If, however, the brushes of selector S—1 engage the terminals of an idle intermediate selector such as S—4, relay 137 is operatively energized in a circuit from battery through the winding of relay 135, upper contact of springs 138, back contact of magnet 136, winding of relay 147, lower normally-closed contact of the eleventh rotary-step springs 139, through conductor 123 to ground. Relay 135 is marginal and does not reoperate in series with the winding of relay 137. At its inner lower front contact, relay 137 connects conductor 123 to the

test brush 143 thereby immediately guarding the selected intermediate selector from seizure by another incoming selector. Relay 137 disconnects the winding of relay 131 from conductors 121 and 122 and connects these conductors to the brushes 141 and 142, thence through the engaged terminals to the line relay of the intermediate selector S—4. Relays 131 and 132 release in succession, relay 137 being held under control of relay 112 of trunk circuit IT—1. Relay 137 disconnects resistor 150 from conductor 124 and connects this conductor through brush 144 to a similar resistor (not shown) in the intermediate selector S—4.

The next train of dial impulses received by signaling relay 110, are repeated to control relay 111 of trunk circuit IT—1 and to the line relay (not shown) of selector S—4. The selector S—4 is similar to the selector S—1 and its brushes 441 to 444, inclusive, are directively advanced to select a desired level and are automatically advanced to seize a set of terminals in the selected group. The call in question being one from toll line TL—1 to toll line TL—4, the selector S—4 is operated to seize a set of terminals 446 connecting to an idle outgoing trunk circuit OT—4 associated with composite signaling circuit CX—4 and toll line TL—4. Upon connection of the incoming trunk circuit IT—1 through selectors S—1 and S—4 to trunk OT—4, the simplex circuit path from the winding of relay 111 of trunk circuit IT—1 is extended through brushes 441 and 442 of selector S—4, conductors 721 and 722, through the windings of retard coil 720, and through resistors 715, 716, 717 and 718 to the winding of relay 711 of trunk circuit OT—4. Relay 711 operates in series with relay 111 under control of signaling relay 110. Relay 711 connects signaling battery through conductor 705, retard coil 709, the middle winding of relay 710 and the upper windings of retard coils 708 to the upper conductor of toll line TL—4 as a seizure signal. If additional trains of dial impulses are received over toll line TL—1, relay 110 repeats the impulses to relay 711, and relay 711 transmits the impulses over the upper conductor of toll line TL—4. Since both of toll lines TL—1 and TL—4 are provided with transmission pads, the resistors 115 and 116 at one end of the simplex signaling path through selectors S—1 and S—4 and the resistors 715, 716, 717 and 718, at the other end of this path, are such that there is no difference in potential across the winding of pad control relay 114 of trunk circuit IT—1 and also no difference in potential across the winding of pad control relay 714 of trunk circuit OT—4. Pad control relays 106 and 706 are, therefore, both released and relays 107 and 707 are operated to short-circuit pads P—11 and P—12 associated with toll line TL—1 and to short-circuit pads P—41 and P—42 associated with toll line TL—4.

When the entire desired toll connection is completed, a signal is received over the upper conductor of toll line TL—4 to operate relay 710. Relay 710 connects ground through conductors 704 and 724, brush 444 of selector S—4, brush 144 of selector S—1, inner upper front contact of relay 137, upper normally-closed contact of springs 139, conductor 124 to the winding of relay 125. The resistor 750 connected to conductor 724 does not allow sufficient current through the winding of marginal relay 125 to effect its operation prior to the operation of relay 710. When relay 125 operates, it connects signaling battery through conductor 105, retard coil 133, middle winding of relay 110, upper windings of retard coils 108 to the upper conductor of toll line TL—1 to indicate completion of the connection. The talking connection includes repeating coil RC—1, conductors 101 and 102, conductors 121 and 122, brushes 141 and 142, brushes 441 and 442, conductors 721 and 722, conductors 701 and 702, and repeating coil RC—4. Supervisory signals received by relay 110 are repeated by relay 711 to toll line TL—4 and supervisory signals received by relay 710 are repeated by relay 125 to toll line TL—1.

The connection is under the control of the calling toll operator or subscriber. When relay 110 releases due to release of the toll line TL—1 at its distant end, it opens the circuit through the windings of relays 111 and 711 to cause the release of these relays and to also cause the release of relay 112. When relay 112 releases, it disconnects ground from conductor 123 thereby effecting the release of relay 137 of selector S—1 and the release of the corresponding relay of selector S—4. The release of relay 711 disconnects signaling battery from the upper conductor of toll line TL—4 as a disconnect signal. The release of relay 137 closes a circuit for operating the release magnet 140 of selector S—1 to return the brushes of this selector to normal. In like manner the selector S—4 is restored to normal.

Call from toll line TL—1 to toll line TL—5

On a call from toll line TL—1 to toll line TL—5 the composite signaling circuit CX—1, incoming trunk circuit IT—1, and selectors S—1 and S—4 are operated as above described except that the brushes of selector S—4 are advanced to select a different group and into engagement with a set of terminals 445 which are connected to an idle outgoing trunk circuit OT—5. Upon extension of the connection from trunk circuit IT—1 to trunk circuit OT—5, a circuit is closed from battery through the winding of marginal relay 125, conductor 124, upper back contact of springs 139, inner upper front contact of relay 137, brush 144 of selector S—1, brush 444 of selector S—4, conductor 824, and through the high-resistance upper winding of relay 825 to ground. Relay 825 operates but relay 125 being marginal does not operate. Relay 825 closes a circuit for operating relay 826. Relay 826 disconnects the lower winding of relay 811 from resistor 815 and completes the simplex circuit path from the winding of relay 111 of trunk circuit IT—1 through brushes 141 and 142 of selector S—1, brushes 441 and 442 of selector S—4, conductors 821 and 822, left windings of repeating coil RC—52, through resistors 815, 816, 817 and 818, and through the upper back contact of relay 820 to the upper winding of relay 811. Relay 811 is thereupon operated in series with relay 111 under the control of relay 110. Relay 811 closes a circuit for operating the slow-to-release relay 812 and connects signaling battery through conductor 805, retard coil 809, middle winding of relay 810, upper windings of retard coils 808 to the upper conductor of toll line TL—5 as a seizure signal. Relay 812 closes a locking circuit for relay 826. The marginal pad control relay 814 is bridged across the left windings of repeating coil RC—52 and, if the simplex is unbalanced, relay 814 operates to close a circuit for holding relay 806 operated. If the simplex is balanced, relay 814 does not operate; in which case relay 806 releases, closing a circuit for operating relay 807. The

operation of relay 807 short-circuits the transmission pads P—51 and P—52.

Relay 811 may now respond to dial impulses, received by relay 110 over toll line TL—1 and repeat these impulses over the upper conductor of toll line TL—5. When the desired toll connection is completed and relay 810 operates responsive to the connection of signaling battery to the distant end of the upper conductor of toll line TL—5, ground is connected through conductor 804 and the outer lower front contact of relay 826 to the lower, low-resistance winding of relay 825 thereby causing the operation of marginal relay 125 of trunk circuit IT—1, and relay 125 effects the transmission of a supervisory signal over the upper conductor of a toll line TL—1 to the calling operator or subscriber. Supervisory signals received over toll line TL—1 by relay 110 are repeated by relay 811 to toll line TL—5; and supervisory signals received over toll line TL—5 by relay 810 are repeated by relay 125 to toll line TL—1. When the toll line TL—1 is released at the calling end, relay 110 releases, causing the successive release of relays 111 and 112 and the successive release of relays 811 and 812. When relay 112 releases, disconnecting ground from conductor 123, the selectors S—5 and S—4 are restored to normal as hereinbefore described. The release of relay 811 effects the sending of a disconnect signal over the upper conductor of toll line TL—5. When the connection between relay 125 and relay 825 is opened, relay 825 releases; and, with relay 812 released, relay 826 releases.

Call from toll line TL—3 to toll line TL—6

When the toll line TL—3 is seized at its distant end by connecting a bridge across its conductors, relay 331 of selector S—3 operates. Relay 331 closes a circuit for operating the slow-to-release relay 332. When the first series of dial impulses are received over toll line TL—3, relay 331 alternately releases and reoperates in response to each impulse of the train. The first release of relay 331 closes a circuit for operating the vertical-stepping magnet 337 and the slow-to-release relay 333 in series. Relay 332 does not release during the response of relay 331 to dial impulses and relay 333 remains operated until all of the impulses in the series have been received. The magnet 337 operates when relay 331 releases and releases when relay 331 reoperates at the end of each impulse. Each operation of magnet 337 raises the brushes 341, 342 and 343 one step, thereby selecting the level corresponding to the number of impulses in the series. When the shaft of the switch is moved out of normal by the first operation of magnet 337, the vertical off-normal springs 349 are actuated, thereby closing a circuit including the front contact of relay 333 for operating relay 335. Relay 335 closes a locking circuit which includes the back contact of the rotary stepping-magnet 338. When relay 333 releases after the last impulse of the series has been received, it closes a circuit including the upper front contact of relay 335 for operating the rotary-stepping magnet 338. The operation of magnet 338 rotates the brushes into engagement with the first set of terminals in the selected level and causes the release of relay 335. When relay 335 releases, it causes the release of magnet 338. If the intermediate selector connected to the first set of terminals is busy, the guarding ground potential encountered by the test brush 343 effects the reoperation of relay 335; and relay 335 closes the circuit for operating magnet 338 to advance the brushes to the next set of terminals. Relay 335 and magnet 338 thus cooperate to advance the brushes step by step until they engage a set of terminals connected to an idle intermediate selector. If no idle selector is available in the selected group, the brushes are advanced to the eleventh rotary position, actuating the eleventh rotary-step springs, thereby connecting the winding of magnet 337 in series with relay 336 to a common interrupter INT. Each time the interrupter connects ground to conductor 330, relay 336 operates but magnet 337 is marginal and does not operate in series with relay 336. Each operation of relay 336 reverses the current over toll line TL—3 as an all-trunks-busy signal.

If and when the brushes of selector S—3 engage a set of terminals connected to an idle intermediate selector in the selected group, the brush 343 does not encounter a guarding ground potential and the winding of relay 334 is operatively energized in series with relay 335. Being marginal, relay 335 does not reoperate. Relay 334 connects guarding ground potential from the upper front contact of relay 332 through brush 343 to the test terminal of the engaged set of terminals to prevent seizure by another selector having access thereto. Relay 334 disconnects the toll line TL—3 from relay 331 and connects the toll line through brushes 341 and 342 to the selected intermediate selector. If a set of terminals 345 are seized, the associated intermediate selector S—6 is directively operated in response to the next train of dial impulses transmitted over toll line TL—3, or if a set of terminals 346 are seized, the associated intermediate selector S—5 is directively operated by these dial impulses. Each of the selectors S—5 and S—6 is similar to the selector S—3. The selector S—5 is represented in the drawings by its brushes 541, 542, 543 and 544, two sets of terminals 545 and 546 and relay 534. The selector S—6 is represented by its brushes 641, 642 and 643 and two sets of terminals 645 and 646. Assuming the use of selector S—6 on the call in question, the operation of this selector in response to the next series of impulses incoming over toll line TL—3 effects the seizure of a set of terminals 645 which are connected to an outgoing trunk circuit OT—6 and toll line TL—6.

Upon seizure of the trunk circuit OT—6 by a selector S—6 and connection of the conductors of toll line TL—3 to conductors 921 and 922, relays 910 and 911 are operatively energized in a loop signaling circuit over toll line TL—3. This circuit is traced from battery through the middle winding of relay 911, inner lower back contact of relay 926, lower winding of relay 910, lower left winding of repeating coil RC—6, conductor 922, brush 642 of selector S—6, brush 342 of selector S—3, outer lower front contact of relay 334, out over the lower conductor and back over the upper conductor of toll line TL—3, outer upper front contact of relay 334, brush 341 of selector S—3, brush 641 of selector S—6, conductor 921, upper left winding of repeating coil RC—6, upper winding of relay 910, inner upper back contact of relay 926, and through the upper winding of relay 911 to ground. Relay 910 closes a circuit for operating the slow-to-release relay 912. Relay 912 connects ground to conductor 923 to hold selectors S—6 and S—3, closes a circuit for energizing the lower polarizing winding of relay 911 to make this relay more quickly responsive to incoming dial impulses, and closes a bridge including the front contact of relay 911, the right windings of repeating coil RC—6

and the winding of polarized relay 925 across the toll line TL—6 as a seizure signal. If additional series of dial impulses are received over toll line TL—3, relay 911 repeats these impulses over toll line TL—6. When relay 910 releases in response to the first impulse of a series, it closes a circuit for operating the slow-to-release relay 913. Relay 913 remains operated until all of the impulses in the series have been received. With relay 913 operated, the bridge connected across toll line TL—6 each time relay 911 reoperates includes resistor 924 instead of the right windings of repeating coil RC—6 and the winding of relay 925. Being slow in releasing, relay 912 remains operated while dial impulses are being received and repeated. When the desired connection is completed, the current over toll line TL—6 is reversed to cause the operation of relay 925. Relay 925 closes a circuit for operating relay 926. Relay 926 opens the short circuit around resistor 927 to reduce the current in the polarizing winding of relay 911 and interchanges the connections between conductors 921 and 922 and the windings of relay 911 so as to reverse the current over toll line TL—3. The talking connection includes repeating coil RC—6. Supervisory signals incoming over toll line TL—3 are repeated by relay 911 to toll line TL—6 and supervisory signals incoming over toll line TL—6 are repeated by relays 925 and 926 to toll line TL—3.

When the toll line TL—3 is released, relays 910 and 911 release. The release of relay 910 opens the energizing circuit of relay 912 and the release of relay 911 opens the bridge across toll line TL—6 as a disconnect signal. When relay 912 releases, it disconnects ground potential from conductor 923 thereby releasing the cut-through relay 334 of selector S—3 and also the corresponding relay of selector S—6. The releases of relay 334 closes a circuit for operating the release magnet 339. The operation of magnet 339 effects the return of the brushes to normal. When the vertical off-normal springs 340 are restored to normal the circuit for energizing the release magnet 339 is opened. The selector S—6 is restored to normal in like manner.

Call from toll line TL—3 to toll line TL—5

When the toll line TL—3 is seized at its distant end, relay 331 operates. The selector S—3 is selectively operated in response to the first series of dial impulses incoming over toll line TL—3 to select an idle intermediate selector S—5 or S—6, as described on a call to toll line TL—6. The intermediate selector S—5 or S—6 is actuated in like manner to select an outgoing trunk circuit OT—5. Assuming connection of the toll line TL—3 through selectors S—3 and S—6 to the trunk circuit OT—5, a circuit is closed for operating relay 811. This circuit is traced from battery through the upper winding of relay 811, upper back contact of relay 820, resistors 818 and 816, lower left winding of repeating coil RC—52, conductor 822, brush 642 of selector S—6, brush 342 of selector S—3, outer lower front contact of relay 334, out over the lower conductor and back over the upper conductor of toll line TL—3, outer upper front contact of relay 334, brush 341 of selector S—3, brush 641 of selector S—6, conductor 821, upper left winding of repeating coil RC—52, resistor 815, inner upper back contact of relay 826, lower back contact of relay 820, and through the lower winding of relay 811 to ground. Since there is no circuit over conductor 824 when trunk circuit OT—5 is seized by selector S—6, relay 825 is not operated and therefore relay 826 is not operated. Relay 811 closes a circuit for operating relay 812 and relay 812 connects ground potential to conductor 823 to hold selectors S—6 and S—3. Relay 811 connects signaling battery to and through conductor 805 and retard coil 809 to the upper conductor of toll line TL—5 as a seizure signal. Dial impulses incoming over toll line TL—3 in a loop signaling circuit are repeated by relay 811 through composite signaling circuit CX—5 to toll line TL—5. When the desired toll connection is completed, a supervisory signal incoming over toll line TL—5 to composite signaling circuit CX—5 operates relay 810. Relay 810 closes a circuit through conductor 804 for operating relay 820. Relay 820 reverses the current over toll line TL—3. Supervisory signals incoming over toll line TL—3 are repeated by relay 811 to toll line TL—5 and supervisory signals incoming over toll line TL—5 are repeated by relays 810 and 820 to toll line TL—3. The talking connection includes repeating coils RC—51 and RC—52. When toll line TL—3 is released, relay 811 releases thereby disconnecting battery from and connecting ground to the upper conductor of toll line TL—5 as a disconnect signal. When relay 812 releases, ground is disconnected from conductor 823 causing the return of selectors S—6 and S—3 to normal in the manner hereinbefore described.

Call from toll line TL—2 to toll line TL—4

Upon seizure of toll line TL—2 at its distant end, signaling battery is connected to its upper conductor causing the operation of relay 210 of signaling circuit CX—2. Relay 210 closes a circuit through conductor 204 for operating relay 211 of the associated incoming trunk circuit IT—2. Relay 211 closes a circuit for operating relay 212. The selector S—2 is similar to the selector S—1 and the windings of relays 225 and 226 of trunk circuit IT—2 are normally connected through conductor 224 in series with a resistor of selector S—2 similar to the resistor 150 of selector S—1. Relay 225 is marginal and does not operate in this circuit but relay 226 is normally operated, closing a circuit for operating relay 227. With relay 227 operated, the circuit for operating relay 206 is open and relay 207 is energized so that pads P—21 and P—22 are normally connected in series with conductors 201 and 202. With relay 227 operated, the release of relay 211 is ineffective to cause the operation of relay 213. With relays 211 and 227 operated, a circuit is closed from ground through the lower front contact of relay 211, a lower front contact of relay 227, the winding of polarized relay 219, thence in a simplex circuit path through resistors 218, 217, 216 and 215, the right windings of repeating coil RC—22, conductors 221 and 222, to the line relay (not shown) of selector S—2. The line relay of selector S—2 is operated by the closure of this circuit but relay 219 does not operate at this time because the current therethrough is not in the operating direction. With relays 212 and 227 operated, ground is connected to conductor 223 of selector S—2 to hold the selector S—2 and the succeeding intermediate selector when connection is completed with a desired outgoing trunk. The first train of impulses, incoming over toll line TL—2 to relay 210, are repeated by relay 211 to the line relay of selector S—2 and the brushes of this selector are stepped up to the desired

level. The brushes are then advanced automatically to hunt for a set of terminals in the selected group which are connected to an idle intermediate selector. On the call in question, a set of terminals 247 are selected, thereby extending the connection to the intermediate selector S—4. The next train of impulses received by relay 210 are repeated by relay 211 to the line relay (not shown) of selector S—4. The brushes of selector S—4 are thereby stepped up to the desired level and automatically advanced therein into engagement with a set of terminals 446 connected to an idle outgoing toll line. Upon selection of the terminals 446, the outgoing trunk circuit OT—4 and associated composite signaling circuit CX—4 are operated as hereinbefore described to send a seizure signal over toll line TL—4. If additional series of dial impulses are received over toll line TL—2, relay 210 repeats the impulses to relay 211, relay 211 repeats them to relay 711 and relay 711 repeats them over toll line 2L—4. Since both of toll lines TL—2 and TL—4 are equipped with transmission pads, the simplex circuit path between relay 711 and the winding of relay 219 is balanced, and the pad control relays 214 and 714 are not operated. Relays 206 and 706 are, therefore, not operated and relays 207 and 707 are operated to short-circuit pads P—21 and P—22 and pads P—41 and P—42. The operation of relay 710, when the desired connection is completed, connects ground through conductors 704, conductor 724, brush 444, brush 244, to conductor 224 to hold relay 226 and operate the marginal relay 225. Relay 225 connects signaling battery through its front contact, the back contact of relay 219, conductor 205, retard coil 209, middle winding of relay 210, upper windings of retard coils 208, to the upper conductor of toll line TL—2 as an answering supervisory signal. The talking path includes repeating coils RC—21, RC—22 and RC—4. Supervisory signals incoming over toll line TL—4 to relay 710 are repeated by relay 225 to toll line TL—2; and supervisory signals incoming over toll line TL—2 to relay 210 are repeated by relay 711 to toll line TL—4. When toll line TL—2 is released, the release of relay 210 effects the release of relay 211; the release of relay 211 causes the release of relay 711; and relay 711 transmits a disconnect signal over toll line TL—4 by disconnecting battery from and connecting ground to the upper conductor of the toll line. The release of relay 211 causes the release of relay 212; and relay 212 disconnects the holding ground potential from conductor 223 thereby causing the return of selectors S—2 and S—4 to normal.

Call from toll line TL—2 to toll line TL—5

On a call from toll line TL—2 to toll line TL—5, the operation of the signaling circuit CX—2, incoming trunk circuit IT—2 and selector S—2 is similar to that on a call to toll line TL—4, hereinbefore described, except that the first series of impulses received over toll line TL—2 effect the seizure of a set of terminals 247 connected to an intermediate selector S—4 or a set of terminals 246 connected to an intermediate selector S—5. If the call is routed through selector S—4, the second series of impulses received by relay 210 effects the operation of this selector to select the corresponding group of terminals and to hunt therein and seize a set of terminals 445 connected to an idle trunk circuit OT—5. If the call is routed through selector S—5, the second series of impulses effects the operation of this selector to select the corresponding group and to hunt therein and seize a set of terminals 546 connected to a trunk circuit OT—5. The selector S—5 is arranged for receiving impulses in a loop circuit and is similar to selector S—3 except that it has a fourth conductor which is used when seized by a simplex-controlled selector, such as S—2, on calls outgoing through trunk circuits, such as OT—4 or OT—5. This fourth conductor is extended to a fourth brush 544 upon operation of the cut-through relay 534 which is otherwise similar to relay 334 of selector S—3. Upon seizure of the set of terminals 246 by the brushes of selector S—2, relay 226 of incoming trunk circuit IT—2 releases since the fourth conductor of selector S—5 is normally open. The release of relay 226 effects the release of relay 227 and the winding of relay 219 is thereby bridged across conductors 221 and 222 to operate the line relay (not shown) of selector S—5 in a loop circuit. The next series of impulses incoming over toll line TL—2 to relay 210 are repeated by relay 211 to the line relay of selector S—5, thereby controlling this selector to select a corresponding group of terminals and to seize a set of terminals 546 therein connected to an idle trunk circuit OT—5. The cut-through relay 534 is operated when the brush 543 engages the test terminal of an idle trunk.

Upon connection of incoming trunk circuit IT—2 through selectors S—2 and S—5 to outgoing trunk circuit OT—5, the outgoing trunk circuit OT—5 and signaling circuit CX—5 function in similar manner to that hereinbefore described on a call from toll line TL—1. A circuit is closed through the windings of relays 225 and 226, conductors 224 and 524 and the upper high resistance winding of relay 825. Relays 226 and 825 operate but marginal relay 225 is not operated. Relay 226 closes the circuit for operating relay 227 and relay 825 closes the circuit for operating relay 826. Relays 211, 227 and 826 complete the simplex circuit path for operating relay 811. Relay 811 operates relay 812; and relay 812 closes a locking circuit for relay 826. The operation of relay 811 connects signaling battery to the upper conductor of toll line TL—5 as a seizure signal. If additional series of dial impulses are received over toll line TL—2, relay 210 repeats the impulses to relay 211, relay 211 repeats them to relay 811, and relay 811 repeats them over toll line TL—5. The pad control relays 214 and 814 are not operated, relays 206 and 806 are not operated, and relays 207 and 807 are operated to short-circuit pads P—21 and P—22 and pads P—51 and P—52. When the desired connection is completed, relay 810 operates, connecting ground to the low resistance winding of relay 825 to cause the operation of relay 225 of trunk circuit OT—2; and relay 225 effects the connection of signaling battery to the upper conductor of toll line TL—2. The talking connection includes repeating coils RC—21, RC—22, RC—52 and RC—51. Supervisory signals received over toll line TL—5 by relay 810 are repeated by relay 225 to toll line TL—2; and supervisory signals received over toll line TL—2 by relay 210 are repeated by relays 211 and 811 to toll line TL—5. When toll line TL—2 is released, the release of relay 210 causes the successive release of relays 211 and 212. The release of relay 211 causes the successive release of relays 811, 812 and 826. The release of relay 212 disconnects ground from conductor 223 and selectors S—2 and S—4 or S—5 are restored to normal. The release of relay 811

disconnects signaling battery from and connects ground to the upper conductor of toll line TL—5 as a disconnect signal.

Call from toll line TL—2 to toll line TL—6

On a call from toll line TL—2 to toll line TL—6 the operation of the signaling circuit CX—2, incoming trunk circuit IT—2 and selector S—2 is similar to that on a call to toll line TL—4, above described, except that the first route digit may be such as to effect the seizure of a set of terminals 246 connected to an intermediate selector S—5 or to a set of terminals 245 connected to an intermediate selector S—6. Relay 534 operates, relay 227 releases upon connection with selector S—5 or S—6 which are arranged for loop impulsing, and relay 211 repeats the next train of impulses to the line relay (not shown) of selectors S—5 or S—6 in a loop circuit. If the call is routed through selector S—5, the second series of impulses received by relay 210 effect the seizure of a set of terminals 545 connected to a trunk circuit OT—6; or if the call is routed through selector S—6, the second series of impulses effect the seizure of a set of terminals 645 connected to a trunk circuit OT—6. Upon connection of incoming trunk circuit IT—2 to an outgoing trunk circuit OT—6, relays 226 and 227 of trunk circuit IT—2 remain normal since the selected outgoing trunk is arranged for loop signaling and has no conductor for connection to conductor 224 of selector IT—2. With relay 227 normal, pad control relay 206 is operated, relay 207 is not operated and the pads P—21 and P—22 are included in the connection. A circuit is thereupon closed from battery through the middle winding of relay 911, inner lower back contact of relay 926, lower winding of relay 910, lower left winding of repeating coil RC—6, conductor 922, terminal and brush 542 of selector S—5 or terminal and brush 642 of selector S—6, terminal and brush 242 of selector S—2, conductor 222, lower right winding of repeating coil RC—22, resistor 216, the lowermost back contact of relay 227, winding of polarized relay 219, resistors 217 and 215, upper right winding of repeating coil RC—22, upper front contacts of relay 211, conductor 221, brush 241 of selector S—2, brush 541 of selector S—5 or brush 641 of selector S—6, conductor 921, upper left winding of repeating coil RC—6, upper winding of relay 910, inner upper back contact of relay 926 and through the upper winding of relay 911 to ground. Relays 910 and 911 are operated, but the polarized relay 219 is not operated, by the current in this circuit. Relay 910 closes a circuit for operating the slow-to-release relay 912. Relay 912 connects ground to conductor 923 to hold the selectors through which connection with trunk circuit OT—6 was established, closes a circuit for energizing the lower polarizing winding of relay 911 and closes a bridge including the right windings of repeating coil RC—6 and the winding of relay 925 across the toll line TL—6 as a seizure signal. If additional series of dial impulses are received over toll line TL—2, relay 210 repeats the impulses to relay 211, relay 211 repeats them to relays 910 and 911, and relay 911 repeats them over toll line TL—6. When relay 910 releases in response to the first impulse of a series, it closes a circuit for operating relay 913. Relay 913 is slow to release and remains operated until all of the impulses in the series have been received. While relay 913 is operated, the impulse bridge, connected across toll line TL—6 each time relay 911 reoperates, includes resistor 924 instead of the right windings of repeating coil RC—6 and winding of relay 925. Being slow in releasing, relay 912 remains operated during the repeating of dial impulses. When the desired connection is completed, the current over toll line TL—6 is reversed to operate the polarized relay 925. Relay 925 closes a circuit for operating relay 926. Relay 926 opens the short circuit around resistor 927 and interchanges the connection between the windings of relay 911 and conductors 921 and 922. The current through the winding of polarized relay 219 of trunk circuit IT—2 is thereby reversed to cause the operation of this relay. Relay 219 connects signaling battery to the upper conductor of toll line TL—2. The talking connection includes repeating coils RC—21, RC—22 and RC—6. Supervisory signals received by relay 219 over toll line TL—2 are repeated by relays 211 and 911 to toll line TL—6; supervisory signals received by relays 926 and 925 are repeated by relay 219 to toll line TL—2. When the toll line TL—2 is released at its distant end, relay 210 releases, causing the release of relay 211. The release of relay 211 causes the release of relays 910 and 911 and the release of relay 219, if operated. The release of relay 211 causes the release of relay 212; and relay 212 disconnects holding ground potential from conductor 223. The release of relay 910 causes the release of relay 912, and relay 912 disconnects holding ground potential from conductor 923. The release of relay 911 opens the bridge across toll line TL—6 as a disconnect signal.

What is claimed is:

1. In combination, an incoming line, outgoing lines, a selector for connecting said incoming line to any one of said outgoing lines, signal repeating means associated with said incoming line for repeating signals from the incoming line to the selected outgoing line, means in one of said outgoing lines for responding to signals received over a loop circuit, means in another of said outgoing lines for responding to signals received over a simplex circuit, and circuit means including a conductor of said selector for adapting said signal repeating means to repeat the signals in a loop circuit when the selected outgoing line is one arranged to receive signals in a loop circuit and to repeat the signals in a simplex circuit when the selected outgoing line is one arranged to receive signals in a simplex circuit.

2. In combination, incoming lines, an outgoing line, selectors individual to said incoming lines, said selectors having access to said outgoing line, signal receiving means associated with said outgoing line, signal repeating means associated with one of said incoming lines for repeating incoming signals to said outgoing line in a loop circuit, signal repeating means associated with another of said incoming lines for repeating incoming signals to said outgoing line in a simplex circuit, and circuit means for adapting said signal receiving means to receive signals in a loop circuit when the incoming line from which the signals are being received is arranged to repeat the signals in a loop circuit and to receive signals in a simplex circuit when the incoming line from which the signals are being received is arranged to repeat the signals in a simplex circuit.

3. In a telephone system, lines, certain of said lines being arranged for composite signaling and others for loop signaling, a trunk circuit, means for interconnecting any one of said lines and said trunk circuit, said trunk circuit being arranged for either composite signaling or loop signaling.

4. In a telephone system according to claim 3, means in said trunk circuit for determining the character of the signaling for which an interconnected line is arranged.

5. In a telephone system according to claim 3, means in said trunk circuit for determining the character of the signaling for which an interconnected line is arranged and for selectively controlling the signaling arrangement of said trunk circuit.

6. In a telephone system, a line arranged for composite signaling, a line arranged for loop signaling, a trunk circuit, means for interconnecting said trunk circuit with a desired one of said lines, said trunk circuit being normally arranged for composite signaling, and means effective upon interconnection of said trunk circuit with the line arranged for loop signaling to arrange said trunk circuit for loop signaling.

7. In a telephone system, a line arranged for composite signaling, a line arranged for loop signaling, a trunk circuit, means for interconnecting said trunk circuit with a desired one of said lines, said trunk circuit being normally arranged for loop signaling, and means effective upon interconnection of said trunk circuit with the line arranged for composite signaling to arrange said trunk circuit for composite signaling.

8. In a telephone system, a trunk line, a trunk circuit individual to said line, said line and trunk circuit being arranged for composite signaling, a selector, a circuit including both of the talking conductors between said trunk circuit and said selector for repeating selective signals incoming over said line to said selector, another selector, said other selector being seizable by the first-mentioned selector, said other selector arranged for receiving selective signals in a loop circuit, and means in said trunk circuit effective upon seizure of said other selector by said first-mentioned selector to close a loop signaling circuit for repeating selective signals to said other selector.

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