

Nov. 6, 1945.

E. M. STAPLES ET AL

2,388,347

SIGNALING SYSTEM

Filed June 27, 1944

6 Sheets-Sheet 1

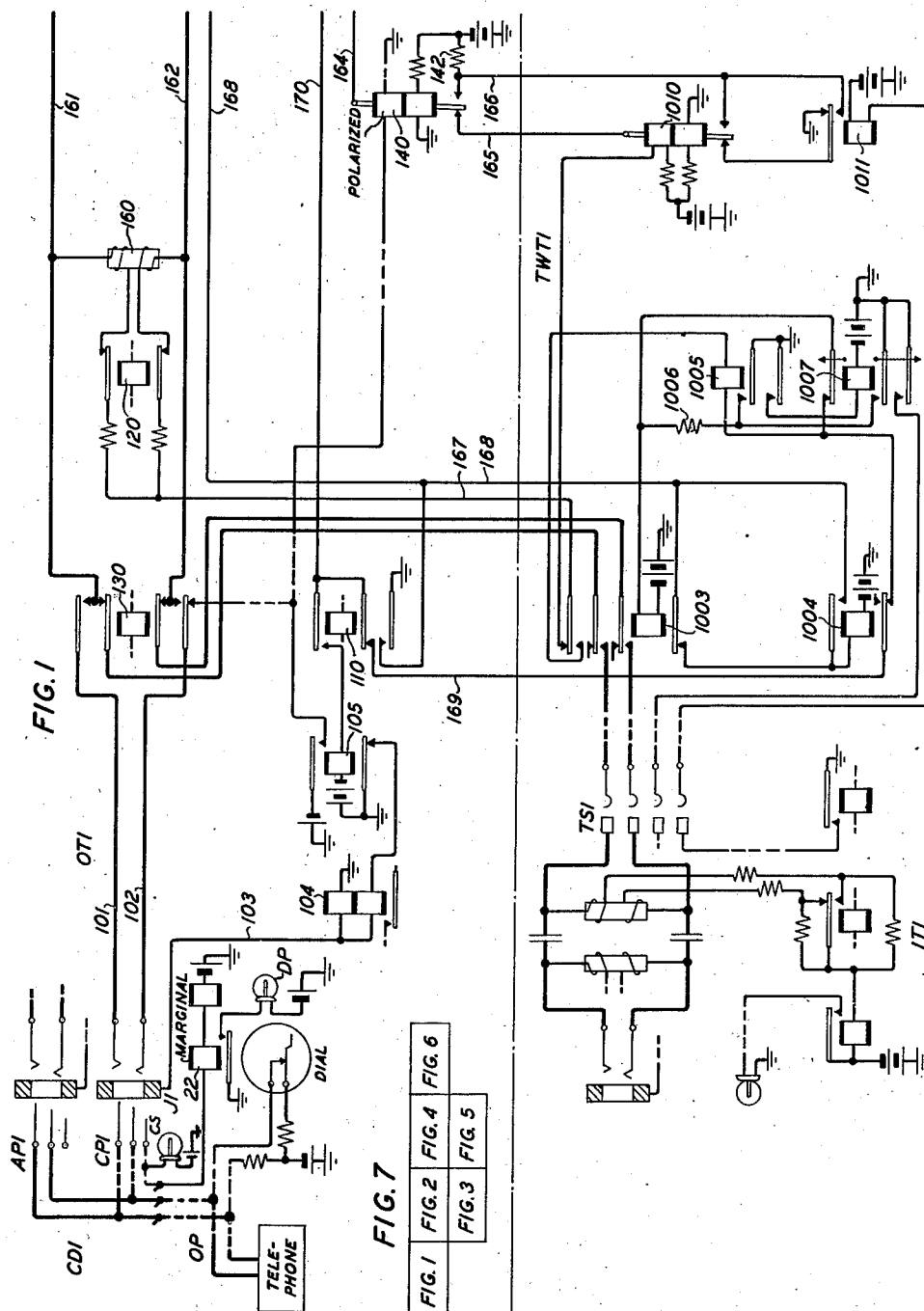


FIG. 1

FIG. 1	FIG. 2	FIG. 4	FIG. 6
FIG. 3	FIG. 5		

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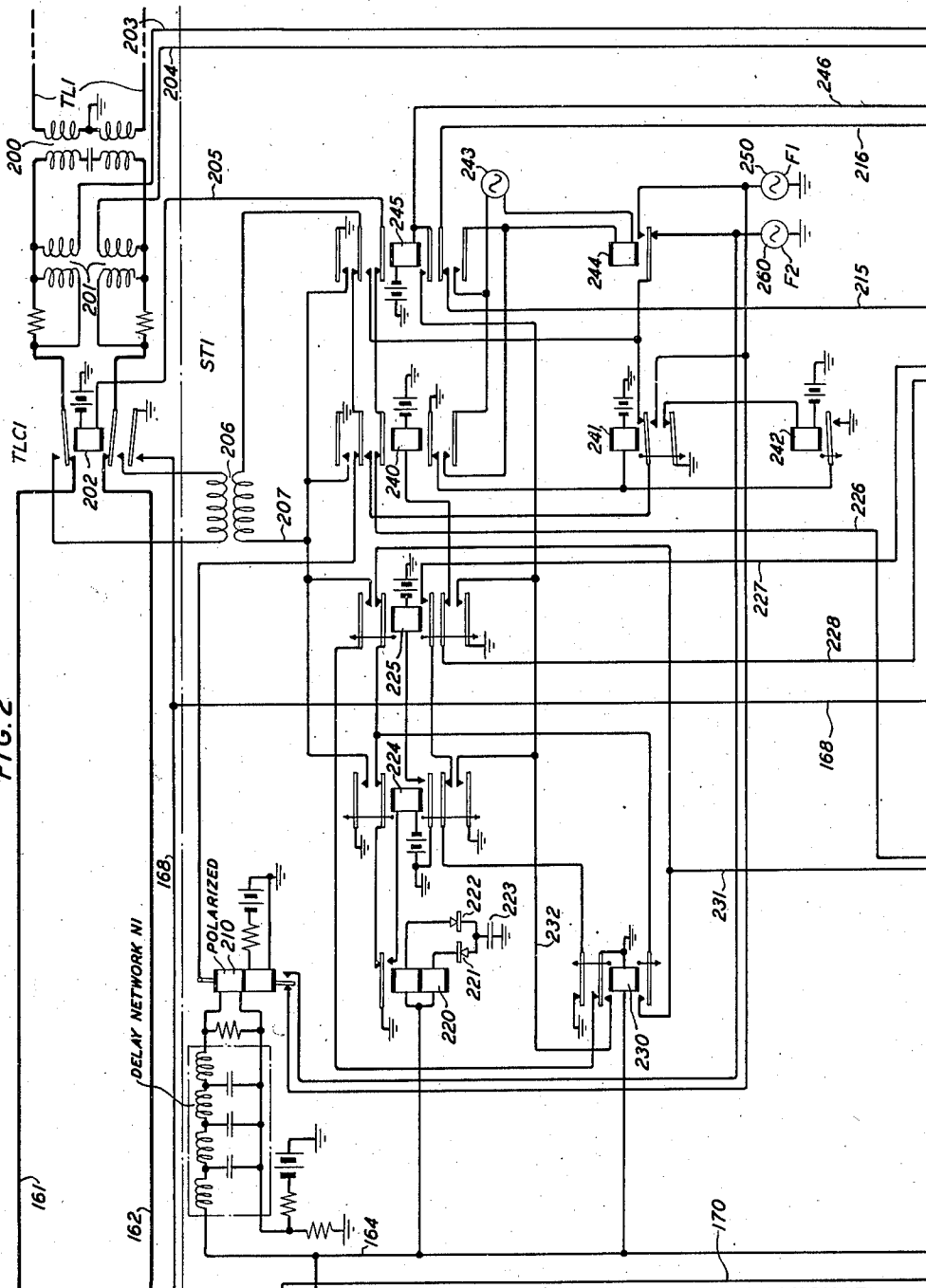
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FIG. 2



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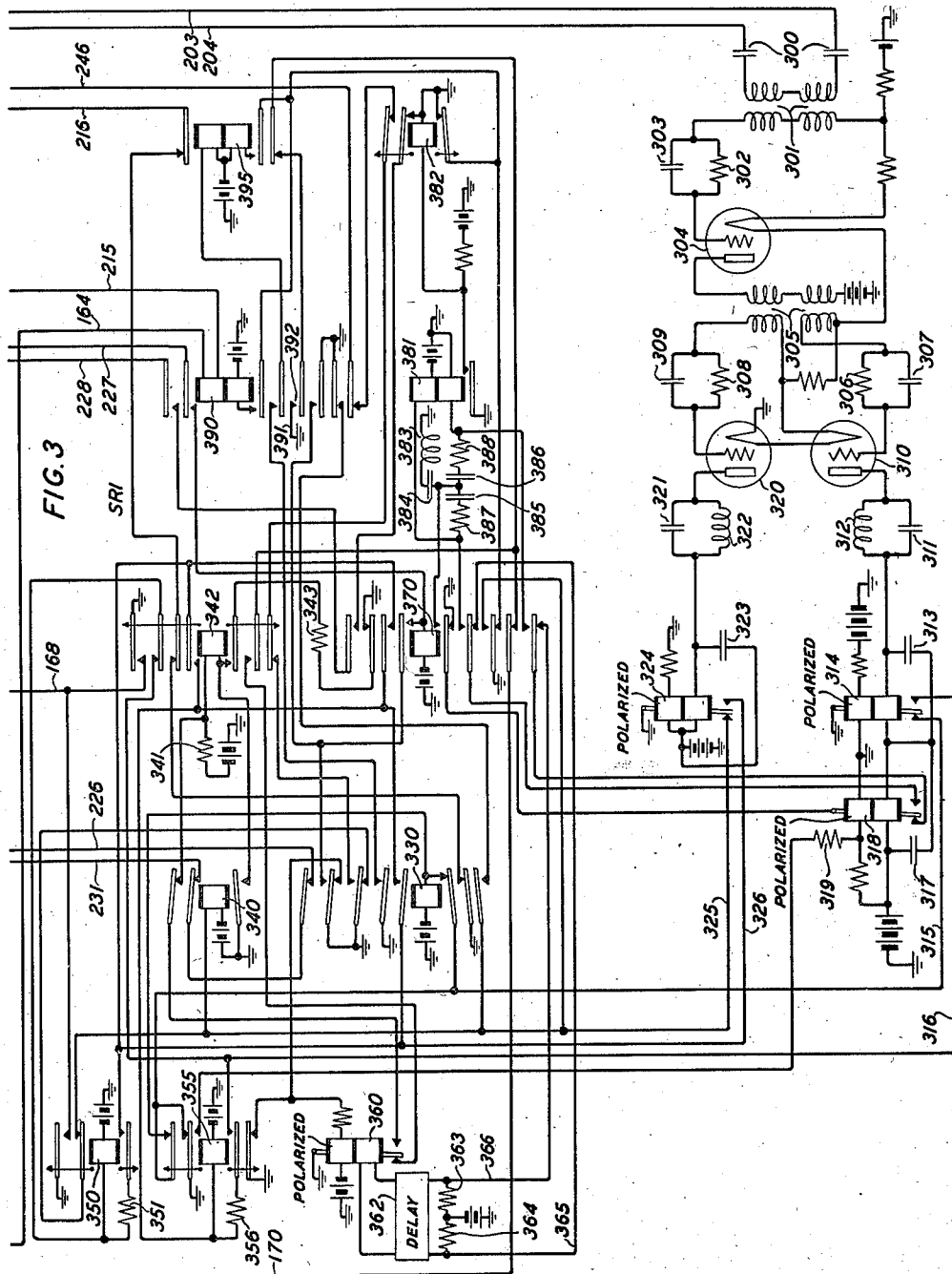
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SIGNALING SYSTEM

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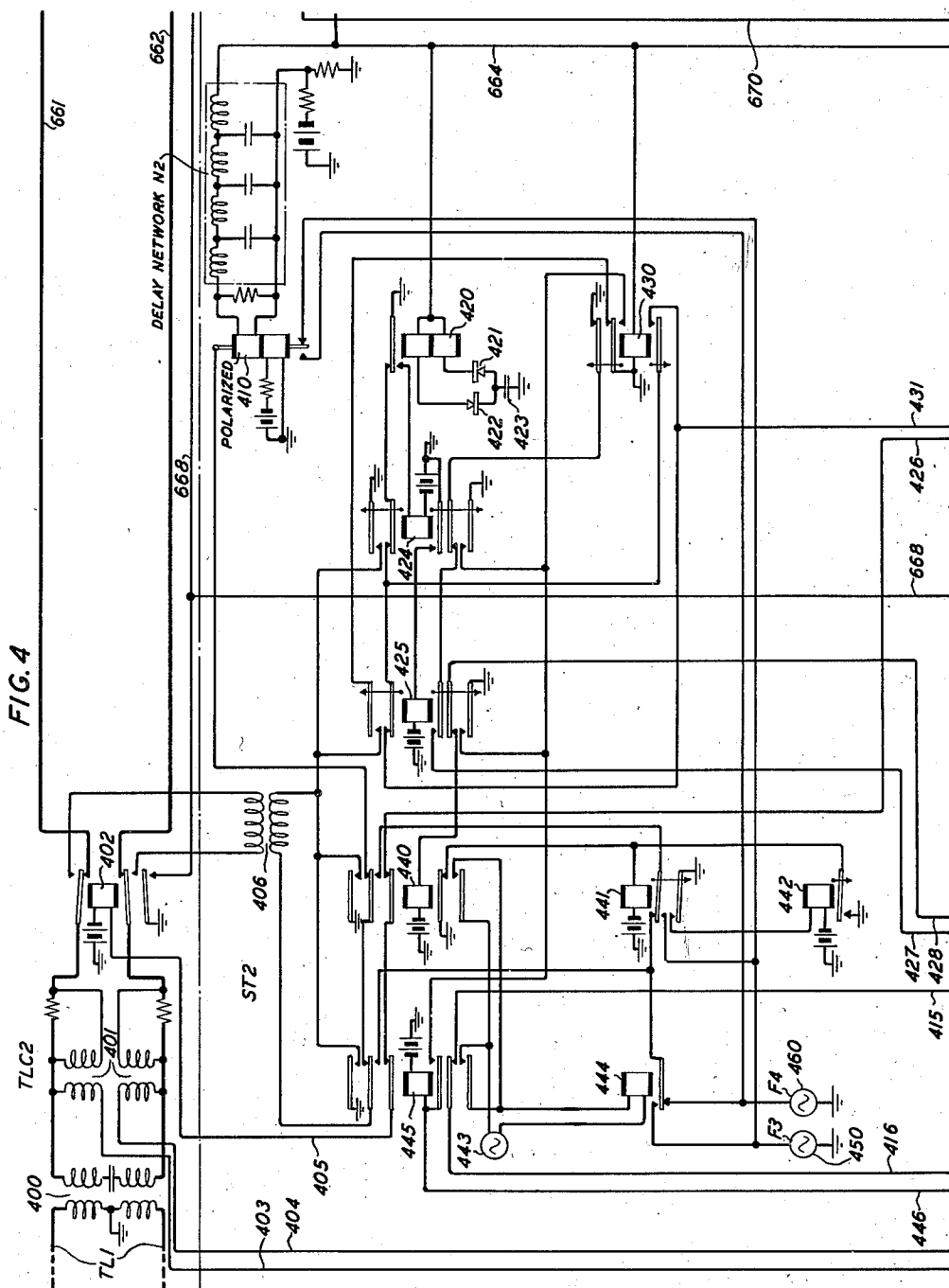
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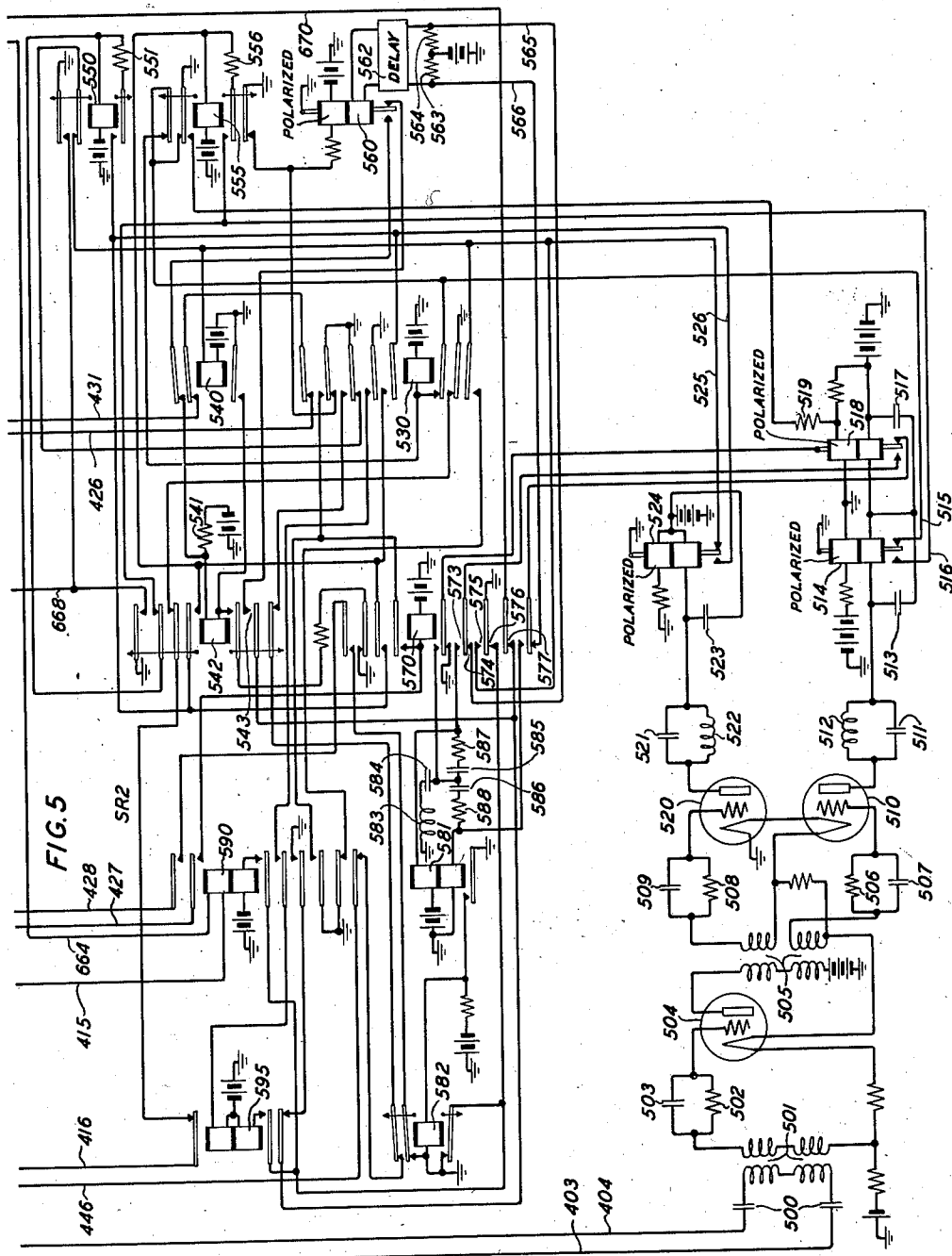
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6 Sheets-Sheet 5



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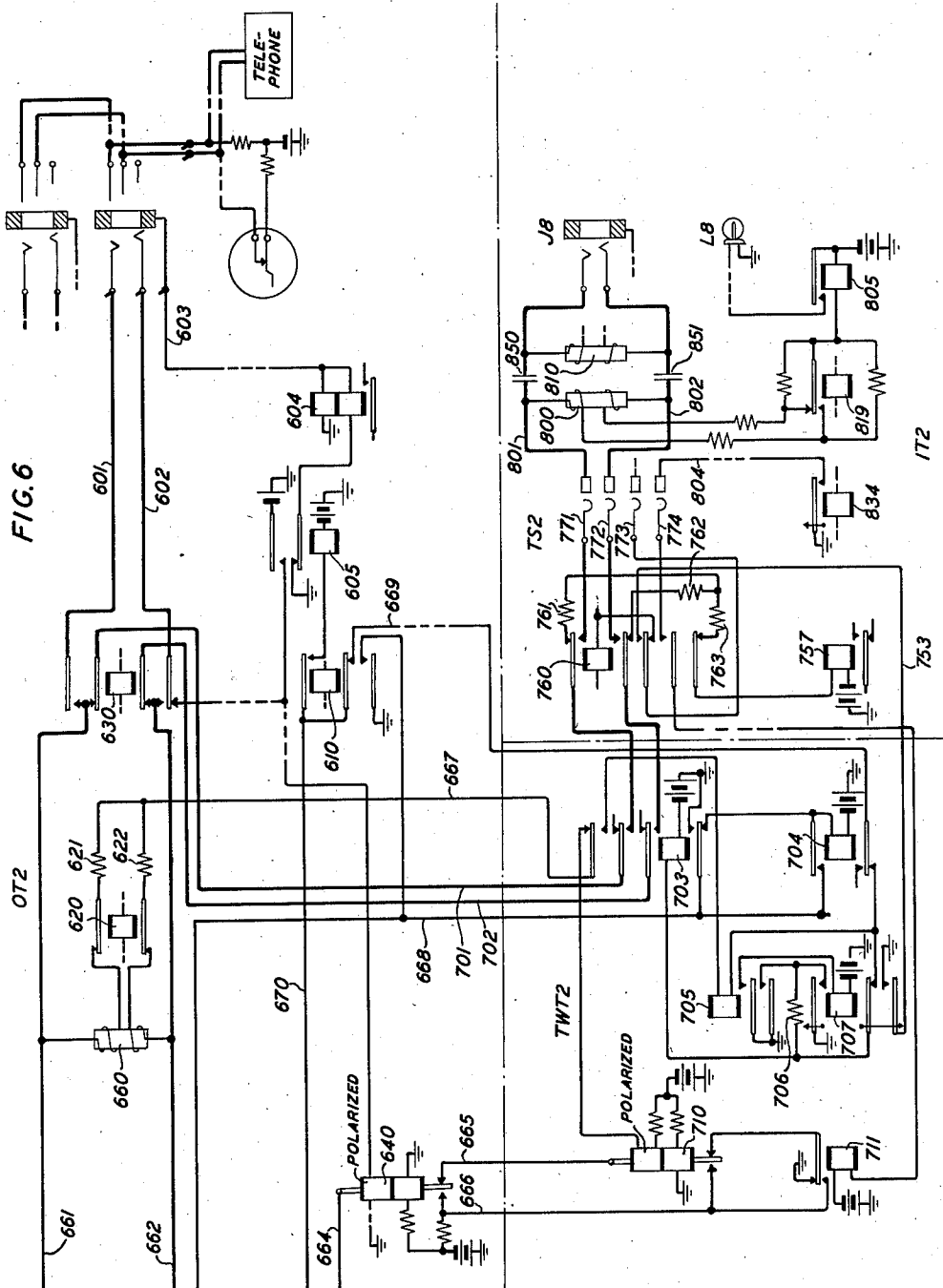
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6 Sheets-Sheet 6



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UNITED STATES PATENT OFFICE

2,388,347

SIGNALING SYSTEM

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11 Claims. (Cl. 179-43)

This invention relates to signaling systems and particularly to telephone systems in which voice frequency signaling currents are employed.

Objects of the invention are the provision of more reliable signal transmitting and receiving means in systems employing voice frequency signaling and the prevention of false operation in response to voice currents or other interfering currents.

This invention is a signaling system comprising means for transmitting signals consisting of an impulse of alternating current of a first frequency followed by an impulse of alternating current of a second frequency or for transmitting signals consisting of an impulse of current of the second frequency followed by an impulse of current of the first frequency and means for responding to such signals without responding to voice currents or other interfering currents. Similar transmitting and receiving means are connected to both ends of a toll telephone line, different frequencies being used for signaling in each direction thereover. The signal transmitting means is arranged to convert direct current signals to voice frequency signals of the desired character and the signal receiving means is arranged to convert the incoming voice frequency signals to direct current signals. Means are provided for opening the talking connection over the associated toll telephone line whenever signals are being transmitted or received thereover, the connection opening means being non-responsive to voice currents or other interfering currents having a signaling frequency component. Signal delay networks are provided both in the signal transmitting and in the signal receiving means for delaying the transmission of, and response to, each impulse of alternating current a short interval of time; so that, on calls completed through an intermediate toll office, the alternating current signal impulses transmitted through the intermediate office to a succeeding office prior to the opening of the talking connection at the intermediate office will be ineffective to cause a signal response at the succeeding office.

A feature of the invention is a signaling system in which signals consist of impulses of alternating current of each of two particular frequencies in succession, the signaling apparatus at the ends of a line over which the signals are transmitted being arranged to transmit one or more disconnect signals on an outgoing call, to transmit a disconnect acknowledgment signal on an incoming call responsive to the receiving of a disconnect signal and repeat the transmission of the

disconnect acknowledgment signal as long as disconnect signals are being received, and to end the transmission of disconnect signals on an outgoing call when a disconnect acknowledgment signal is received. According to this feature the disconnect signal first transmitted from the calling end of the line consists of an impulse of current of a first one of two particular frequencies followed by an impulse of current of the second of these frequencies, the impulse of the first frequency being long enough to enable response to the impulse of the second frequency and the impulse of the second frequency being long enough to effect the required release operations at the called end of the line; and each of the succeeding disconnect signals transmitted consists of impulses of current of said first and second frequencies alternately for a plurality of cycles, the last impulse of the second frequency in each cycle being long enough to effect the required release operations at the called end of the line.

Another feature of the invention is an arrangement in a system of the above described type which insures release of the line over which signals are being transmitted, in case the line is seized simultaneously at both ends.

A clear and complete understanding of the invention will be facilitated by considering a system embodying the invention and its features, one such system being represented schematically in the drawings which form a part of this specification. The invention is not limited in its application to the particular system and circuit arrangement shown in the drawings, but is applicable generally to any voice frequency signaling system.

Referring to the drawings:

Figs. 1, 2 and 3 represent a first toll office comprising an operator's position OP and cord CD1, an outgoing trunk circuit OT1, a two-way trunk circuit TWT1, a toll selector TS1, an incoming trunk circuit IT1, a toll line circuit TLC1 terminating a toll line TL1, a signal transmitting circuit ST1 and a signal receiving circuit SR1;

Figs. 4, 5 and 6 show a second toll office, similar to that of the first toll office; and

Fig. 7 shows the relative position in which each of Figs. 1 to 6 is to be placed to form an operative arrangement.

Reference may be had to the patent to King-Miller No. 2,208,765, granted July 23, 1940, for a detailed description of the operator's position and cord circuits provided in each of the two toll offices for interconnecting calling and called lines and trunks and controlling the completion of

toll calls. The toll line circuits TLC1 and TLC2, outgoing trunk circuits OT1 and OT2, incoming trunk circuits IT1 and IT2, the two-way trunk circuits TWT1 and TWT2 and the toll route selector circuits TS1 and TS2 are all similar to corresponding circuits described in detail in Patent No. 2,306,236 granted to J. G. Walsh December 22, 1942. The toll line circuit TLC1 comprises a repeating coil 200, a directionally selective coil 201 and a normally operated cut-off relay 202 connecting the repeating coil 200 to the talking conductors of the outgoing trunk circuit OT1. The coil 201 transmits signaling current incoming over toll line TL1 to the signal receiver SR1 but prevents the transmission of any substantial portion of the signaling energy outgoing from transmitter ST1 to the signal receiver SR1. Further protection from interference due to signals transmitted by signal transmitter ST1 may be secured by the insertion of filters, tuned to suppress frequencies F1 and F2, between coil 201 and the input transformer 301 of signal receiver SR1. The normally operated cut-off relay 202 is released, to open the talking connection between the toll line TL1 and the trunk circuits OT1 and TWT1, whenever signals are being sent by transmitter ST1 or received by signal receiver SR1. The toll line circuit TLC2 is similar to the circuit TLC1, the reference characters of like elements in these circuits having the same tens and units digits. The operators' positions are provided with dials for use in controlling the operation of incoming and auxiliary toll route selectors in other toll offices and for controlling the operation of selector and connector switches in local and community dial offices.

The signal transmitter ST1 comprises relays 210, 220 and 230 connected in multiple to conductor 164 and controlled by relay 140 of outgoing trunk circuit OT1. Relay 210 is a polarized relay having a biasing winding. The operating winding of relay 210 is connected to conductor 164 through a delay network N1; whereby the operation and release of relay 210 are each delayed for an interval of about .05 second. The network N1 is a multisection low pass filter so that the delay thus introduced is substantially constant for varying rates of dial impulse transmission. Relay 220 has two windings connected in parallel between conductor 164 and condenser 223, rectifiers 221 and 222 being connected in series with the windings of relay so that one winding is operatively energized while condenser 223 is charging responsive to operation of relay 140, so that the other winding is operatively energized while condenser 223 is discharging responsive to release of relay 140, and so that both windings are energized in series to maintain the operation of relay 220 for an interval of about .1 second following the operative energization of either one of the windings. Relay 230 is a slow-to-release relay having a release time of about .025 second. The signal transmitter ST1 further comprises relays 224 and 225 which are controlled by relay 220 and cooperate with relay 210 to effect the transmission of seizure, selective, ringing, supervisory and disconnect signals. The transmitter ST1 further comprises relays 240, 241, 242, 244 and 245 for transmitting repeated disconnect signals and for transmitting disconnect acknowledgment signals. The signal transmitter ST1 further comprises a source 250 of alternating current of a first signaling frequency F1 and a source 260 of alternating current of a second signaling frequency F2 for use in sending signals

consisting of a sequence of impulses of these two particular frequencies. Another source of alternating current, the source 243, is provided for controlling relay 244, the frequency of this source determining the rate at which the frequencies F1 and F2 are alternating during the transmission of a disconnect acknowledgment signal.

The signal transmitter circuit ST2 is similar to the transmitter circuit ST1, the reference characters of like elements in each circuit having the same tens and units digits. The two frequencies F1 and F2 used for transmitting signals over toll line TL1 in one direction are different from the two frequencies F3 and F4 used for transmitting signals in the other direction. For instance the frequencies 600 cycles and 1500 cycles may be used to transmit signals in one direction and the frequencies 700 cycles and 1700 cycles may be used to transmit signals in the opposite direction. The signal receiver SR1 comprises an input transformer 301, a volume limiting amplifier 304 and an output transformer 305 through which all current incoming over line TL1 is transmitted. The receiver further comprises volume limiting detector 310 and polarized relays 314 and 318 responsive to signaling current of frequency F3, and a volume limiting detector 320 and polarized relay 324 responsive to signaling current of frequency F4. The condenser 311 and inductive coil 312 constitute a network which is tuned to have a high impedance at the signaling frequency F3; and the condenser 321 and inductive coil 322 constitute a network which is tuned to have a high impedance at the signaling frequency F4. Each of relays 314, 318 and 324 has a biasing winding and an operating winding, the left contact of each of these relays being normally closed as shown in the drawing due to the normal energization of the operating winding. The signal receiver SR1 further comprises normally operated relays 330 and 340, slow-to-release relays 342, 350 and 355 and a polarized relay 360 for responding to seizure, selective, ringing and answering supervisory signals. Relay 330 is normally energized under control of each of relays 314 and 355; and relay 340 is normally energized under control of relay 324 and also under the control of relays 330 and 350. Relay 360 has a normally energized biasing winding and an operating winding which is energized in one direction when relay 318 is normal and in the opposite direction when relay 318 is operated. A low pass delay network 362, similar to delay network N1 of signal transmitter ST1, delays the response of relay 360 for .05 second. The left contact of relay 360 is normally closed as shown in the drawings, and this contact is held closed as long as the biasing winding is energized. This delay prevents false signal operations on tandem switched connection due to transmission of all of the first impulse and part of the second impulse of a signal before the cut-off relay releases to open the talking connection at the intermediate switching point. The signal receiver SR1 further comprises relays 370, 381 and 382 for response to disconnect and disconnect acknowledgment signals; and comprises relays 390 and 395 for control of the signal transmitter ST1 and signal receiver SR1 according to whether the call is an outgoing or an incoming call. Relay 382 is normally operated, thereby providing a locking path for relay 390. Relay 381 has associated therewith a network comprising coil 383, condensers 384, 385 and 386 and resistors 387

and 388, which network tunes relay 381 for response to disconnect acknowledgment signals. The signal receiving circuit SR2 is similar to the receiving circuit SR1, the reference characters of like elements in these circuits have the same tens and units digits.

Further explanation of the invention will be facilitated by describing in detail the circuit operations involved on calls over toll line TL1. Assume that a call incoming to the operator's position OP has been answered with answering plug AP1 of cord CD1, that the calling plug CP1 of this cord has been inserted in jack J1 of outgoing trunk circuit OT1, and that the call is one which may be completed through intertoll trunk line TL1. Relays 104, 110 and 140 are operated, responsive to insertion of plug CP1 in jack J1, in the manner described in the aforementioned patent to King-Miller. The operation of relay 110 connects ground to conductor 168 to operate and lock relay 1004 of two-way trunk circuit TWT1. The operation of relay 140 closes a circuit including conductor 164 for operating relays 210, 220 and 230 of the signal transmitter ST1 and for operatively energizing the upper winding of relay 390 of signal receiver SR1. Relay 390 closes a locking circuit through its lower winding, which circuit is under the joint control of relays 370 and 382. It is assumed that relay 370 is normal and relay 382 operated when relay 140 operates, this being the case when no incoming seizure signal has been received at the time that relay 390 operates. The operation of relay 390 prepares the signal transmitting circuit for the repeated transmission of a disconnect signal when the connection is released; prepares the signal receiving circuit for response to supervisory and disconnect acknowledgment signals; and prevents the operation of relay 245, so that the signal transmitter is unable to send a disconnect acknowledgment signal on an outgoing call. If the office at the distant end of line TL1 includes links arranged to send a stop dial signal while preparing to receive dial signals, conductor 391 is connected to ground and the operation of relay 390 connects this ground through contact 392, back contacts of relays 395 and 370, to conductor 170, to operate relay 105 as a stop dial signal. The operation of relay 105 opens the circuit through the lower, high resistance winding of relay 104 thereby to effect the extinguishing of a supervisory lamp at the operator's position to indicate that dialing should not be started. This local circuit operation of relay 105 in advance of the receipt of a stop dial signal over line TL1 insures the extinguishing of the operator's supervisory lamp early enough to be effective as a stop dial signal. If the called office is of such a character that a stop dial signal is not required, conductor 391 is not provided. The operation of relay 220 responsive to the connection of ground to conductor 164 causes the operation of relays 224 and 225 in succession and the release of cut-off relay 202 of the toll line circuit TLC1. Relay 202 is normally energized in a circuit including the inner upper back contact of relay 245, inner upper back contact of relay 240, conductor 226, uppermost front contact of normally operated relay 330, inner upper front contact of normally operated relay 340, conductor 231, and through back contacts of relays 225, 224 and 220 to ground. The release of relay 202 disconnects the talking conductors 161 and 162 of outgoing trunk circuit OT1 from repeating coil 200 of toll line TL1,

connects the upper winding of coil 206 of signal transmitter ST1 to repeating coil 200, and connects ground to conductor 168 to hold relay 1004 of two-way trunk circuit TWT1. The operation of relay 230 connects ground to conductor 232 and so also does the operation of relays 224 and 225 thereby to provide a locking ground connection for relay 245 if and when relay 245 operates as hereinafter described. The operation of relay 224 connects ground to conductor 207 thereby completing a circuit through the lower winding of transformer 206, outer upper back contacts of relays 245 and 240, left contact of relay 210 and the source 250, thereby initiating the transmission of signaling current of frequency F1 through transformer 206, back contacts of relay 202, coil 200 and toll line TL1. About, but not less than, .025 second after the release of relay 202 and operation of relay 224, relay 210 operates. The operation of relay 210 disconnects source 250 from and connects source 260 to the lower winding of transformer 206 thereby terminating the transmission of current of frequency F1 and initiating the transmission of current of frequency F2 over toll line TL1. Relays 210 and 230 remain operated as long as relay 140 remains operated; but relay 220 releases about .1 second after its operation, causing the successive release of relays 224 and 225 unless the transmission of dial impulses is initiated before either or both of these relays has released. The release time of relay 224 is approximately .05 second and the release time of relay 225 is approximately .2 second. When relay 224 releases, it disconnects ground from conductor 207 thereby ending the transmission of current of frequency F2 through transformer 206 and coil 200. When relay 224 releases, relay 202 reoperates, disconnecting transformer 206 from coil 200 and reconnecting coil 200 to conductor 161 and 162. Thus a seizure signal, consisting of an impulse of current of frequency F1 for not less than .025 second followed by an impulse of current of frequency F2 for about .1 second, is transmitted over toll line TL1 responsive to seizure of outgoing trunk circuit OT1 at position OP.

Consider now the operation of the signal receiver SR2 responsive to the seizure signal. The voltage generated across the secondary windings of coil 400 due to current incoming over toll line TL1 causes a current through the left windings of coil 401, conductors 403 and 404, condensers 500 and the primary winding of transformer 501 of signal receiver SR2. The secondary winding of transformer 501 is connected, through condenser 503 and resistor 502 in parallel, to the grid of amplifier tube 504. The anode-cathode circuit of tube 504 includes the primary winding of transformer 505; and this transformer has two secondary windings through which the output of tube 504 is separately applied to the grids of detector tubes 510 and 520. The amplifier 504 and detectors 510 and 520 have volume limiting characteristics due to the voltage drop introduced by the resistors 502, 506 and 508, respectively. The volume limiting action of tubes 510 and 520 prevents false signal operations from voice or interference currents since the current through the operating windings of relays 514 and 518 is not reduced sufficiently to effect the operation of these relays unless the current in the primary winding of transformer 501 is substantially all of signaling frequency F1; and since the current through the operating winding of relay 524 is not

reduced sufficiently to effect the operation of this relay unless the current in the primary winding of transformer 501 is substantially all of signaling frequency F2. The volume limiting action of tube 504 prevents overloading of tubes 510 and 520 thereby helping to prevent false operations of relays 514, 518 and 524. The anode-cathode circuit of tube 510 includes a tuned network, consisting of condenser 511 and inductance 512, and the operating windings of relays 514 and 518; and the anode-cathode circuit of tube 520 includes a tuned network, consisting of condenser 521 and inductance 522, and the operating winding of relay 524. Condensers 513, 517 and 523 are connected in parallel with the operating windings of relays 514, 518 and 524 respectively to prevent these relays from tending to operate responsive to alternating current of the signaling frequencies and to provide a low impedance path for other frequencies.

When a seizure signal is received by signal receiver SR2, the impulse of current of frequency F1 effects the operation of relay 514. Although the lower, operating winding of relay 518 is in series with the lower, operating winding of relay 514, relay 518 does not respond due to the high normal bias of relay 518. The operation of relay 514 closes a circuit from ground through the left contact of relay 514, conductor 516 and outer upper back contact of relay 542 for operating relay 550. When the impulse of current of frequency F1 ends, relay 514 releases. The release of relay 514 opens the operating circuit of relay 550; but being slow to release, relay 550 remains operated for about .015 second; and, during this time, the impulse of current of frequency F2, which follows the impulse of frequency F1, effects the operation of relay 524. The operation of relay 524 before relay 550 releases, closes a locking circuit for relay 550 which circuit is traced from battery through the winding of relay 550, resistor 551, lower front contact of relay 550, conductor 526 and the left contact of relay 524 to ground. With both of relays 524 and 550 operated, the normally operated relay 540 releases. The release of relay 540 causes the release of the normally operated relay 402 of line circuit TLC2 and causes the operation of relay 542. The release of relay 402 disconnects coil 400 from talking conductors 661 and 662 and connects the upper winding of transformers 406 to coil 400. Relay 542 locks through its inner lower front contact under control of relay 570, closes a circuit for energizing relay 555, and connects ground to conductor 670 to effect the operation of relay 703 of two-way trunk circuit TWT2. The circuit for operating relay 555 includes the inner upper front contact of relay 542 and the left contact of relay 524; and relay 524 may or may not remain operated long enough to effect the operation of relay 555. The circuit for operating relay 703 is traced from battery through its winding, back contacts of relays 701 and 704, conductor 669, back contact of relay 610 of outgoing trunk circuit OT2, conductor 670, back contact 577 of relay 570, front contact 543 of relay 542, and the normally closed right contact of relay 560 to ground. Conductor 670 is the signaling conductor over which all signals incoming over toll line TL1 are transmitted to the two-way trunk circuit TWT2, outgoing trunk circuit OT2, selector TS2 and any succeeding selectors or trunks to which the connection may be extended. When the impulse of current of frequency F2 ends, relay 524 re-

leases. The release of relay 524 causes the reoperation of relay 540, the release of relay 550 and the release of relay 555, if operated; but relay 542 remains operated and the connection of ground to conductor 670 is maintained. The reoperation of relay 540 causes the reoperation of relay 402, whereby coil 400 is again connected to talking conductors 661 and 662.

It is to be noted that the operation of relay 542 responsive to the seizure signal opens the operating circuit of relay 550, thereby disabling the operation of the signal receiver responsive to any signal or interference current beginning with frequency F1, thereby reducing the possibility of false operations of signal receiver SR2 after response to a seizure signal. The aforementioned operation of relay 542 also prevents the operation of relay 590 when battery is connected to conductor 664 to effect the transmission of a supervisory signal. Relay 542 is sufficiently slow in releasing so that it will remain operated during the receipt of dial impulse signals or a rering signal.

The aforementioned release of relay 402 effects the connection of ground to conductors 668 and so also does the operation of relay 703; whereby the toll line TL1 is marked busy at the multiple jacks at which trunk circuit OT2 terminates and at the terminal banks of toll selectors such as TS2 having access to the toll line TL1, as set forth in detail in the aforementioned patent to J. G. Walsh. The aforementioned operation of relay 703 closes a circuit for operating relay 705 of two-way trunk circuit TWT2 and the line relay 757 of selector TS2. This circuit is traced from battery through the winding of relay 757, lowermost back contact of relay 760, resistor 763, thence in simplex through resistors 761 and 762, back contacts of relay 760, front contacts of relay 703, conductors 701 and 702, back contacts of relay 630 of outgoing trunk circuit OT1, both windings of retard coil 660, back contacts of relay 620 and resistors 621 and 622, thence through conductor 667, uppermost front contact of relay 703 of two-way trunk circuit TWT2, winding of relay 705, back contact of relay 704, conductor 669, back contact of relay 610 and through conductor 670, back contact of relay 570, front contact of relay 542 to ground at the right contact of relay 560 as described for operating relay 703. The operation of relay 705 closes a circuit for operating the slow-to-release relay 707 and closes a holding circuit through resistor 706 for holding relay 703 operated after relay 707 operates. Relay 707 also connects ground to resistor 706 to hold relay 703 operated, opens the operating circuit of relay 703, and connects ground to conductor 753 to hold the switch TS2 after it has selected a trunk as hereinafter described. The operation of relay 757 prepares the selector TS2 for selective response to the first train of dial impulses incoming to signal receiving circuit SR2 in the manner described in the aforementioned patent to J. G. Walsh.

If it is necessary to transmit a "stop dial" signal to the calling operator, as would be the case where a finder switch operates to extend a calling trunk line to an incoming selector, the "stop dial" signal is transmitted in the manner hereinafter described for the transmission of an "off hook" signal. And when dialing may be started, a "start dial" signal is transmitted in similar manner to the transmission of an "on hook" signal as hereinafter described.

When the operation at position OP dials the first digit of the code which identifies the called toll or local office, relay 140 is alternately released and reoperated as many times as there are units in the digit dialed under the control of the impulse contact of the dial at position OP. Each release and reoperation of relay 140 effects a corresponding release and reoperation of relay 210, the response of relay 210 being delayed in each case for about .050 second by the network N1. Relay 220 is energized by the discharge of condenser 223 when relay 140 releases in response to the first impulse of the digit; and since relay 140 reoperates after each release during dialing before relay 220 has released, relay 220 remains operated during response of relay 140 to the impulses of each digit and releases about .1 second after relay 140 reoperates at the end of the last impulse of each digit dialed. Thus relay 220 operatively energizes relay 224 at the beginning of each train of dial impulses; and relays 224 and 225 are operated and remain operated during the transmission of each train of dial impulses. The operation of relay 220 causes the release of relay 202. Relay 230 releases each time relay 140 releases responsive to dial impulses. Since the release time of relay 230 is not less than .025 second, relay 230 will not release before relay 224 operates responsive to the first dial impulse of a digit, thereby preventing the false operation of relay 370 of signal receiver SR1 in case relay 225 is operated at the time relay 230 releases responsive to the first impulse of a series as is the case when the first digit is dialed as soon as the trunk OT1 is seized. Since relay 210 is operated at the time the first digit is dialed, the operation of relay 224 or, if relay 225 has not released prior to the dialing of the first digit, the release of relay 230 connects ground to conductor 207 to initiate the transmission of signaling current of frequency F2 over toll line TL1. When relay 210 releases about .050 second after relay 140 releases responsive to the first dial impulse and not less than .025 second after the connection of ground to conductor 207, the source 260 is disconnected from, and the source 250 is connected to, transformer 206 thereby ending the impulse of current of frequency F2 and initiating the transmission of current of frequency F1 over toll line TL1. When relay 210 reoperates at the end of the first impulse of a digit, source 250 is disconnected from, and source 260 is connected to, transformer 206 thereby ending the transmission of current of frequency F1 and initiating transmission of current of frequency F2. The release and reoperation of relay 210 responsive to each succeeding impulse of the train effects the transmission of an impulse of current of frequency F1 followed by current of frequency F2. When relay 210 remains operated after receiving the last dial impulse of a digit, relays 220, 224 and 225 release in succession, the release of relay 224 being effective to end the transmission of current of frequency F2 in the manner above described for terminating the current of this frequency at the end of the seizure signal. In like manner, the dialing of each succeeding digit of the toll route code, and also the dialing of each digit of a called subscriber's number, by the operator at position OP causes the transmission of a train of dial impulse signals by the signal transmitter ST1 over toll line TL1. At the end of the dialing of each digit, the conditions existing in signal transmitter ST1 are the same as they were following transmission of the seizure signal.

The signal receiver SR2 responds to each train of dial impulse signals coming over the toll line TL1, the first train being effective to control the selective operation of selector TS2. The current of frequency F2, transmitted over toll line TL1 responsive to the first opening of the impulse contacts of the dial, causes the operation of relay 524. The operation of relay 524 connects ground to conductor 526, causing the operation of relay 555. The operation of relay 555 connects ground to resistor 519 thereby reducing the current in the biasing winding of relay 518 to render this relay operative responsive to the reduction of current in its lower winding when and if an impulse of current of frequency F1 is received over toll line TL1 before relay 555 releases. When the impulse of current of frequency F2 ends, relay 524 releases; but, being slow to release, relay 555 remains operated for about .015 second after relay 524 releases. The impulse of current of frequency F1, which follows the impulse of frequency F2 before relay 555 releases, effects the operation of both of relays 514 and 518. The operation of relay 514, before relay 555 releases, closes a holding circuit for relay 555; which circuit is traced from battery through the winding of relay 555, resistor 556, lower front contact of relay 555, conductor 516 and the left contact of relay 514 to ground. With relays 514 and 555 both operated, the normally operated relay 530 releases, and it cannot reoperate until relay 555 releases. The release of relay 530 connects conductor 525 to ground at a back contact of relay 590 to prevent the release of relay 540; and causes the release of relay 402, whereby coil 400 is disconnected from talking conductors 661 and 662. With relay 530 released and relay 555 operated, the upper winding of relay 560 is deenergized, thereby rendering relay 560 operatively responsive to operations of relay 518. With relay 518 normal, the lower winding of relay 560 is energized in one direction in a circuit traced from battery through resistor 564, delay network 562 and lower winding of relay 560 in series, conductor 566, lowermost back contact of relay 570, right contact of relay 518, and inner lower back contact of relay 570 to ground. With relay 518 operated, the lower winding of relay 560 is energized in the other direction in a circuit traced from battery through resistor 563, delay network 562 and lower winding of relay 560 in series, conductor 565, back contact 574 of relay 570, left contact of relay 518, to ground at the inner lower back contact of relay 570. The response of relay 560 to each operation and each release of relay 518 is delayed for about .05 second by the delay network 562. Thus the operation of relay 518, responsive to the impulse of current of frequency F1 representing the first dial impulse of a digit, causes the operation of relay 560; and the release of relay 518, at the end of this impulse, causes the release of relay 560. The impulse of current of frequency F2 representing the closing of the dialing circuit at the end of the first impulse, causes the reoperation of relay 524. Each succeeding impulse of current of frequency F1, representing a dial impulse of the first digit dialed, effects the operation of relays 514 and 518; and each succeeding impulse of current of frequency F2 representing the closing of the dialing circuit at the end of a dial impulse effects the operation of relay 524. Each operation of relay 514 holds relay 555 operated, each operation and release of relay 518 causes the operation and release of relay 560, and each operation of relay 524 holds relay 555 operated. Thus relay 555 is oper-

ated due to the operation of relay 524 at the beginning of each train of dial impulse signals, and is held operated during the response of relay 560 to a train of dial impulse signals; and while relay 555 is operated, relay 530 cannot reoperate. The release of relay 524 at the end of the impulse of current of frequency F2 which is received for about .1 second at the end of a train of dial impulse signals, causes the release of relay 555 followed by the reoperation of relay 530.

Each operation and release of relay 560 responsive to the first train of dial impulse signals transmitted over line TL1 disconnects ground from and reconnects ground to conductor 670, thereby causing the release and reoperation of relay 705 of two-way trunk circuit TWT2 and release and reoperation of relay 757 of selector TS2 responsive to each dial impulse signal of the train. Being slow to release, relay 707 of two-way trunk circuit TWT2 remains operated during the transmission of dial impulses over conductor 670. The selector TS2 is thereby selectively operated under the control of relay 757 to select a level corresponding to the first digit of the toll route code and to select an idle trunk connected to this level, relay 760 being thereupon operated to extend the connection through brushes 771, 772, 773 and 774 to the selected trunk, all in the manner described in detail in the aforementioned patent to J. G. Walsh.

The trunk selected by selector TS2 responsive to the first digit dialed by the operator at OP may extend to an auxiliary route selector similar to selector TS2, to another toll line, to a trunk to a local office, or to an incoming trunk circuit IT2 at a toll operator's position. If the operator at position OP dials additional digits, the signal transmitter ST1 transmits a train of dial impulse signals corresponding to each digit dialed and the signal receiver SR2 repeats these dial impulses over conductor 670 to effect the selective operation of additional selectors through which the connection is extended. When dialing is completed and the position dial key (not shown) is restored to normal, relay 130 is operated to connect the talking conductors of cord CD1, through front contacts of this relay and the talking conductors 161 and 162 of trunk circuit OT1 to the repeating coil 200 as described in the aforementioned King-Miller patent.

Assuming that the call is routed to a toll operator through an incoming trunk circuit IT2 connected to terminals in the bank of selector TS2, the operation of relay 760 of selector TS2 closes a circuit through brushes 771 and 772 for operating relay 805. The operation of relay 805 lights the lamp L3 associated with jack J8. When an operator answers the call by inserting the plug of a cord in jack J8, relay 834 is operated as described in detail in the aforementioned patent to J. G. Walsh. The operation of relay 834 connects ground through conductor 804, brush 774 and a front contact of relay 760, to operate relay 711 of two-way trunk circuit TWT2. The operation of relay 711 disconnects ground from and connects signaling battery to conductor 664 to effect the transmission of an answering supervisory or "off hook" signal by transmitter ST2 over line TL1 to the calling toll office in similar manner to that in which the seizure signal was transmitted by signal transmitter ST1 responsive to the connection of signal battery to conductor 164 as hereinbefore described. The "off hook" signal thus transmitted consists of an impulse of current of frequency F3 followed by an impulse

of current of frequency F4 instead of impulses of current of frequencies F1 and F2; and, since relay 542 of signal receiver SR2 is operated, relay 590 of signal receiver SR2 is not operated, as did relay 390 of signal receiver SR1. The signal receiver SR1 responds to this signal in similar manner to that in which SR2 responds to a seizure signal as hereinbefore described; except that, since relay 110 has been operated in outgoing trunk circuit OT1, the connection of ground to conductor 170 effects the operation of relay 105 of outgoing trunk circuit OT1 instead of operating relay 1003 of two-way trunk circuit TWT1. The operation of relay 105 disconnects ground from the lower winding of relay 104, whereby the supervisory lamp CS is extinguished. In case dialing has not been completed, when relay 105 operates, the sleeve conductor of plug CPI is connected to relay 22 instead of to lamp CS; and in this case the marginal relay 22 releases to extinguish the dial pilot lamp DP as a stop dialing signal.

If the answering operator disconnects the answering plug from jack J8, relay 834 releases, causing the release of relay 711 of two-way trunk circuit TWT2. The release of relay 711 reconnects ground to conductor 664, whereby the signal transmitter ST2 is operated to transmit an "on hook" signal. When battery is disconnected from, and ground is connected to, conductor 664 by the release of relay 711, relay 420 is operated for about .1 second and relays 410 and 430 are deenergized, the release of relay 430 occurring at the end of an interval of about .025 second and the release of relay 410 occurring at the end of an interval of about .050 second. The operation of relay 420 causes the release of relay 402 and the successive operation of relays 424 and 425. The operation of relay 424 closes a circuit from ground, through the lower winding of transformer 406, back contacts of relays 445 and 440 and left contact of relay 410 to source 460 of current of frequency F4; and with relay 402 released, current of frequency F4 is transmitted through transformer 406 and coil 400 over toll line TL1. When relay 410 releases, the lower winding of transformer 406 is transferred from source 460 to source 450 thereby ending the transmission of current of frequency F4 and initiating the transmission of current of frequency F3 over toll line TL1. When relay 420 releases, it causes the successive release of relays 424 and 425, the release time of relay 424 being about .050 second and the release time of relay 425 being about .2 second. Since relay 590 is not operated, the release of relay 424 does not cause the operation of relay 570 of signal receiver SR2. When relay 425 releases, ground is disconnected from the lower winding of transformer 406 thereby ending the impulse of current of frequency F3, the duration of this impulse being about .3 second. When relay 425 releases, it again closes the normally closed circuit for operating relay 402.

When a "start" dial" or "on hook" signal is received by signal receiver SR1, relay 324 operates responsive to the current of frequency F4. The operation of relay 324 closes a circuit from ground through its right contact, conductor 326, and inner upper front contact of relay 342 (this relay having been operated and locked responsive to the "off hook" signal) for operating relay 355. Relay 355 connects ground to resistor 319 to reduce the bias of relay 318 and opens the operating circuit of relay 330. When the impulse of current of frequency F4 ends, relay 324 releases.

Relay 355 is slow to release and the impulse of current of frequency F3, which follows the current of frequency F4 before relay 355 has time to release, causes the operation of both of relays 314 and 318. When relay 314 operates, it holds relay 355 and causes the release of relay 330, thereby rendering relay 360 responsive to the energization of its lower winding under the control of relay 318. The operation of relay 318 causes the operation of relay 360, the network 362 being effective to delay the response of relay 360 for about .05 second. When relay 360 operates, it disconnects ground from conductor 170, to cause the release of relay 105; and connects ground through its right contact and a front contact of relay 340 to resistor 341, thereby short-circuiting the winding of relay 342. The release of relay 105 connects ground to the low resistance winding of relay 104, causing the cord supervisory lamp CS to light. Since the impulse of current of frequency F3 continues for .3 second, relay 342 releases; thereby preventing the reconnection of ground to conductor 170 when relay 360 releases at the end of the impulse. The release of relay 330 closes a circuit for operating relay 395 and opens the operating circuit of relay 390. Relay 395 locks through its lower winding under control of relays 370 and 382. If the signal is an "on hook" signal with conductor 391 omitted or is an "on hook" signal following an "off hook" signal, ground is disconnected from conductor 170 as soon as relay 360 operates; but in the case of a "start dial" signal, it is to be noted that ground is not disconnected from conductor 170 until relay 395 operates to end the local "stop dial" signal condition, established responsive to seizure of trunk circuit OTI.

If the calling operator operates the ringing key (not shown) in the cord CD1 to recall the answering operator, relay 140 is released and re-operated to effect the transmission of a ringing signal. The signal transmitter ST1 and signal receiver SR2 are operated in the same manner as if the digit 1 had been dialed by the operator, the connection of ground to conductor 670 being thereby momentarily opened to give the answering operator a recall signal in the manner described in the aforementioned J. G. Walsh patent.

Disconnect

When the calling operator removes the plug CP1 from jack J1, relays 140, 130, 110 and 104 of outgoing trunk circuit OT1 release, as described in the aforementioned patent to J. G. Walsh. At that time, relay 342 may or may not be operated, depending upon whether an "on hook" or an "off hook" signal condition exists in the signal receiver SR1. The release of relay 140 disconnects signaling battery from and connects ground to conductor 164, causing the release of relay 210 at the end of an interval of .050 second, causing the operation of relay 220 for .1 second and causing the release of relay 230 at the end of an interval of .025 second. The operation of relay 220 causes the release of relay 402 and the successive operation of relays 224 and 225. The operation of relay 224 closes a circuit through the lower winding of transformer 206 and the source 260 of current of frequency F2; and with relay 202 released, current of frequency F2 is transmitted over toll line TL1. When relay 210 releases, the lower winding of transformer 206 is transferred from source

260 to source 250, thereby ending the transmission of current of frequency F2 and initiating the transmission of current of frequency F1 over toll line TL1. When relay 220 releases, it causes the successive release of relays 224 and 225, the release time of relay 224 being about .050 second and the release time of relay 225 being about .2 second. Since relay 390 was operated and locked when the seizure signal was sent out, the release of relay 224 closes a circuit for operating relay 370 of signal receiver SR1. This circuit is traced from ground at the outer upper back contact of relay 230, through the lower back contact of relay 224, inner lower front contact of relay 225, conductor 227, inner upper front contact of relay 390, and winding of relay 370 to battery. Relay 370 locks under the control of relay 390; opens the locking circuit of relay 342, if this relay is operated; transfers the contacts of relay 318 from relay 360 to relay 381; connects ground to conductor 325 to hold relay 340 operated, independent of relay 324; disconnects ground from conductor 170, if connected thereto; and prevents the operation of relay 1003 of two-way trunk circuit TWT1 in case the "off hook" signal condition exists in signal receiver SR1 at the time relay 110 of outgoing trunk circuit OT1 releases. When relay 225 releases, it ends the transmission of current of frequency F1. Thus, a disconnect signal is transmitted consisting of an impulse of current of frequency F2 for about .025 second followed by an impulse of current of frequency F1 for about .3 second. If a disconnect acknowledgement signal is not received over toll line TL1 from the called office before relay 225 releases, relay 240 is operated by the closure of a circuit which includes the lower back contact of relay 225, conductor 228, a front contact of relay 390, a front contact of relay 370 and a front contact of the normally operated relay 382. The operation of relay 240 maintains the deenergization of relay 202, connects ground to the lower winding of transformer 206, and transfers the control of the energization of this winding from relay 210 to relays 241 and 244. The operation of relay 240 opens the normally closed circuit for operating relay 241 and connects the 20-cycle source 243 to the winding of relay 244, whereby relay 244 is operated and released twenty times per second to effect the alternate transmission of current of frequencies F2 and F1 through coils 206 and 200 over toll line TL1 until relay 241 releases. When relay 241 releases, .25 second after the operation of relay 240, it connects source 250 to the lower winding of transformer 206 to effect the transmission of current of frequency F1 through coils 206 and 200 and also opens the normally closed operating circuit of relay 242. The release of relay 242 about .25 second later closes a circuit for reoperating relay 241. The operation of relay 241 ends the transmission of current of frequency F1 and again initiates the alternate transmission of current of frequencies F2 and F1 under the control of relay 244 and 20-cycle source 243. The operation of relay 241 also closes the circuit for operating relay 242. Thus, relays 241, 242, 244 and the source 243 effect the cyclic transmission of current of frequencies F1 and F2 alternately at a 20-cycle rate for .25 second followed by current of frequency F1 for .25 second, the cycle being repeated until relay 240 releases due to the receipt of a disconnect acknowledgement signal as hereinafter described. When the disconnect signal is received by signal

receiver SR2, relay 524 operates and releases responsive to each impulse of current of frequency F2 and relays 514 and 518 operate and release responsive to each impulse of current of frequency F1. The operation of relay 524 causes the operation of relay 555; and the operation of relay 555 renders relay 518 operative. The operation of relay 514 closes a circuit through resistor 556 for holding relay 555 operated. With both of relays 514 and 555 operated, relay 530 releases. With relay 518 operated and relay 530 released, the lower winding of relay 560 is energized in a direction which effects the operation of relay 560 at the end of an interval of .050 second. The operation of relay 560 connects ground to resistor 541 and disconnects ground from conductor 670 to cause the release of relay 705 of two-way trunk circuit TWT2 and relay 805 of trunk circuit IT2; and since the impulse of current of frequency F1 continues for about .3 second, relay 560 remains operated for a long enough interval to cause the release of relay 542. The disconnection of ground from conductor 670 due to the operation of relay 560 and release of relay 542 causes the successive release of relays 707 and 703 of two-way trunk circuit TWT2. If and when relay 707 releases, it disconnects ground from conductor 753 thereby causing the return of selector TS2 and trunk circuit IT2 to normal as described in the aforementioned patent to J. G. Walsh. If there is interference, for instance due to the alternate transmission of "off hook" and "on hook" signals or to the transmission of a busy tone, when an all-trunks-busy or called-line-busy condition is encountered in extending a connection, relay 560 of signal receiver SR2 may not be operated for a long interval in response to the first long impulse of current of frequency F1 to effect the release of relay 542 and relays 707 and 703 of two-way trunk circuit TWT2. In this event, the operation of relay 560 responsive to one of the long impulses of current of frequency F1 of a succeeding disconnect signal will be effective to cause the release of these relays. In any event, relay 555 is held operated and relay 530 remains released as long as relays 514, 518 and 524 continue to operate and release responsive to the disconnect signal transmitted over line TL1. Relays 514 and 524 may not continue to operate due to interference; but, when they do operate responsive to the 20 cycle alternations of the disconnect signal during a short off period of the interference, relay 555 operates, relay 530 releases and relay 402 releases. This opens the talking circuit to end the transmission of a busy tone and allows the next long pulse of current of frequency F1 to release relay 542.

If and when relay 560 is operated for a long enough interval to cause the release of relay 542, relay 445 of signal transmitter ST2 is operated by the current in a circuit which is traced from the winding of relay 445 through conductor 446, lowermost back contact of relay 590, a front contact of the normally operated relay 582, lower back contact of relay 542, to ground at a back contact of relay 530. Relay 445 connects ground to one end of the lower winding of transformer 406, connects the other end of this winding through contacts of relay 444 to source 460 of current of frequency F4, and connects the 20-cycle source 443 to the winding of relay 444. The alternate operation and release of relay 444 twenty times per second effects the alternate transmission of impulses of current of frequencies F4 and F3 through coils 406 and 400 over toll line TL1 as long as relay 445 remains operated. This

constitutes a disconnect acknowledgment signal.

The disconnect acknowledgment signal thus transmitted over line TL1 causes the operation of relay 324 responsive to each impulse of current of frequency F4 and the operation of relays 314 and 318 responsive to each impulse of current of frequency F3. The operation of relay 324 causes the operation of relay 355 and the operation of relay 355 renders relay 318 operative. The operation of relay 314 closes a circuit through resistor 356 for holding relay 355 operated. With both of relays 314 and 355 operated, relay 330 releases. The release of relay 330 causes the release of relay 202. With relay 370 operated as described previously when the disconnect signal was sent, the operation and release of relay 318 twenty times per second causes the operation of relay 381, relay 381 being tuned as hereinbefore described. The operation of relay 381 short-circuits the winding of relay 382; and relay 382 releases about .1 second after relay 381 operates. The release of relay 382 causes the release of relay 240 thereby disconnecting ground from transformer 206 to end the transmission of the disconnect signal. The release of relay 240 also causes the reoperation of relay 241 if not then operated, and disconnects source 243 from the winding of relay 244, thereby ending the transmission of the disconnect signal over line TL1. The delay in the release of relay 382 reduces the possibility of false release responsive to voice or other interference currents and thus prevents the stopping the transmission of the disconnect signal before it has become effective. The aforementioned release of relay 382 also causes the release of relays 390 and 395. Relay 355 remains operated, relay 330 released and relay 370 operated, as long as relays 314 and 324 continue to be alternately operated by the disconnect acknowledgment signal; and relay 381 remains operated and relay 382 released as long as relay 318 continues to be operated and released responsive to the disconnect acknowledgment signal. Relay 202 cannot reoperate while relay 330 remains released.

When the transmission of the disconnect signal over line TL1 ends, the contacts of relays 514, 518 and 524 return to or remain in normal position, thereby causing the release of relay 555 and reoperation of relay 530. The reoperation of relay 530 opens the operating circuit of relay 445; and, if relays 425, 424 and 430 are normal as is the case if selector TS2 has restored to normal or the answering operator has disconnected from jack J8, relay 445 releases thereby terminating the transmission of the disconnect acknowledgment signal over line TL1 to the calling office. The release of relay 445 also closes the circuit for operating relay 402; and the operation of relay 402 disconnects ground from conductor 668 thereby marking the toll line TL1 as idle in the banks of toll selectors and at the operators' outgoing multiple jacks.

When the transmission of the disconnect acknowledgment signal ends, the contacts of relays 314, 318 and 324 return to or remain normal, thereby causing the release of relay 355 and reoperation of relay 330 and causing the release of relay 381 and reoperation of relay 382. The reoperation of relay 330 causes the release of relay 370 and closes the circuit for operating relay 202. The operation of relay 202 disconnects ground from conductor 168 to mark the toll line TL1 as idle in the banks of toll selectors and at the operators' outgoing multiple jacks.

It is to be noted that relays 202 and 402 are

each released as long as any signal is being transmitted over line TL1, thereby maintaining the connection of ground potential to conductors 163 and 563 to prevent seizure of line TL1 at either end. In case the line TL1 is seized at both ends simultaneously, the seizure signal transmitted from each end is received at the other end as a "stop dial" signal. If after a time a first one of the originating operators disconnects, a disconnect signal will be transmitted over line TL1, which signal will act as a "start dial" signal at the other end. If in response to the "start dial" signal, the second of the two operators' dials, the dial impulse signals transmitted over line TL1 will not effect any selective operations at the end which sent out the disconnect signal because the signal circuits at that end are awaiting a disconnect acknowledgment signal. After a time the second of the calling operators will disconnect, whereupon a disconnect signal is transmitted over line TL1 toward the end from which the transmission of a disconnect signal was first initiated. Thus, disconnect signals are being transmitted in both directions and the line TL1 is marked busy at both ends. At one end, relay 390 is operated, relay 202 is released, and relay 240 is operated to effect the transmission of the disconnect signal consisting of impulses of current of frequencies F1 and F2; and in response to the incoming disconnect signal, relay 355 is operated, relay 330 is released, and relay 370 is operated. At the other end, relay 590 is operated, relay 402 is released and relay 440 is operated to effect the transmission of the disconnect signal consisting of impulses of current of frequencies F3 and F4; and in response to the incoming disconnect signal, relay 555 is operated, relay 530 is released and relay 570 is operated. Although neither end is transmitting a disconnect acknowledgment signal, the disconnect signal from one end will be started before it is started from the other end; and, when the first long impulse of this signal ends, the impulses of the two frequencies then transmitted alternately twenty times per second appears to be a disconnect acknowledgment signal at the other end. Assuming this other end to be the end with which signal receiver SR1 is associated, relay 381 is operated and relay 382 released at the end of .1 second as hereinbefore described. The release of relay 382 causes the release of relays 390, 395 and 340 thus ending the transmission of the disconnect signal consisting of frequencies F1 and F2. The transmission of the disconnect signal consisting of frequencies F3 and F4 in the opposite direction over line TL1 continues and during the receipt of a long impulse of current of frequency F3, relay 381 releases and relay 382 reoperates; whereupon relay 245 is operated to initiate the transmission of a disconnect acknowledgment signal consisting of frequencies F1 and F2. When this disconnect acknowledgment signal is received by signal receiver SR2, relay 581 operates and relay 582 releases to end the transmission of the disconnect signal consisting of frequencies F3 and F4. When the disconnect signal is no longer received by signal receiver SR1, relay 355 releases, relay 330 reoperates, relay 370 releases and relay 245 releases thereby ending the transmission of the disconnect acknowledgment signal consisting of frequencies F1 and F2. When the disconnect acknowledgment signal is no longer received by signal receiver SR2, relay 555 releases, relay 530 reoperates, and relay 570 releases. Re-

lays 202 and 402 are reoperated and the line TL1 is again marked idle at both ends. In case the first 20-cycle alternation of frequencies F1 and F2 should occur at the same time that the first 20-cycle alternation of frequencies F3 and F4 occurs, the transmission of the disconnect signal will be ended at both ends and no disconnect acknowledgment signal will be transmitted from either end.

In the case of a double seizure wherein only one of relays 390 and 590 is operated, one end is in the outward signaling condition and the other in the inward signaling condition. If disconnection occurs first at the end conditioned as the outward end, a disconnect signal will be transmitted therefrom. At the end conditioned as the inward end, receipt of this disconnect signal causes the transmission of a disconnect acknowledgment signal. Receipt of the disconnect acknowledgment signal at the end conditioned as the outward end, stops the transmission of the disconnect signal therefrom; and the transmission of the disconnect acknowledgment signal from the end conditioned as the inward end will thereby be stopped. If disconnection occurs first at the end conditioned as the inward end, an "on hook" signal is transmitted therefrom, which signal acts as a "start dial" signal at the end conditioned as the outward end. The operator at the outward end may then dial without any selective operation being effected and when this operator disconnects the disconnect and disconnect acknowledgment signals will be transmitted as a regularly completed call as hereinbefore described.

What is claimed is:

1. In a signaling system, a trunk line, a trunk circuit connected to one end of said line, a link connected to said trunk circuit, means responsive to disconnection of said link from said trunk circuit for transmitting over said trunk line a disconnect signal consisting of current of one of two frequencies followed by current of the other frequency for a predetermined interval of time and then in recurring cycles current impulses of said two frequencies alternately for a predetermined interval of time followed by current of said other frequency for a predetermined interval of time, release control means at the other end of said trunk line responsive to a disconnect signal consisting of current of said one frequency followed by current of said other frequency for a predetermined minimum interval of time, signal transmitting means at said other end of said trunk line rendered effective by said release control means responsive to a disconnect signal to transmit over said trunk line a disconnect acknowledgment signal consisting of current impulses of two particular frequencies alternately, control means at said one end of said trunk line for terminating the transmission of said disconnect signal, and means operated by disconnection of said link from said trunk circuit for rendering said control means operatively responsive to said disconnect acknowledgment signal.

2. In a signaling system, a trunk line, a trunk circuit connected to one end of said line, a link connected to said trunk circuit, means responsive to disconnection of said link from said trunk circuit for transmitting over said trunk line a disconnect signal consisting of current of one of two frequencies followed by current of the other frequency for a predetermined interval of time and then in recurring cycles current impulses of said two frequencies alternately for a predeter-

mined interval of time followed by current of said other frequency for a predetermined interval of time, release control means at the other end of said trunk line responsive to a disconnect signal consisting of current of said one frequency followed by current of said other frequency for a predetermined minimum interval of time, signal transmitting means at said other end of said trunk line rendered effective by said release control means responsive to a disconnect signal to transmit over said trunk line a disconnect acknowledgment signal consisting of current impulses of two particular frequencies alternately, control means at said one end of said trunk line for terminating the transmission of said disconnect signal, means operated by disconnection of said link from said trunk circuit for rendering said control means operatively responsive to said disconnect acknowledgment signal, and control means at said other end of said trunk line for terminating the transmission of a disconnect acknowledgment signal responsive to termination of a disconnect signal incoming over said trunk line.

3. In a signaling system, a trunk line, a trunk circuit connected to one end of said line, a link connected to said trunk circuit, means responsive to disconnection of said link from said trunk circuit for transmitting over said trunk line a disconnect signal consisting of current of one of two frequencies followed by current of the other frequency for a predetermined interval of time and then in recurring cycles current impulses of said two frequencies alternately for a predetermined interval of time followed by current of said other frequency for a predetermined interval of time, release control means at the other end of said trunk line responsive to a disconnect signal consisting of current of said one frequency followed by current of said other frequency for a predetermined minimum interval of time, signal transmitting means at said other end of said trunk line rendered effective by said release control means responsive to a disconnect signal to transmit over said trunk line a disconnect acknowledgment signal consisting of current impulses of two particular frequencies alternately, control means at said one end of said trunk line for terminating the transmission of said disconnect signal, means operated by disconnection of said link from said trunk circuit for rendering said control means operatively responsive to said disconnect acknowledgment signal, control means at said other end of said trunk line for terminating the transmission of a disconnect acknowledgment signal responsive to termination of a disconnect signal incoming over said trunk line, and means for marking said trunk line busy at said one end as long as said disconnect acknowledgment signal is being received.

4. In a signaling system, a trunk line, a trunk circuit connected to one end of said line, a link connected to said trunk circuit, means responsive to disconnection of said link from said trunk circuit for transmitting over said trunk line a disconnect signal consisting of current of one of two frequencies followed by current of the other frequency for a predetermined interval of time and then in recurring cycles current impulses of said two frequencies alternately for a predetermined interval of time followed by current of said other frequency for a predetermined interval of time, release control means at the other end of said trunk line responsive to a disconnect signal consisting of current of said one frequency

followed by current of said other frequency for a predetermined minimum interval of time, signal transmitting means at said other end of said trunk line rendered effective by said release control means responsive to a disconnect signal to transmit over said trunk line a disconnect acknowledgment signal consisting of current impulses of two particular frequencies alternately, control means at said one end of said trunk line for terminating the transmission of said disconnect signal, means operated by disconnection of said link from said trunk circuit for rendering said control means operatively responsive to said disconnect acknowledgment signal, control means at said other end of said trunk line for terminating the transmission of a disconnect acknowledgment signal responsive to termination of a disconnect signal incoming over said trunk line, and means for marking said trunk line busy at said other end as long as said disconnect acknowledgment signal is being transmitted therefrom.

5. In a signaling system, a trunk line, a trunk circuit connected to one end of said line, a link connected to said trunk circuit, means responsive to disconnection of said link from said trunk circuit for transmitting over said trunk line a disconnect signal consisting of current of one of two frequencies followed by current of the other frequency for a predetermined interval of time and then in recurring cycles current impulses of said two frequencies alternately for a predetermined interval of time followed by current of said other frequency for a predetermined interval of time, release control means at the other end of said trunk line responsive to a disconnect signal consisting of current of said one frequency followed by current of said other frequency for a predetermined minimum interval of time, signal transmitting means at said other end of said trunk line rendered effective by said release control means responsive to a disconnect signal to transmit over said trunk line a disconnect acknowledgment signal consisting of current impulses of two particular frequencies alternately, control means at said one end of said trunk line for terminating the transmission of said disconnect signal, means operated by disconnection of said link from said trunk circuit for rendering said control means operatively responsive to said disconnect acknowledgment signal, control means at said other end of said trunk line for terminating the transmission of a disconnect acknowledgment signal responsive to termination of a disconnect signal incoming over said trunk line, and means at each end of said trunk line for marking said trunk line busy while a disconnect acknowledgment signal is being transmitted thereover.

6. In a telephone system, an interoffice trunk line, trunk and signaling circuits terminating one end of said trunk line, similar trunk and signaling circuits terminating the other end of said trunk line, means at each end of said trunk line for seizing the trunk circuit thereat on an outgoing call, means at each end of said trunk line responsive to seizure of the trunk circuit thereat for conditioning the signaling circuit for the transmission of a disconnect signal responsive to release of the associated trunk circuit, said last mentioned means at each end being inoperative in case said trunk line is simultaneously seized at both ends, means in the signaling circuit at each end of said trunk line responsive to release of the trunk circuit thereat for transmitting a disconnect signal consisting of current of a first one of two particular frequencies followed by cur-

rent of the second of said two frequencies for a predetermined interval of time and then in recurring cycles current impulses of said two frequencies alternately for a predetermined interval of time followed by current of the second of said two frequencies for a predetermined interval of time, release control means at each end of said trunk line responsive to a disconnect signal transmitted from the other end of said trunk line, means in the signaling circuit at each end of said trunk line rendered operative by the associated release control means responsive to a disconnect signal to transmit over said trunk line a disconnect acknowledgment signal consisting of current impulses of two particular frequencies alternately, control means in the signaling circuit at each end of said trunk line for terminating the transmission of said disconnect signal, and means in the signaling circuit at each end of said trunk line effective upon release of the trunk circuit thereat for rendering the last mentioned control means operatively responsive to a disconnect acknowledgment signal incoming over said trunk line.

7. In a telephone system, an interoffice trunk line, trunk and signaling circuits terminating one end of said trunk line, similar trunk and signaling circuits terminating the other end of said trunk line, means at each end of said trunk line for seizing the trunk circuit thereat on an outgoing call, means at each end of said trunk line responsive to seizure of the trunk circuit thereat for conditioning the signaling circuit for the transmission of a disconnect signal responsive to release of the associated trunk circuit, said last mentioned means at each end being inoperative in case said trunk line is simultaneously seized at both ends, means in the signaling circuit at each end of said trunk line responsive to release of the trunk circuit thereat for transmitting a disconnect signal consisting of current of a first one of two particular frequencies followed by current of the second of said two frequencies for a predetermined interval of time and then in recurring cycles current impulses of said two frequencies alternately for a predetermined interval of time followed by current of the second of said two frequencies for a predetermined interval of time, release control means at each end of said trunk line responsive to a disconnect signal transmitted from the other end of said trunk line, means in the signaling circuit at each end of said trunk line rendered operative by the associated release control means responsive to a disconnect signal to transmit over said trunk line a disconnect acknowledgment signal consisting of current impulses of two particular frequencies alternately, control means in the signaling circuit at each end of said trunk line for terminating the transmission of said disconnect signal, means in the signaling circuit at each end of said trunk line effective upon release of the trunk circuit thereat for rendering the last mentioned control means operatively responsive to a disconnect acknowledgment signal incoming over said trunk line, and control means in the signaling circuit at each end of said trunk line for terminating the transmission of a disconnect acknowledgment signal responsive to termination of a disconnect signal incoming over said trunk line.

8. In a telephone system, an interoffice trunk line, trunk and signaling circuits terminating one end of said trunk line, similar trunk and signaling circuits terminating the other end of said trunk line, means at each end of said trunk line for

seizing the trunk circuit thereat on an outgoing call, means at each end of said trunk line responsive to seizure of the trunk circuit thereat for conditioning the signaling circuit for the transmission of a disconnect signal responsive to release of the associated trunk circuit, said last mentioned means at each end being inoperative in case said trunk line is simultaneously seized at both ends, means in the signaling circuit at each end of said trunk line responsive to release of the trunk circuit thereat for transmitting a disconnect signal consisting of current of a first one of two particular frequencies followed by current of the second of said two frequencies for a predetermined interval of time and then in recurring cycles current impulses of said two frequencies alternately for a predetermined interval of time followed by current of the second of said two frequencies for a predetermined interval of time, release control means at each end of said trunk line responsive to a disconnect signal transmitted from the other end of said trunk line, means in the signaling circuit at each end of said trunk line rendered operative by the associated release control means responsive to a disconnect signal to transmit over said trunk line a disconnect acknowledgment signal consisting of current impulses of two particular frequencies alternately, control means in the signaling circuit at each end of said trunk line for terminating the transmission of said disconnect signal, means in the signaling circuit at each end of said trunk line effective upon release of the trunk circuit thereat for rendering the last mentioned control means operatively responsive to a disconnect acknowledgment signal incoming over said trunk line, control means in the signaling circuit at each end of said trunk line for terminating the transmission of a disconnect acknowledgment signal responsive to termination of a disconnect signal incoming over said trunk line, and means at each end of said trunk line for marking said trunk line busy as long as a disconnect acknowledgment signal is being transmitted over said trunk line.

9. In a telephone system, an interoffice trunk line, trunk and signaling circuits terminating one end of said trunk line, similar trunk and signaling circuits terminating the other end of said trunk line, means at each end of said trunk line for seizing the trunk circuit thereat on an outgoing call, means at each end of said trunk line responsive to seizure of the trunk circuit thereat for conditioning the signaling circuit for the transmission of a disconnect signal responsive to release of the associated trunk circuit, said last mentioned means at each end being inoperative in case said trunk line is simultaneously seized at both ends, means in the signaling circuit at each end of said trunk line responsive to release of the trunk circuit thereat for transmitting a disconnect signal consisting of current of a first one of two particular frequencies followed by current of the second of said two frequencies for a predetermined interval of time and then in recurring cycles current impulses of said two frequencies alternately for a predetermined interval of time followed by current of the second of said two frequencies for a predetermined interval of time, release control means at each end of said trunk line responsive to a disconnect signal transmitted from the other end of said trunk line, means in the signaling circuit at each end of said trunk line rendered operative by the associated release control means responsive to a disconnect signal to transmit over said trunk line a discon-

nect acknowledgment signal consisting of current impulses of two particular frequencies alternately, means at each end of said trunk line operated responsive to seizure of the associated trunk circuit for preventing the transmission of a disconnect acknowledgment signal upon operation of the associated release control means responsive to an incoming disconnect signal, whereby the transmission of a disconnect acknowledgment signal from either end is prevented in case the trunk circuits at both ends of said trunk lines are simultaneously seized, control means in the signaling circuit at each end of said trunk line for terminating the transmission of said disconnect signal, and means in the signaling circuit at each end of said trunk line effective upon release of the trunk circuit thereat for rendering the last mentioned control means operatively responsive to a disconnect acknowledgment signal incoming over said trunk line, said last mentioned control means at each end of said trunk line being responsive to that part of an incoming disconnect signal which consists of current impulses of said two frequencies alternately for a predetermined interval of time, thereby to terminate the transmission of the disconnect signal therefrom and thus enable the transmission of a disconnect acknowledgment signal therefrom responsive to the incoming disconnect signal.

10. In a signaling system in which signals consist of alternating current of either one of two signaling frequencies followed by current of the other of said frequencies, a signal receiver comprising a first relay operatively responsive only to current of one of said frequencies, a second relay and a third relay each operatively responsive only to current of the other of said frequencies, said third relay being normally non-responsive, relay means responsive to the operation of said first relay for enabling the operation of said third relay, a normally inoperative signal relay, relay means responsive to the operation of said second relay within a predetermined interval after the release of said first relay for rendering said signal relay operative, and circuit means including a delay network connecting the operating winding of said signal relay to the contacts of

said third relay, said delay network being effective to delay for a predetermined interval of time the operative response of the signal relay to each operation of said third relay.

11. In a signaling system, a first signal relay, responsive to direct current signals, a line, a signal transmitter connected to one end of said line and controlled by said first signal relay for transmitting over said line alternating current signals consisting of an impulse of current of either one of two particular frequencies followed by an impulse of current of the other of said frequencies, said transmitter comprising a source of current of each of said frequencies, and relay means for connecting said sources to said line one after the other, said relay means including a control relay for transferring the line from one source to the other and including a delay network connecting the operating winding of said relay to the contacts of said first signal relay to delay the response of said control relay for a predetermined interval of time during which the first impulse of the alternating current signal is transmitted, and a signal receiver connected to the other end of said line, said signal receiver comprising a first relay operatively responsive only to current of one of said frequencies, a second relay and a third relay each operatively responsive only to current of the other of said frequencies, said third relay being normally non-responsive, relay means responsive to the operation of said first relay for enabling the operation of said third relay, a normally inoperative signal relay, relay means responsive to the operation of said second relay with a predetermined interval after the release of said first relay for rendering said signal relay operative, and circuit means including a delay network connecting the operating winding of said signal relay to the contacts of said third relay, said delay network being effective to delay for a predetermined interval of time the operative response of the signal relay to each operation of said third relay.

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