

Jan. 7, 1936.

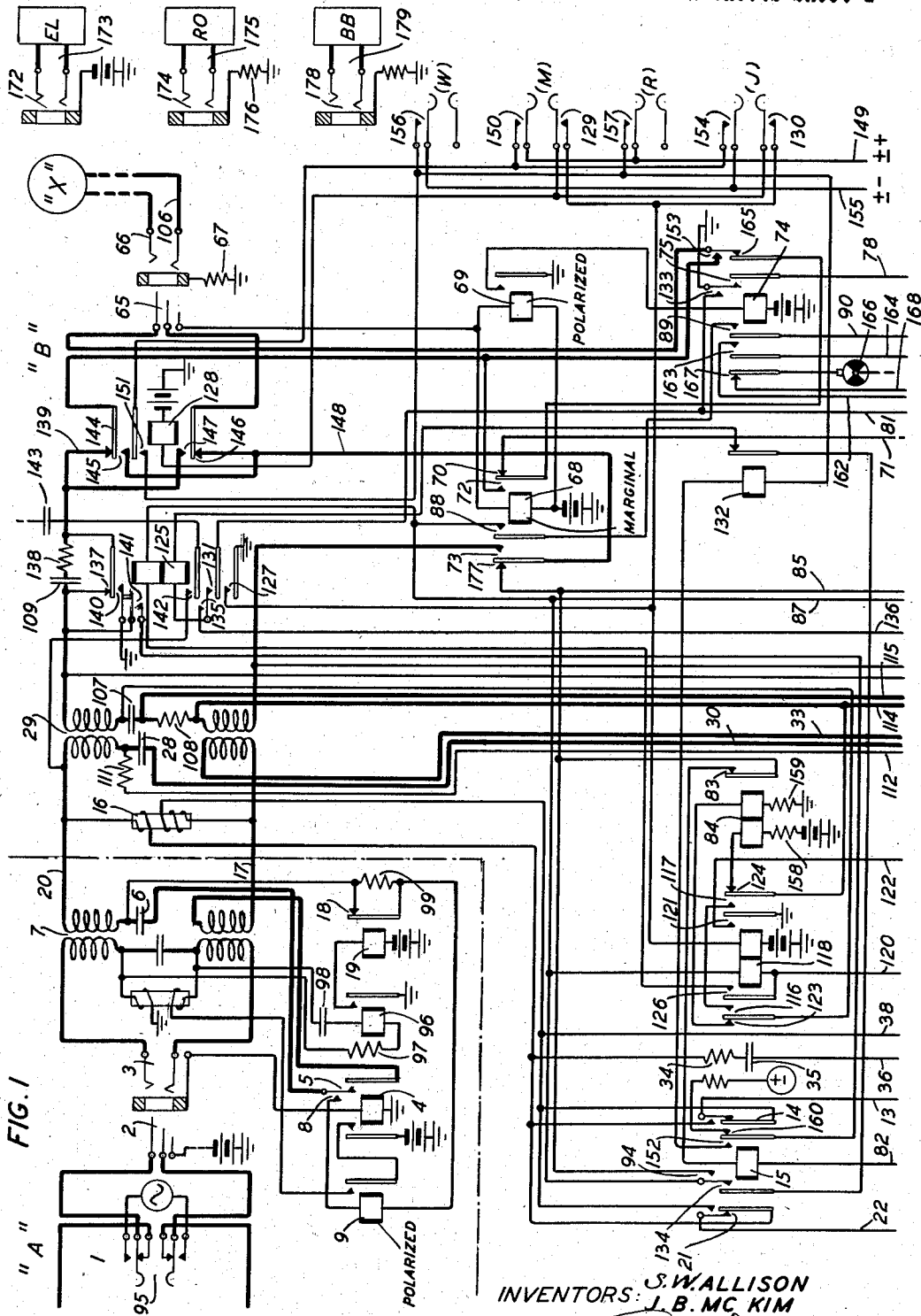
S. W. ALLISON ET AL

2,027,142

TELEPHONE EXCHANGE SYSTEM

Filed Dec. 7, 1933

2 Sheets-Sheet 1



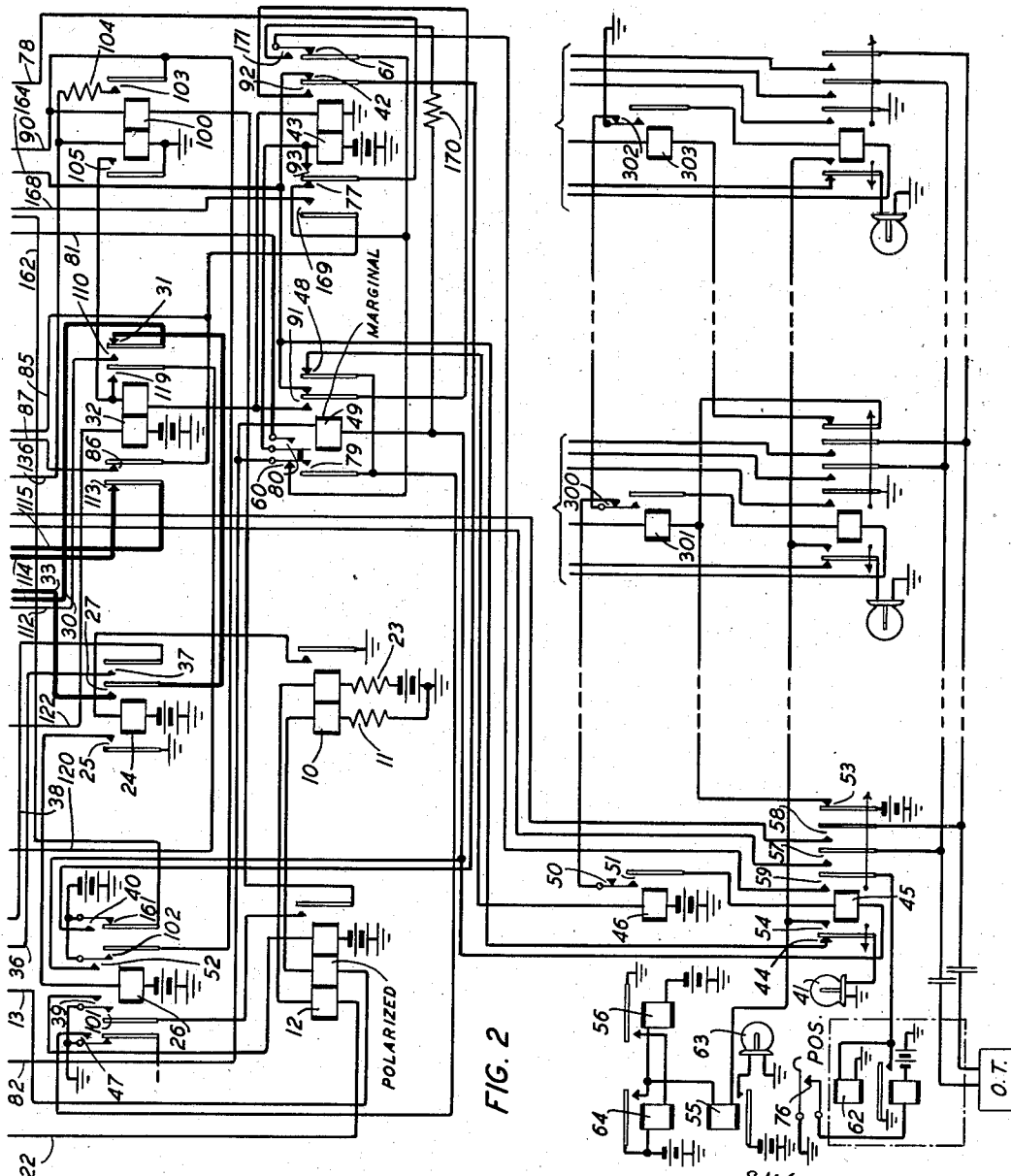
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2 Sheets-Sheet 2



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2,027,142

TELEPHONE EXCHANGE SYSTEM

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15 Claims. (Cl. 179—45)

This invention relates to improvements in telephone exchange systems and particularly to trunking systems between exchanges.

More specifically the invention relates to circuit arrangements adapted for use with long toll switching trunks, employing reverse battery supervision, extending from a toll operator in one exchange to a local or switching operator at a distant exchange.

An object of the invention is to control from the toll position, by means of direct current over the trunk line, the application of ringing current to a called subscriber's line at the local exchange thereby eliminating clicks, acoustic shocks, and the like frequently experienced with alternating circuit ringing.

Another object is to filter out the higher harmonics in the ringing current so applied at the local exchange in order to minimize annoyance to the called subscriber in case his receiver is connected to the line and held to the ear during the ringing period.

Another object is to permit a ringing signal to be transmitted over the trunk either after the trunk line has been connected to the called line, or immediately upon seizure of the trunk at the toll office and before the called line has been connected to.

Other objects of the invention will be apparent from the following description.

A feature whereby the first object is attained resides in introducing a ringing control relay winding in series with the signaling battery source and line and normally neutralizing the effect of this winding by means of an auxiliary winding in a local circuit which includes the same battery. When the ringing signal is applied to the trunk the resistance of the circuit including the line winding of the relay is increased which reduces the flux caused by the line windings whereupon the relay operates due to the greater flux exerted by the auxiliary or compensating winding.

A feature whereby the second object is attained resides in connecting the ringing current source to the called line through the called line side of the trunk repeating coil at the local exchange. This winding acts as a filter to eliminate the harmonics of the ringing frequency.

Features whereby the other objects are attained will be understood from the following description when read in connection with the accompanying drawings, which, when placed together with Fig. 1 at the top, represent a connection from a toll office to a called subscriber via a toll switching trunk with its common position equipment, in accordance with the invention.

It will be assumed that a toll operator (A) has received a request to complete a connection

to subscriber (X) and has inserted the answering end of her cord into the calling trunk or toll line (not shown). The toll operator then proceeds to extend the connection by inserting the calling plug 2 of cord 1 in jack 3 of the switching trunk embodying the present invention, whereupon sleeve relay 4 of the trunk operates in an obvious circuit to close its contacts 5 which connect condenser 6 between the right hand windings of repeating coil 7 and at its contacts 8 bridges relay 9 across condenser 6 to operate line relay 10 at the distant end of the trunk in a circuit which can be traced from ground, compensating resistance 11 (Fig. 2) left hand winding of line relay 10, middle winding of ringing relay 12, conductor 13, contacts 14 of reversing relay 15, lower winding of retardation coil 16, trunk conductor 17, lower right hand winding of repeating coil 7, contacts 5 and 8 of relay 4, winding of polarized supervisory relay 9, contacts 18 of relay 19, upper right hand winding of repeating coil 7, conductor 20, upper winding of retardation coil 16, contacts 21 of relay 15, conductor 22, left hand winding of ringing relay 12, right hand winding of relay 10, and compensating resistance 23 to battery.

Ringing relay 12 and supervisory relay 9, being polar relays, do not operate with current flowing through their windings in the direction described above.

Line relay 10 in operating, completes an obvious circuit for operating relay 24 whose contacts 25, in closing, cause relay 26 to operate.

Relay 24 in operating, completes at its contacts 27, a circuit for connecting condenser 28 in series with the left hand windings of repeating coil 29 which circuit can be traced from the upper half of repeating coil 29, condenser 28, conductor 30, normal contacts 31 of relay 32, contacts 27 of relay 24, conductor 33 to the lower left hand winding of repeating coil 29.

Relay 24 in operating also completes a circuit for connecting resistance 34 and condenser 35 in service between the upper and lower winding of retardation coil 16 which circuit can be traced from the upper winding of retardation coil 16, resistance 34, condenser 35, conductor 36, contacts 37 of relay 24, conductor 38 to the lower left hand winding of retardation coil 16.

Relay 26 in operating, closes at its contacts 39 an obvious energizing circuit for the right hand winding of ringing relay 12. Relay 12 does not operate at this time however, as the current flowing in the previously traced circuit through the middle and left hand windings creates a magnetic flux which neutralizes the flux of the right hand winding due to the fact that this winding is connected differentially with respect to the middle and left hand windings.

Relay 26 in operating, also closes at its contacts 40, a circuit for lighting guard and disconnect lamp 41 at the "B" operator position which circuit can be traced from battery through contacts 40 of relay 26, contacts 42 of relay 43, normal contacts 44 of relay 45, and lamp 41 to ground.

When relay 26 operates, it also actuates the start relay 46 associated with this particular trunk, the circuit for which can be traced from ground through contacts 47 of relay 26, contacts 48 of relay 49 and the winding of relay 46 to battery. Relay 46 in operating, opens at its contacts 50 the energizing circuit for relays corresponding to and to the left of relay 45 associated with trunks in the same sequence group and completes at its contacts 51 a circuit for operating relay 45, which circuit can be traced from battery, through contacts 52 of relay 26, winding of relay 45 contacts of relay 46 and chain of contacts 300 of relay 301 and 302 of relay 303 to ground.

Relay 45 in operating, opens at its contacts 53, the energizing circuit for relays corresponding to and to the right of relay 46 associated with preceding trunks in the same sequence group such as relays 301, 302, etc. for example.

Relay 45 in operating, also completes a circuit through its contacts 54 to operate relays 55 and 56 whose functions will appear later in the description. The circuit for operating relays 55 and 56 can be traced from ground through guard and disconnect lamp 41, contacts 54 of relay 45, winding of relays 55 and 56 to battery. The resistance of relay 56 is sufficient to dim guard and disconnect lamp 41.

When relay 45 operated, it also closed its contacts 57 and 58 to connect the trunk to the position circuit POS where the (B) operator's telephone set O. T. is ultimately connected to the trunk. Therefore since relays 45 and 46 have opened the energizing circuits for corresponding relays to the right and left in other trunks in the same sequence group, it is apparent that no other trunk can be connected to the position until the operator is released from the present trunk.

Relay 45 in operating, closes at its contacts 59 an energizing circuit for relay 49 which can be traced from battery through contacts 52 of relay 26, winding of relay 49, normally closed contacts 60 of relay 49, normally closed contacts 61 of relay 43, and contacts 59 of relay 45 to ground through a high resistance relay 62 in the position circuit POS. Relay 49, being marginal, does not operate when this circuit is closed, due to the high resistance ground. The position circuit (not shown in detail) however, functions to send two short "zips" of tone back to the toll office in a well known manner as a signal to the calling operator to pass the number of the calling subscriber. When the "zip" tones are completed the (B) operator's telephone set O. T. is connected to the trunk. Since the operation of the position circuit is not affected by this invention it will not be described in detail.

Relay 55 operates in series with relay 56 and closes at its contacts, an obvious circuit for lighting pilot lamp 63 and remains operated as long as the trunk is connected to the position.

Relay 56, in conjunction with relay 64 provides a circuit for flashing the guard and disconnect lamp 41 to indicate to the (B) operator the trunk to which her telephone set is con-

nected. Relay 56 in operating, completes an obvious circuit for operating relay 64. When relay 64 operates and closes its contacts, direct battery is applied to guard and disconnect lamp 41 over the circuit previously described, lighting the lamp, and at the same time this battery short-circuits the winding of relay 56 causing it to release and open its contacts to release relay 64. When relay 64 releases, the short circuit is removed from relay 56, guard and disconnect lamp 41 is dimmed, and the circuit is ready to repeat the cycle of operation just described as long as the trunk is connected to the position.

When the trunk operator (B) has received the number and party designation, if any, of the called subscriber (X), she depresses the proper ringing key, key M for party M etc. and makes the usual busy test by touching the tip of plug 65 to the sleeve of jack 66 and, if she hears no click, inserts the plug into the jack, whereupon an obvious circuit is completed through low resistance 67 to operate polar relay 69 and marginal relay 68 in parallel.

Relay 68 in operating, opens its normally closed contacts 70, to disconnect the busy test conductor 71 from the tip, and completes, at its contacts 72 and 73, circuits for connecting the tip and ring of plug 65 to the right hand windings of repeating coil 29.

Relay 69 in operating, completes an obvious circuit for operating relay 74.

Relay 74 in operating, closes at its contact 75 a circuit for applying direct ground to the winding of relay 49 to cause its operation, provided it has not been operated by means of the "release" key 76 in the position circuit, which operation will be covered later in the description. Relay 49, being marginal, was not operated when connected to high resistance ground in the position circuit as previously described. However, when direct ground is applied to the winding of relay 49 by the operation of relay 74, relay 49 operates in a circuit that can be traced from battery through contacts 52 of relay 26, winding of relay 49, contacts 60 of relay 49, contacts 77 of relay 43, conductor 78 and contacts 75 of relay 74 to ground.

Relay 49 in operating, completes, through its continuity contacts 79, a connection through contact 47 of relay 26 to ground to lock itself under control of relay 26.

Relay 49 in operating, also closes a circuit through its contacts 80 for operating relay 43, which circuit can be traced from ground through contacts 133 of relay 74, conductor 81, contacts 80 of relay 49 and the left hand winding of relay 43 to battery.

The operation of relay 49 further performs the function of operating relay 15 over a circuit that can be traced from ground through contacts 47 of relay 26, contacts 79 of relay 49, conductor 82, winding of relay 15, contacts 83 of relay 84, conductor 85, contacts 86 of relay 32, conductor 87, contacts 88 of relay 68, contacts 89 of relay 74, conductor 90, and contacts 102 of relay 26 to battery.

Relay 49 in operating also dismisses the position circuit by opening at its contacts 48 the energizing circuit for relay 46 causing it to release.

When relay 46 releases, it closes the chain contacts to ground through the relays corresponding to and to the left of relay 45 in the succeeding associated trunks in the same sequence group to

provide energizing paths for other calls, and opens the energizing circuit for relay 45 causing it to release.

Relay 45 in releasing, opens at its contacts 44 the circuit for flashing guard and disconnect lamp 41, thereby releasing relay 55 to extinguish the pilot lamp 63.

When relay 45 releases, it also closes the chain contacts to battery through the relays corresponding to and to the right of relay 46 in the preceding associated trunks in the same sequence group, to provide energizing paths for connecting these relays to the position circuit.

When relay 43 operated it completed a holding circuit for itself, under control of relay 26 that can be traced from ground through the right hand winding of relay 43, make contacts 91 of relay 49, make contacts 92 of relay 43 and make contact 40 of relay 26 to battery. At the same time relay 43 closes at its make contact 93 a holding circuit for itself under control of relay 74 that can be traced from battery through the left hand winding of relay 43, make contact 93 of relay 43, conductor 78 and make contact 75 of relay 74 to ground. This joint control over relay 43 is provided to permit the sending of a reorder signal to the toll operator on a premature disconnect by the trunk operator, to lock in the disconnect signal until the trunk is disconnected from the subscriber's line, and to permit a second call on the same trunk to be connected to the position circuit before the trunk is disconnected from the previous call as will be later described.

When relay 15 operates, it reverses, at its contacts 14 and 21, the current flow, over the circuit previously traced, through polarized relay 9 at the toll office, causing it to operate and complete, an obvious circuit for applying battery to the ring of jack 3 to give the toll operator (A) a signal that the trunk has been extended to subscriber (X) and that the trunk circuit is ready to ring on the subscriber's line.

Relay 15 in operating, also completes, at its contacts 94, a locking circuit for itself under control of supervisory relay 84. This locking circuit is the same as the energizing circuit except that contacts 94 short circuit contacts 86 of relay 32, thereby removing control of relay 15 from relay 32.

When toll operator (A) depresses her ringing key 95 ringing current is applied over the tip and ring of plug 2 to operate relay 96 over a circuit that can be traced from the tip of jack 3, upper left hand winding of repeating coil 7, resistance 97, winding of relay 96, condenser 98 and the lower left hand winding of repeating coil 7 to the ring of jack 3.

When relay 96 operates, it completes an obvious circuit for operating relay 19, which in operating, opens at its contacts 18 the short circuit around resistance 99 thereby inserting resistance 99 in the circuit previously traced through relay 12.

Resistance 99 is of such a value that it reduces the current flow through the left hand and middle windings of polar relay 12 so that the flux produced in these windings no longer neutralizes the flux in the right hand winding whereupon the relay operates and closes a circuit for operating relay 100.

When the toll operator releases the ringing key, relay 96 releases and opens at its contacts the energizing circuit for relay 19 which releases and closes its contacts to short circuit resistance

99. With resistance 99 short circuited the current through the left hand and middle winding of relay 12 builds up and the windings set up a flux that is sufficient to neutralize the flux in the right hand winding to a point where the relay releases. It is to be noted that since the same sources of battery and ground are applied to the three windings of relay 12 the operation of the relay is practically independent of voltage variations.

The energizing circuit for relay 100 can be traced from ground through contacts 101 of relay 26, contacts of relay 12, right hand winding of relay 100 and contacts 102 of relay 26 to battery.

When relay 100 operates, it closes at its contacts 103, an obvious locking path for itself through resistance 104 and at contacts 105, it completes a circuit for operating relay 32 that can be traced from ground, through contacts 105 of relay 100, right hand winding of relay 32, contacts 91 of relay 49, contacts 92 of relay 43 and contacts 40 of relay 26 to battery.

Ringing filter

As referred to in the statement of features, the present arrangement utilizes, during the ringing interval, a portion of repeating coil 29 as one element of a filter circuit through which the ringing current is passed to the called subscriber's line 106.

Specifically, certain changes are effected, as will later be described, whereby the left hand windings of repeating coil 29 are opened, to improve the impedance characteristics of the coil, condenser 107 and resistance 108 normally connected between the right hand windings of repeating coil 29 are short circuited, condenser 109 is connected across the ringing leads and the source of ringing supply is connected in series with the right hand windings of repeating coil 29, the tip and ring of the trunk, and the subscriber's line, thereby introducing a filter in the ringing circuit which offers very little impedance to the low frequency ringing current, but presents a high impedance to the higher harmonics of the ringing supply since these higher frequencies are objectionable when heard in the subscriber's receiver.

Relay 32 in operating, opens at its contacts the circuit that was closed by contact 27 of relay 24 to connect condenser 28 between the left hand windings of repeating coil 29, and at its contact 110 bridges resistance 111 across condenser 28 to discharge it. This discharge path, which is provided to leave the condenser in a discharged condition so that it will not introduce a click when it is reconnected to the trunk, can be traced from condenser 28, conductor 30, contact 110 of relay 32, conductor 112 and resistance 111 back to condenser 28. Resistance 111 provides protection for contacts 110 of relay 32 against excessive currents caused by the discharge of condenser 28.

As mentioned in the preceding reference to the ringing circuit filter, one reason for opening the connection between the left hand windings of repeating coil 29 is to improve the impedance characteristics of the coil when used as a filter. This also prevents clicks from being transmitted back over the trunk to the toll operator during the establishment and breakdown of the filter circuit.

Relay 32 in operating, also opens at its contacts 113, an obvious short circuit, over conductors

114 and 115, around resistance 108 so that the resistance may serve later as a protection for contacts 116 and 117 of relay 118.

When relay 32 operated, it opened at its contacts 86 the energizing circuit for relay 15 but that relay remains operated through its locking contacts 94.

Relay 32 in operating further performs the function of completing the energizing circuit for relay 118 which circuit can be traced from ground, through contacts 105 of relay 100, contacts 119 of relay 32, conductor 120, left hand winding of relay 118, contacts 88 of relay 68, contacts 89 of relay 74, conductor 90 and contacts 102 of relay 26 to battery.

Relay 118 in operating, closes at its contacts 121, an obvious circuit over conductor 122 for holding relay 32 operated until relay 118 releases. This is necessary to maintain a predetermined sequence of operation in the restoration of the repeating coil to its normal function as part of the speech transmission circuit after it has served its purpose as a filter.

Relay 118 in operating also disconnects at its contacts 123 and 124, the circuit for connecting supervisory relay 84 across the tip and ring of plug 65 and at contacts 116 and 117, short circuits condenser 107 in series with resistance 108. This short circuit connects the two right hand windings of repeating coil 29 together to form the inductive portion of the ringing filter. The short circuit also discharges condenser 107 through resistance 108 so that it will be in a discharged condition when it is reinserted between the right hand windings of repeating coil 29 at the conclusion of ringing thereby eliminating the possibility of producing a click in the subscriber set at the moment it is inserted in the circuit.

Relay 118 further performs the function of completing the energizing circuit for relay 125 which circuit can be traced from ground through contacts 105 of relay 100, contacts 119 of relay 32, conductor 120, contacts 126 of relay 118, upper winding of relay 125, contacts 88 of relay 68, contacts 89 of relay 74, conductor 90 and contacts 102 of relay 26 to battery.

Relay 125 in operating, completes, at its contacts 127, an obvious circuit for holding relay 118 operated, thereby insuring the proper relay release sequence in breaking down the filter and, if ringing key (J) or (M) has been depressed, completes the energizing circuit for relay 128 which circuit can be traced from ground through contacts 127 of relay 125, contacts 129 of key (M) or 130 of key (J) and the winding of relay 128 to battery.

Relay 125 in operating also completes at its contacts 131, a locking circuit for itself under control of tripping relay 132 that can be traced from ground through contacts 133 of relay 74, contacts 131 of relay 125, lower winding of relay 125, contacts of relay 132, contacts 134 of relay 15, contacts 88 of relay 68, contacts 89 of relay 74, conductor 90 and contacts 102 of relay 26 to battery.

Contacts 131 and 135 of relay 125 also complete a circuit for short circuiting the winding of relay 100 to cause its release since the ringing relay train has been set up at this time. The short circuiting path can be traced from ground through contacts 133 of relay 74, contacts 131 and 135 of relay 125, conductor 136, resistance 104, contacts 103 of relay 100 and contacts 102 of relay 26 to battery. Resistance 104 is provided to permit the application of ground to both

ends of the left hand winding of relay 100 to cause its release without blowing the fuse in the battery lead.

Relay 125 in operating, further performs at its contacts 137 the function of opening the short circuit around condenser 109 and resistance 138 while at its contacts 140 it applies ringing ground to conductor 139. Condenser 109 is the second element of the ringing filter previously referred to, the other element being the right hand windings of repeating coil 29. Resistance 139 is provided to protect contacts 137 of relay 125 from excessive current flow that occurs when relay 125 releases and completes the discharge circuit for condenser 109 through resistance 139, since the condenser will be in a charged condition at the time the relay releases.

Relay 125 in operating also connects, at its contacts 141, the selected ringing potential to the upper right hand terminal of repeating coil 29.

When relay 125 operates, its contacts 142 complete a circuit from condenser 143 to conductor 20 to pass a tone to the toll operator to indicate that ringing current is being applied to the subscriber's line.

When relay 100 releases, it opens, at its contacts 105, the energizing circuit for relays 32, 118, and 125. These relays remain operated however on their holding windings.

Let us assume that the called subscriber is party "M" on line 106, and that the trunk operator (B) has depressed the "M" ringing key thereby operating relay 128 over the circuit previously traced which reverses at its contacts 144, 145, 146 and 147 the connections between conductors 139 and 148 and the tip and ring of plug 65.

Relay 128 in operating also completes a circuit for applying positive pulsating current to the tip of plug 65 and ringing ground to the ring of plug 65. This circuit can be traced from positive pulsating current on conductor 149, contacts 150 of ringing key "M", contacts 151 of relay 128, winding of tripping relay 132, contacts 152 of relay 15, contacts 141 of relay 125, upper right hand winding of repeating coil 29, contacts 116 and 117 of relay 118, lower right hand winding of repeating coil 29, contacts 73 of relay 68, contacts 145 of relay 128, contacts 153 of relay 74, tip of plug 65, over line 106 through the subscriber's set and back to the ring of plug 65, contacts 147 of relay 128, and contacts 140 of relay 125 to ringing ground. The windings of repeating coil 29 and condenser 109 form the ringing filter previously described.

If the called subscriber is party "J" instead of "M", the trunk operator operates key "J" and its contacts 130 and 154 function to complete the circuits previously described as being completed by contacts 129 and 150 of key "M" with the exception that negative pulsating current is supplied from conductor 155 rather than the positive pulsating current from conductor 149.

If the "W" party is desired, the "W" key is operated. Relay 128 does not operate under this condition and negative pulsating current is applied directly to the tripping relay 132 from conductor 155 through contact 156 of key (W), whence it follows the circuit previously traced to contacts 146 and 144 of relay 128 where the negative pulsating current is connected to the ring of plug 65 and ringing around to the tip of the plug.

When the called subscriber is party "R", the

trunk operator presses key "R" and positive pulsating current is connected from conductor 149 through contact 157 to the tripping relay whence it follows the circuit described for party "W".

5 If the called subscriber has a direct line, the trunk operator presses either the "R" or "W" key, dependent upon the operating practice decided upon.

10 When the called subscriber's receiver is removed from the switchhook, tripping relay 132 operates in the usual manner due to the increased current flowing through its winding.

15 Relay 132 in operating, opens at its contacts the circuit for holding relay 125 operated, causing it to release.

20 Relay 125 in releasing, opens its contacts 141 to disconnect the ringing supply from the called line, thereby releasing relay 132, and at contacts 140 it disconnects ringing ground from conductor 139 and at its contacts 137 short circuits condenser 109 and resistance 138. Condenser 109 discharges through resistance 138.

25 Relay 125 in releasing, also opens, at its contacts 142, the circuit for transmitting tone to the toll operator as an indication that ringing current has been removed from the subscriber's line.

30 Relay 125 in releasing, further performs the function of opening at its contacts 127 the energizing circuit of relay 128 (if key "J" or "M" is operated), and the holding circuit for relay 118.

When relay 128 releases, it restores at its contacts 144 and 146, the normal connections between repeating coil 29 and plug 60.

35 Relay 118 in releasing, opens at its contacts 116 and 117, the short circuit on resistance 108 and condenser 107 and at its contacts 123 and 124 completes a circuit for operating relay 84, which circuit can be traced from battery through resistance 158, left hand winding of relay 84, contact 124 of relay 118, lower right hand winding of repeating coil 29, make contact 73 of relay 68, contact 146 of relay 128, ring of plug 60, ring of jack 61, over line 106 through the subscriber's set and back to the tip of jack 61, tip of plug 60, contact 153 of relay 74, contact 144 of relay 128, break contact 137 of relay 125, upper right hand winding of repeating coil 29, contact 123 of relay 118, right hand winding of relay 84 and resistance 159 to ground.

50 Relay 118 in releasing also opens at its contacts 121 the circuit, over conductor 122, for holding relay 32 operated, thus causing its release.

35 Relay 32 in releasing, applies, at its contacts 113, a short circuit around protective resistance 108 thereby leaving condenser 107 bridged, between the upper and lower right hand windings of repeating coil 29 to establish a normal talking condition.

60 Relay 32 in releasing, at its contacts 110, disconnects resistance 111 from condenser 28 and bridges the condenser between the left hand windings of repeating coil 29 thereby completing the talking connection between the toll operator (A) and subscriber (X).

Relay 32 in releasing, also restores the path for energizing relay 15.

70 Relay 84 in operating, opens at its contacts the energizing circuit for relay 15 causing it to release.

75 Relay 15 in releasing, restores at its contacts 14 and 21, the normal direction of current flow through relay 9 causing it to release and disconnect battery from the toll cord supervisory

relay to extinguish the toll operator's supervisory lamp as an indication that the called subscriber had answered.

Relay 15 in releasing, also connects a source of pulsating current to contacts 160 of relay 125 to provide a continuous ringing supply for recall purposes to be later described.

When the receiver at the called station is replaced on the switchhook, supervisory relay 84 releases, reestablishing the energizing circuit for relay 15 over the path previously traced.

Relay 15 in operating, reverses at its contacts 14 and 21, the circuit through relay 9 causing it to reoperate and apply battery to the toll cord supervisory relay, causing that relay to operate 15 and light the toll supervisory lamp as an indication that the called subscriber has hung up.

Relay 13 in operating, also completes at its contacts 94 its original holding circuit previously described.

20 When the toll operator (A) disconnects the toll cord 2 from jack 3, relay 4 releases and disconnects the battery supply from the ring of jack 3.

Relay 4 in releasing, opens at its contacts 5 25 and 8, the energizing circuit for relays 9 and 10 and the connection for bridging condenser 6 between the right hand windings of repeating coil 7.

When relay 10 releases, it releases relay 24 30 which opens, at its contacts 37, the circuit over the conductors 36 and 38 for bridging resistance 34 and condenser 35 between the upper and lower windings of retardation coil 16.

Relay 24 in releasing, also opens, at its con- 35 tacts 27, the circuit over conductors 30 and 33 for bridging condenser 28 between the left hand windings of repeating coil 29.

Relay 24 in releasing, further performs the function of opening, at its contacts 25, the ener- 40 gizing circuit for relay 26 causing its release.

Relay 26 in releasing, opens at its contacts 40, the holding circuit through the right hand winding of relay 43 and completes a circuit for lighting guard and disconnect lamp 41, as a disconnect signal for the (B) operator. The circuit for lighting lamp 41, can be traced from battery through contacts 161 of relay 26, conductor 162, contacts 163 of relay 74, conductor 164, contacts 44 of relay 55 and lamp 41 to ground.

50 Relay 26 in releasing, also opens at its contacts 39, the energizing circuit for the right hand winding of relay 12 causing that relay to release. Relay 12 operated when the circuit through the left hand and middle windings was opened at the toll board by the release of relay 4, but, due to the slow acting characteristics of relays 32 and 118, did not have time to set up the ringing condition before its release.

60 Relay 26 in releasing further performs the function of opening at its contacts 52 and 47 the energizing circuit for relay 49 thereby causing that relay to release.

Relay 43 does not release when the circuit 65 through its right hand winding is opened, provided the trunk is connected to the subscriber's line, since it is held operated by its left hand winding under control of sleeve relay 74. This sleeve control of the release of relay 43 is provided to lock in the disconnect signal until the trunk is disconnected from the subscriber's line by holding open the energizing circuit for relay 49 until relay 43 releases. This prevents relay 49 from operating if a second call is originated 75

by the toll operator before the trunk is disconnected from the first called subscriber's line.

When the trunk operator disconnects plug 65 from jack 66, relays 68 and 69 release.

5 When relay 68 releases, it prepares, in part, a circuit for sending a recall signal to the toll operator which function will be later described in detail.

10 Relay 69 in releasing, opens at its contacts the energizing circuit for relay 74 causing its release.

When relay 74 releases, it opens, at its contacts 163, the circuit previously traced for lighting guard and disconnect lamp 41, and, at its contacts 165, connects the tip of plug 65 to the busy test lead 71 through contacts 70 of relay 68.

15 Relay 74 in releasing also opens at its contacts 75 the holding circuit, over conductor 78, for relay 43 causing it to release, restoring the circuit to normal.

20 If the (B) operator disconnects the trunk from the subscriber's line before the disconnect signal is set at her position, the circuit is arranged to give the toll operator a reorder signal as follows:

25 Removal of plug 65 from jack 66, while the toll cord is connected to the trunk, causes the release of relays 84 (if operated) 68 and 69 and relay 69 in releasing, releases relay 74.

30 When relay 74 releases it opens at its contacts 75 the circuit through the left hand winding of relay 43 over conductor 78, but relay 43 does not release as it is held operated by its right hand winding under control of relay 26.

35 Relay 74 in releasing, completes a circuit for flashing relay 15 that can be traced from battery, interrupter 166, contacts 167 of relay 74, conductor 168, contacts 169 of relay 43, conductor 85, contacts 83 of relay 84, winding of relay 15, conductor 82, contacts 79 of relay 49 and contacts 47 of relay 26 to ground.

40 Relay 15 follows the interrupter and each time it operates, reverses, through its contacts 14 and 21, the current flow through polarized relay 9 at the toll office causing that relay to intermittently light the supervisory lamp in the toll cord as previously described.

45 Relay 15 in operating cannot lock at this time as the circuit for supplying locking battery is opened at contacts 88 of relay 68 and contacts 89 of relay 74.

50 The toll operator answers the recorder signal by withdrawing plug 2 from jack 3 and then originates a new call. Withdrawal of plug 2 causes relays 10, 24 and 26 to release as previously described for the disconnection of a regular call. Relay 26 in releasing opens at its contacts 40 the holding circuit for relay 43 causing it to release and return to normal with the other relays. The new call proceeds as previously described.

55 Should the toll operator originate a second call before the (B) operator disconnects the trunk from the subscriber's line of the previous call, the circuit functions in the following manner.

60 Upon the insertion of plug 2 in jack 3, the call progresses as on a regular call until start relay 46 operates. When relay 46 operates it performs the functions previously described except that the connection to ground through the high resistance relay in the position circuit is now traced from battery through contacts 52 of relay 26, resistance 170, contacts 171 of relay 75 43, which relay is operated since the trunk has

not been disconnected from line 106, contacts 59 of relay 45 and winding of relay 62 to ground.

Pilot lamp 63 lights and guard and disconnect lamp 41 flashes to indicate the trunk that is connected to the position. Under this condition, i. e., the trunk connected to line 106, the (B) operator cannot disconnect the trunk from the position circuit by the operation of the "release" key 76 until the trunk is disconnected from the line, thereby releasing relays 68, 69, 74, and 43. Relay 43 in releasing substitutes, at its continuity contacts 61 and 171, relay 49 for resistance 170 and the circuit then assumes the condition of a regular call.

15 The trunk operator may disconnect the position circuit from the trunk circuit by operation of the position "release" key 76 unless the call being answered is a "second call", that is, one that has been connected to the position circuit before the trunk operator has disconnected from the previous call. In that case the position cannot be disconnected until the connection to the subscriber's line has been taken down as previously described.

20 Operation of "release" key 76 causes the position circuit to function, in the usual manner, and lower the resistance in series with relay 49 over the circuit previously traced, thereby causing relay 49, which is marginal, to operate and disconnect the trunk from the position circuit.

Emergency listening

25 If the position circuit is not functioning, the trunk operator completes the connection to her telephone set by inserting plug 65 in jack 172 of line 173 to the emergency listening circuit EL. The insertion of plug 65 in jack 172 completes an obvious energizing circuit for relays 68 and 69. Relay 69 being polarized, does not operate since the current flow is in the non-operate direction, but marginal relay 68 does operate and completes at its contacts 72 and 73, a circuit for connecting repeating coil 29 through to the emergency listening circuit. Battery is then connected through resistance 158, the left hand winding of relay 84, contacts 124 of relay 118 lower right hand winding of repeating coil 29, contacts 73 of relay 68, contacts 146 of relay 128, the ring of plug 65 50 and the ring of jack 172 to the ring of line 173 where it causes the emergency listening circuit to function and connect the trunk to the (B) operator's telephone circuit. Since the operation of the emergency listening circuit is not a part of this disclosure its operation will not be described in detail. The emergency listening circuit is held over the circuit just traced to the ring of line 173 where it passes through the winding of a relay in the emergency listening circuit to the tip of line 173, tip of jack 172, tip of plug 65, contacts 165 of relay 74, contacts 72 of relay 68, contacts 144 of relay 128, contacts 137 of relay 125, upper right hand winding of repeating coil 29, contacts 123 of relay 118, right hand winding of relay 84 and resistance 159 to ground. The toll operator is then in direct communication with the (B) operator and can pass the desired number.

65 It is essential that relay 69 does not operate while the trunk is connected to the emergency listening circuit to prevent sending a reorder signal to the toll operator when the trunk operator transfers the trunk cord plug 65 from jack 172 to jack 66. Relay 69 if operated, would 75

cause the subsequent operation of relays 74, 49 and 43 with the result that as the trunk plug was removed from jack 172, relays 69 and 74 would release, and, as relay 43 would be operated, a reorder signal would be transmitted to the toll operator as previously described.

When the trunk operator removes trunk plug 65 from jack 172, relay 68 releases and the trunk is ready for connection to the subscriber's line.

Toll operator recall

If the (B) operator desires to recall the toll operator on a standard basis, the trunk cord plug is inserted in jack 174 to connect the trunk to the reorder circuit RO over line 175. When the plug 65 is inserted in jack 174, ground through high resistance 176 is connected through the sleeve of jack 174 and plug 65 to relays 68 and 69 causing polarized relay 69 to operate and cause the operation of relay 74. Marginal relay 68 does not operate when connected to a high resistance ground, so that a circuit is completed through its contacts for flashing the toll operator as soon as the reorder circuit functions. The insertion of plug 65 in jack 174 causes the reorder circuit to function, in a manner not shown, to connect interrupted battery to the ring of jack 174 to "flash" relay 15 thereby causing the toll operator to receive a flashing supervisory lamp in the manner previously described. The circuit for flashing relay 15 can be traced from interrupted battery on the ring of jack 174 through the ring of plug 65, contacts 146 of relay 128, contacts 177 of relay 68, contact 83 of relay 84, winding of relay 15, conductor 82, contacts 79 of relay 49 and contacts 47 of relay 26 to ground. The toll operator answers such a recall by withdrawing plug 2 from jack 3, thereby causing the trunk circuit to function as previously described and set up a disconnect signal for the (B) operator. The toll operator then reinserts plug 2 in jack 3 to reestablish a talking connection to the trunk.

Busy back

When the (B) operator tests the called subscriber's line and finds it "busy", plug 65 is inserted in jack 178, of line 179 to the well known "busy back" circuit BB. This circuit presents the same operating characteristics as the reorder trunk RO, except for the rate of flashing, and the trunk functions as previously described for reorder signals. The flashing rate of the two circuits is made different to enable the toll operator to distinguish between the signals.

If the called subscriber is located at a PBX it may be necessary for the toll operator to recall the PBX operator to pass additional information, in which case she rings on the trunk in the usual manner. The trunk functions as on a regular call, and relays 96, 19, 12, 100, 32, 118, and 125 operate to set up the ringing conditions including the ringing filter. At this time, however, relay 15 is not operated and consequently pulsating current is applied to the line at its contacts 169 over the circuit previously traced for ringing from these contacts. Relay 132 is not connected in the circuit and the holding circuit through the lower winding of relay 125 is held open at contacts 134 of relay 15 to give the toll operator direct control of the continuous ringing supply to the called line. The various relays in the ringing chain therefore

follow the operation of the ringing key at the toll office.

What is claimed is:

1. In a telephone trunking system a first switchboard, a second switchboard, a trunk line therebetween, a called line accessible to said trunk at the second switchboard, means to connect said trunk line to the called line a source of ringing current and means at the second switchboard for controlling the connection of said ringing source to the called line, said means comprising a differential relay controlled over the trunk conductors from the first switchboard.

2. In a telephone system, a first operator's position, a second operator's position, a trunk line therebetween, a link circuit at the first position adapted to be connected to said trunk, a first circuit including a relay and a source of current bridged across the trunk at the second position, means at the first position responsive to connection of said link with said trunk to complete said first circuit over said trunk, an auxiliary circuit also including said current source, an auxiliary winding on said relay included in said auxiliary circuit, said auxiliary winding being so arranged as to neutralize the effect on said relay of the current flowing in said first circuit caused by connection of said line to said trunk, means responsive to a ringing signal transmitted to said trunk from said link circuit to reduce the current in said first circuit sufficiently to permit said relay to operate on its auxiliary circuit winding, a source of ringing current, and means responsive to operation of said relay to connect said ringing source to said trunk circuit.

3. In a telephone system, a first operator's position, a second operator's position, a trunk line therebetween, a link circuit at the first position adapted to be connected to said trunk line, subscribers' lines at the second position adapted to be connected to by said trunk line, a circuit including a source of direct current connected across said trunk line at the second position, a low resistance direct current path adapted to be completed across said trunk line at the first position responsive to connection of said link circuit with said trunk, a source of ringing current at the second position, means for applying said ringing current to said trunk line to ring on a connected one of said subscriber's lines, a multiple wound relay at the second position adapted to control said ringing means, said relay having two windings in a series aiding relation, included in said direct current circuit and having a third winding included in a second circuit which also includes said direct current source, said third winding being so arranged as to neutralize the effect of said first two windings when said low resistance path is connected across the trunk line at the first position, and means at the first position responsive to application of a ringing signal to the trunk thereat to increase the resistance of said direct current path sufficiently to reduce the current flow in the series aiding windings of said multiple wound relay to permit said relay to operate on its third winding, whereby said ringing means is controlled to apply ringing current to the trunk line.

4. In a telephone system, a first operator's position, a second operator's position, a trunk line therebetween, a link circuit at the first position adapted to be connected to said trunk, sub-

scribers' lines at the second position adapted to be connected to by said trunk line, a first circuit including a relay and a source of current bridged across the trunk at the second position, means at the first position responsive to connection of said link circuit with said trunk to complete said first circuit, an auxiliary circuit also including said current source, an auxiliary winding on said relay included in said auxiliary circuit, said auxiliary winding being so arranged as to neutralize the effect on said relay of the current in said first circuit caused by connection of said link to said trunk, means responsive to a ringing signal transmitted to said trunk from said link circuit to reduce the current in said relay sufficiently to permit it to operate on its auxiliary winding, a source of ringing current, a repeating coil interposed in said trunk line and means jointly responsive to operation of said relay and connection of said trunk line to one of said subscriber's line to connect said ringing source through the repeating coil winding, nearest the subscriber's line, to said line.

5. In a telephone trunking system, first and second operators' positions, a trunk line therebetween, a repeating coil interposed in said trunk line at the second position, a called line connected to said trunk line at the second position, a source of ringing current and means at the second position for connecting said ringing source and said called line through the called line side of the repeating coil, said means comprising a differential relay controlled over the trunk line from the first position.

6. In a telephone system, a switchboard, a called line appearing therein, a link circuit terminating thereat and connected to said line, a repeating coil interposed in said link circuit, a source of ringing current and means controlled over said link circuit for connecting said source to the called line through the called line side of the repeating coil.

7. In a telephone system, a switchboard, a called line appearing therein, a link circuit terminating in a plug thereat, said plug being connected to said line, a repeating coil interposed in said link circuit, a source of ringing current, and means for connecting said source to the called line through the repeating coil winding nearest said line.

8. In a telephone system, a switchboard, a called line appearing therein, a link circuit terminating in a plug thereat, said plug being connected to said line, a repeating coil interposed in said link circuit, a source of ringing current, a circuit therefor including a filter, and means for connecting said circuit to the called line through the called line side of said repeating coil.

9. In a telephone system, a switchboard, a called line appearing therein, a link circuit terminating in a plug thereat, said plug being connected to said line, a repeating coil interposed in said link circuit, a source of ringing current, a circuit therefor including a filter, and means for connecting said circuit to the called line through the called line side of the said repeating coil and for opening the other half of said coil.

10. In a telephone system, a switchboard, a called line appearing therein, a link circuit terminating in a plug thereat, said plug being con-

nected to said line, a repeating coil interposed in said link circuit, a source of ringing current, and means for connecting said source to the called line through the repeating coil winding nearest said line, and operator controlled means at the second position for reversing the tip and ring conductors of said plug with respect to the corresponding conductors of said called line.

11. In a telephone exchange system, an operator's position, a trunk line terminating thereat, a differential relay having a first winding connected to said trunk line and having a second winding in a local energizing circuit, arranged to balance said first winding for a certain line current, means for charging the line current, and unbalance the relay and permit it to operate and signal means controlled by operation of said relay.

12. In a signaling system, a relay winding in a closed circuit including a line and a source of current, a differential winding on said relay energized in a local circuit also including said source of current to neutralize the flux due to the line winding and means to change the resistance of said closed circuit to unbalance said relay thereby permitting its operation.

13. In a signaling system, a line, a multiple wound relay having one winding connected on one end of said line, a source of current in series with said winding, means for closing the other end of the line through a predetermined resistance, a differential winding on said relay in a local circuit including said source of current, said differential winding being so arranged as to neutralize the flux in said relay due to the line circuit through said resistance, and means for changing the value of said resistance to unbalance said relay and permit it to operate.

14. In a selective signaling system a transmitting station, a receiving station, a line therebetween, a source of current, a circuit including said source connected across the line at the receiving station, first and second relays at the receiving station, each relay having a winding connected in series in said circuit, means for closing the line at the transmitting station through a resistance to operate said first relay, a differential winding on said second relay, an auxiliary circuit including said differential winding and said source, means for closing said auxiliary circuit upon the operation of said relay, said differential winding being so arranged that, when energized in said auxiliary circuit, it will neutralize the flux in the second relay due to the line current through its other winding in series with said resistance, and means for increasing the value of said resistance at the transmitting station thereby causing a flux unbalance in said second relay and permitting it to operate.

15. In a telephone exchange system an operator's position, a trunk line terminating thereat, signal control means at said position including a differential relay having one winding unvariably energized in a local circuit and a second winding connected to said line, and means for variably energizing said second winding over said line to effect operation of said relay.

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