Aug. 22, 1939. M. C. GODDARD 2,170,403

TELEPHONE SYSTEM

Filed Feb. 27, 1937 3 Sheets-Sheet 1

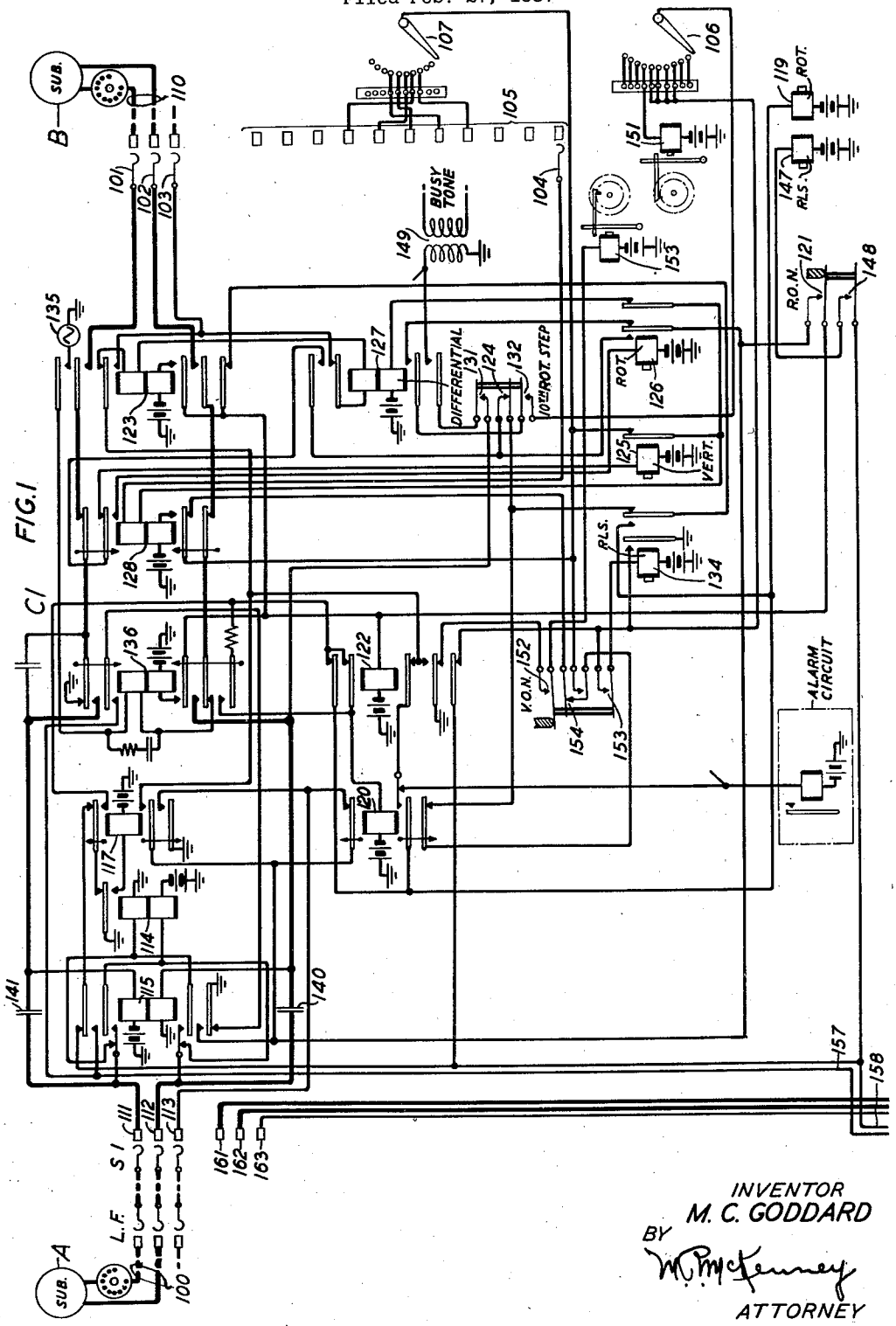

FIG. 1

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TELEPHONE SYSTEM

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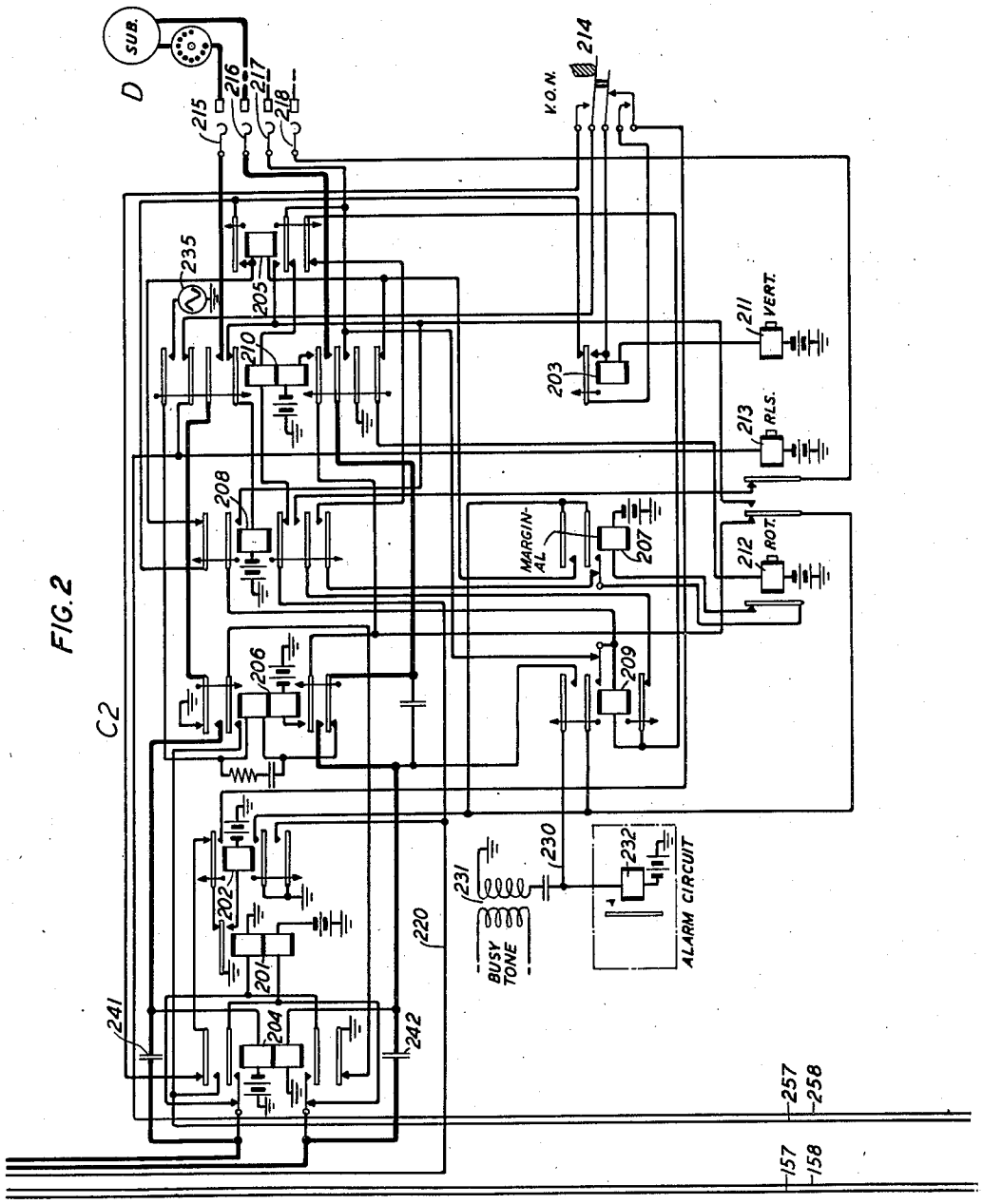

FIG. 2

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TELEPHONE SYSTEM

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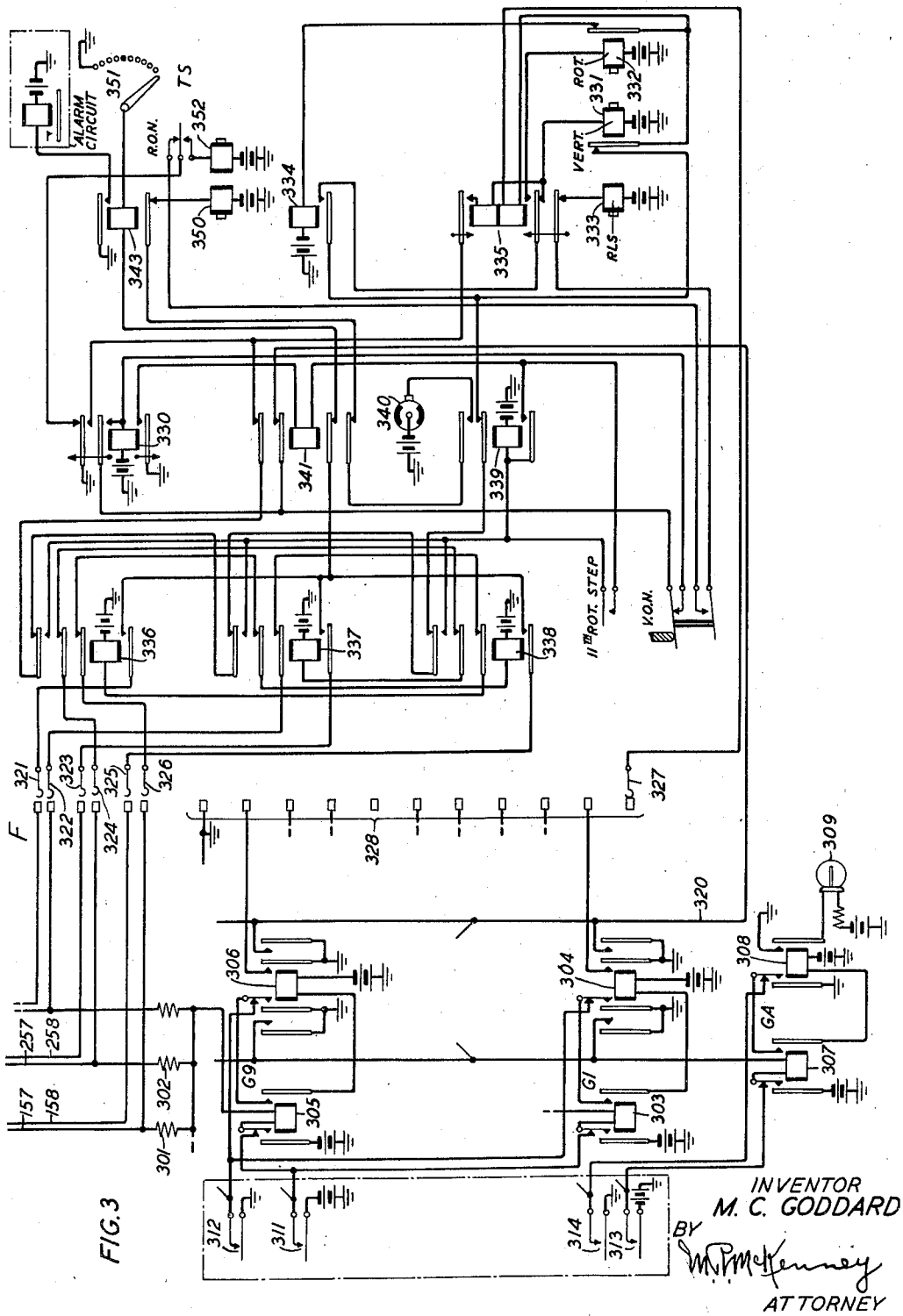

FIG. 3

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2,170,403

UNITED STATES PATENT OFFICE

2,170,403

TELEPHONE SYSTEM

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Application February 27, 1937, Serial No. 128,148

10 Claims. (Cl. 179—27)

This invention relates to telephone systems and particularly to systems comprising automatic switches for use in establishing connections.

It is the object of the invention to increase the efficiency of automatic telephone systems, to minimize the amount of switching equipment required, and to improve the quality of the service rendered by such systems.

It is known in automatic telephone systems to release the switches used in establishing a connection between a calling and a called line under control of the calling subscriber, the called subscriber, or jointly by both the calling and the called subscribers. In systems in which the release of the connection is controlled by the calling subscriber, it is of course possible for the calling subscriber to hold the called subscriber's line busy after the called subscriber has restored the receiver to normal and thereby prevent the subscriber at this called station from originating or receiving calls. It is usual, when such a permanent signal condition exists, to start a timing operation and, at the end of a measured interval of time, to operate an alarm. This interval is usually quite long, such as from 22 to 44 minutes, in order that the number of such permanent signal alarms be minimized, and during this long interval the called subscriber's station is deprived of both incoming and outgoing service. According to this invention, common timing equipment is provided for a group of connectors with means for connecting the timing equipment to a connector when either the calling or the called subscriber's supervisory relay releases and the other of the two supervisory relays is not thereafter released within a short measured interval. The timing equipment thereupon measures off a further short interval of time and then effects partial operation of the release magnet of the connector in question to free the called line, the timing equipment being at the same time released for use with any other of the connectors in the group.

The invention will be better understood by considering a telephone system in which the features of the invention are embodied. One such system is shown schematically in the drawings which form a part of this specification. The invention is, however, not limited in its application to the particular system or switches shown. The three figures of the drawings are to be placed one below the other in numerical order to form an operative arrangement.

Referring to the drawings:

Fig. 1 shows a calling subscriber's station A, a line-finder switch LF and an associated first-selector switch S1, a connector switch C1, and a called subscriber's station B;

Fig. 2 shows a connector switch C2 and a called subscriber's station D; and

Fig. 3 shows group timing units G1 and G9, group alarm unit GA, a finder switch F, a timing switch TS, and associated control relays.

The subscribers' stations are prvided with the usual station equipment used in automatic telephone systems, and include an impulse sender of the dial type for use in establishing connection with any other line of the system. The line-finder switch LF, first-selector switch S1 and connector switches C1 and C2 are of the well-known two-motion step-by-step type. For a description of the structure of such switches and their operation when used as selectors and connectors reference may be had to pages 53 to 67, inclusive, of the second edition of "Automatic Telephony" by Smith and Campbell. For a description of the operation of such a switch when used as a line-finder reference may be had to Patent 1,799,654 granted to R. L. Stokely April 7, 1931. The line-finder switch LF is represented by one set of brushes and a single set of terminals and the associated first-selector switch S1 is represented by a set of brushes and two sets of terminals, all magnets and associated relays being omitted.

The connector switches C1 and C2 are shown in detail, the connector C1 being a level-hunting connector and the connector C2 being a local rotary connector. The level-hunting connector C1 is a modification of the one disclosed in Patent 1,747,169 granted to H. Hovland February 18, 1930; and the local rotary connector C2 is a modification of the one shown in Fig. 2 of Patent 2,014,232 granted to H. Hovland, September 10, 1935. By the modification, the two supervisory circuits (controlled by the calling and called subscribers) have been connected to a conductor leading to one of the group timing units shown in Fig. 3 and to a terminal in the bank of finder switch F; another conductor has been added for connecting the release magnet of the switch to another terminal in the bank of switch F; and contacts have been added to the release magnets, these contacts being actuated upon partial energization of the magnet under the control of the timing equipment. The partial energiation of the release magnet 134 of level-hunting connector C1 closes a circuit for completing the energization of the magnet to release the switch; since in such a connector the cut-through relay is not slow in releasing, other lines are not disturbed while

the brushes are being restored to normal. The partial energization of the release magnet 213 of the rotary connector C2, is effective through an added set of contacts to cause release of the ringing cut-off and cut-through relays and thereby release the called line without restoring the brushes to normal unless and until the connection is released by the calling subscriber. The partial operation of the release magnet of the rotary connector switch C2 is also effective through an added contact to prevent trunk hunting after the cut-through relay releases in case the brushes are in engagement with a trunk to a private branch exchange, other than the last in the group. Both of the connectors C1 and C2 are further modified by adding another connection in place of the aforementioned supervisory circuits whereby a permanent signal alarm is operated, at the end of an interval of from 22 to 44 minutes, in case the permanent signal condition continues for that length of time.

The finder switch F is also a two-motion step-by-step switch comprising three pairs of multiple brushes, 321 and 322, 323 and 324, and 325 and 326, a commutator brush 327 and commutator 328, a vertical-stepping magnet 331, rotary-stepping magnet 332 and release magnet 333. Two conductors from each of the connectors, to which the finder F is common, connect to terminals in the bank of this finder. For instance, conductors 157 and 158 from connector C1 and conductors 257 and 258 from connector C2 are shown connected to terminals in the bank of switch F. One of these two conductors from each connector, for instance conductor 157 or 257 is also connected through an individual resistance, such as 301 or 302, to the winding of a group relay, there being a group timing unit comprising a group relay and a timing relay for the thirty connectors connected to the terminals of each level of the bank of switch F. Two of the ten group timing units are shown; the group G1 comprising relays 303 and 304 is associated with the terminals in the first level of the bank of switch F; and the group G9 comprising relays 305 and 306 is associated with the terminals in the ninth level. The operation of the group relays is under the control of common timing contacts 311 and 312 each of which is closed for six seconds once every thirty seconds. The closing of contacts 312 begins eighteen seconds after the closure of contacts 311 ends, so that there is a delay of from 18 to 48 seconds between the operation of one of relays 303, 305, et cetera, before the operation of the associated one of relays 304, 306, et cetera. Each of relays 304, 306, et cetera, when operated, connects ground to conductor 320 to start the operation of the finder switch F. The timing switch TS is a single-motion step-by-step switch comprising a stepping magnet 350, brush and bank 351 and a release magnet 352. The operation of magnet 350, after finder switch F connects with a connector switch, is effected under control of interrupter 340 so that the advance of brush 351 to the last terminal measures a desired interval, for instance two or three minutes.

The group alarm unit GA comprising relays 307 and 308 effects the operation of a maintenance alarm in case the finder switch F fails to find a connector and cause release of the group timing unit within an interval of from 22 to 44 minutes. The operation of relay 307 is under the control of timing contacts 313 and the operation of relay 308 is under the control of timing contacts 314. Both these contacts are closed for six seconds every 22 minutes, the closure of contacts 313 beginning just after the closure of contacts 314 ends, so that an interval of from 22 to 44 minutes elapses before relay 308 closes the alarm circuit.

Assume first that the calling subscriber's station A and line 100 have been connected by operation of the line-finder switch LF and first selector switch S1 and any intermediate selectors (none shown) to the connector C1. The line relay 114 of the connector C1 is thereupon operated by the current in a circuit from battery through the lower winding of relay 114, inner lower back contact of relay 115, terminal 112 and middle brush of selector S1, middle brush of line-finder LF, over the lower conductor of line 100 and through the subscriber's instrument at station A, back over the upper conductor of line 100, uppermost brushes of switches LF and S1, terminal 111, inner upper back contact of relay 115, and upper winding of relay 114 to ground. Relay 114 closes a circuit for operating relay 117; and relay 117 connects ground to terminal 113 to hold the line-finder and selector switches in usual manner.

When the subscriber at station A dials the next to the last digit of the number of the station B with which connection is desired, relay 114 releases at each interruption of its circuit by the dial. Relay 117 is slow to release and remains operated during dialing. Each release of relay 114 closes a circuit from ground through the back contact of relay 114, upper front contact of relay 117, uppermost back contact of relay 122, and through the winding of the stepping magnet 119 of the auxiliary, rotary, recording switch. Another circuit is closed from ground through these contacts of relays 114 and 117, the inner upper back contact of relay 122 and through the winding of relay 120 to battery. Relay 120 is slow in releasing and, once operated in response to the first impulse received by relay 114, remains operated until all of the impulses in the series have been received. The stepping magnet 119 operates and releases in response to each impulse, the brushes 106 and 107 being thereby advanced a corresponding number of steps. The off-normal contacts 121 and 148 of the recording switch are actuated as soon as the brushes of this switch are moved out of normal position and, when relay 120 releases at the end of the train of impulses, a circuit is closed from battery through the winding of relay 122, off-normal contact 121, upper back contact of relay 120, to ground at the lowermost front contact of relay 117. Relay 122 operates and closes a locking circuit through off-normal contact 121, inner lower front contact of relay 117 to ground at the front contact of relay 122. The operation of relay 122 prevents the operation of relay 120 and stepping magnet 119 when relay 114 responds to the impulses originated by the dialing of the last digit of the called subscriber's number. The setting of the recording switch determines the first level in which the brushes of switch C1 are to be advanced in search for an idle trunk to the called subscriber's private branch exchange.

The aforementioned release of relay 120 also closes a circuit for operating relay 127; this circuit is traced from battery through the lower winding of relay 127, outer back contact of the rotary-stepping magnet 126 of switch C1, back contact of the vertical-stepping magnet 125 of switch C1, inner lower back contact of relay 128,

normally closed contact 154 of the vertical off-normal springs of switch C1, lowermost back contact of relay 120, back contact of the release magnet 134 of switch C1, lower back contact of relay 123, off-normal contact 121 of the recording switch, and through the upper back contact of relay 120 to ground at the lowermost front contact of relay 117. The operation of relay 127 closes a circuit for operating the vertical-stepping magnet 125; this circuit is traced from battery through the winding of magnet 125, inner upper back contact of relay 128, upper front contact of relay 127, contact 124 of the "10th rotary step" springs of switch C1, through the back contact of release magnet 134 and thence to ground at relay 117 as hereinbefore traced. The operation of magnet 125 steps the brushes 101, 102 and 103 of switch C1 up to the first level of its terminal bank. As soon as the shaft of switch C1 is moved out of normal position, the vertical off-normal springs VON are actuated and the circuit through the lower winding of relay 127 is traced through the front contact of spring 154 instead of through the back contact of this spring and the inner lower back contact of relay 128. If the terminal with which brush 107 of the recording switch is in engagement is not connected to the first off-normal segment of the vertical commutator 105 of switch C1, relay 127 releases when magnet 125 operates; the release of relay 127 causes the release of magnet 125; and the release of magnet 125 closes the circuit for operating relay 127. This cycle of operations of relay 127 and magnet 125 is repeated, the brushes being raised one step by each operation of the magnet, until the level is reached which corresponds to the setting of the recording switch; at which time relay 127 is held operated by a circuit which includes brush 107 of the recording switch. Assuming that the terminals of bank 107 of the recording switch are cross-connected to the terminals of the vertical commutator of switch C1 as shown in the drawings and that the brushes of the recording switch have been advanced to the third off-normal position, the circuit for holding relay 127 operated is traced from battery through the lower winding of relay 127, outer back contact of magnet 126, upper winding of relay 128, brush 104 and third off-normal terminal of the vertical commutator 105 of switch C1, brush 107 of the recording switch, the front contact of the off-normal spring 154 and thence to ground at relay 117 as hereinbefore described. Relay 127 holds the vertical-stepping magnet 125 operated until relay 128 operates, thereby preventing the further vertical advance of the brushes of switch C1. Relay 128 is operated by the current through its upper winding and closes a locking circuit through its lower winding and lower front contact, the front contact of off-normal spring 154, and thence to ground at relay 117 as hereinbefore traced. Relay 128 is, however, somewhat slow in operating so that rotary stepping will not begin until the brushes have been properly centered opposite the first level in which the brushes are to hunt for an idle trunk. With relay 128 operated, a circuit is closed from battery through the winding of the rotary-stepping magnet 126, upper front contact of relay 128, upper front contact of relay 127 and thence to ground at relay 117 as hereinbefore traced. The operation of magnet 126 advances the brushes 101, 102 and 103 into engagement with the first set of terminals in the third level of the bank. The idle or busy condition of this set is tested through sleeve brush 103, busy trunks being characterized by a ground potential on the sleeve terminal and idle trunks by a battery potential. The operation of magnet 126 causes the release of relay 127 and the release of relay 127 causes the release of magnet 126. If the first set of terminals is busy, the release of magnet 126 again closes the circuit for operating relay 127, and relay 127 causes the reoperation of magnet 126 to step the brushes to the next set of terminals. This cycle of operations is repeated until the brushes engage the terminals of an idle trunk whereupon, as soon as relay 127 releases, due to the operation of magnet 126, a circuit is closed from the battery potential encountered by brush 103, through the upper back contact and upper winding of relay 127, upper winding and upper back contact of relay 123, to ground at the front contact of relay 122. When magnet 126 releases, relay 127 cannot reoperate since the current through its upper winding electromagnetically opposes the current through its lower winding. Relay 123 is sufficiently energized by the current through its upper winding to close a locking circuit from battery through its lower winding and inner lower front contact, thence through off-normal spring 121 of the recording switch to ground as hereinbefore described. After closing its locking circuit, relay 123 opens its operating circuit, opens the locking circuit of relay 128 to cause the release of relay 128, and opens the operating circuit of relay 127 to prevent its reoperation. The release of relay 128 closes the ringing circuit from ringing source 135, through the uppermost front contact of relay 123, upper winding and lower back contact of ringing cut-off relay 136, lowermost back contact of relay 128, lowermost front contact of relay 123, brush 102, over line 110 and through the ringer (not shown) at station B, back through brush 101, middle upper front contact of relay 123, uppermost back contact of relay 128, and through the uppermost back contact of relay 136 to ringing ground. When the called subscriber answers the call, relay 136 is sufficiently energized to close a circuit through its lower winding and inner lower front contact thence to ground through contact 121 to ground as hereinbefore described. Relay 136, when fully operated, opens the ringing circuit and closes a circuit for operating supervisory relay 115; this circuit is from battery through the upper winding of relay 115, uppermost front contact of relay 136, uppermost back contact of relay 128, middle upper front contact of relay 123, brush 101, over the called line 110 and through the telephone set at station B, back through brush 102, lowermost front contact of relay 123, lowermost back contact of relay 128, middle lower front contact of relay 136, and through the lower winding of relay 115 to ground. Relay 114 is held operated under control of the calling subscriber and relay 115 is held operated under control of the called subscriber during conversation. The talking circuit between the calling and called stations includes condensers 140 and 141. For a further description of the operation of connector C1 other than its release after a talking connection has been established, reference may be had to the aforementioned Hovland Patent 1,747,169.

When the calling subscriber releases the connection relay 114 releases, causing the release of relay 117. When the called subscriber releases the connection, relay 115 releases. The release of

all three of these relays causes the release of relays 122, 136 and 123; disconnects holding ground from terminal 113, thereby causing release of the preceding switches in usual manner; and closes a circuit for operating the release magnet 147 of the recording switch; this circuit is traced from ground at the back contact of relay 114, through the upper back contact of relay 117, uppermost back contact of relay 115, off-normal contact 148 of the recording switch, and through the winding of magnet 147 to battery. The operation of magnet 147 effects the return of the recording switch to normal. The release of relay 122 closes a circuit for operating release magnet 134 of connector switch C1; this circuit is traced from ground at the back contact of relay 114, through back contacts of relays 117 and 115, lowermost back contact of relay 122, off-normal contact 133 of switch C1, and through the winding of magnet 134 to battery. The connector switch and auxiliary recording switch are thereby both restored to normal.

If one of the two connected subscribers releases the connection in advance of the other, ground is connected to conductor 157 to call in the common timing equipment. If relay 114 releases and relay 115 is held operated, conductor 157 is connected through the uppermost front contact of relay 115 and the upper back contact of relay 117, to ground at the back contact of relay 114. If relay 115 releases and relay 114 is held operated, conductor 157 is connected through the inner upper front contact of relay 136 to ground at the lowermost back contact of relay 115. In either case, if this condition continues until the interrupter contact 311 next connects battery to the winding of relay 305 of group timing unit G9, relay 305 is operated through the individual resistor 301 over conductor 157 to ground at relay 114 or at relay 115. Relay 305 locks through its left front contact and remains operated until ground is disconnected from conductor 157. If the condition continues after relay 305 operates until the next closure of interrupter contacts 312, relay 306 operates, the operating circuit being traced through the right front contact of relay 305. Relay 306 locks, through its inner left front contact, under control of relay 305, connects ground to the ninth-level terminal of the commutator bank 328 of switch F, and connects ground through conductor 320, the inner upper back contact of relay 341, normally closed contact of the vertical off-normal springs VON, to the winding of start relay 330. Relay 330 operates and closes a locking circuit through its inner upper front contact to the same ground independent of the vertical off-normal springs VON. Relay 330 closes a circuit for operating relay 334; this circuit is traced from battery through the winding of relay 334, back contacts of rotary-stepping magnet 332 and vertical stepping magnet 331, back contact of relay 339, uppermost back contacts of relays 338, 337, 336 and 341, to ground at the uppermost front contact of relay 330. Relay 334 closes a circuit, for operating the vertical stepping magnet 331, from battery through the winding of this magnet, inner lower back contact of relay 335, front contact of relay 334, back contact of relay 339 and thence to ground at relay 330 as hereinbefore traced The operation of magnet 331 steps the brushes 321 to 327, inclusive, up to the first level of the terminal bank and opens the circuit through the winding of relay 334. Relay 334 releases when magnet 331 operates unless the terminals of the connector to which the timing equipment is to be connected are located in the first level of the bank. Since in the case being described the terminals of connector C1 are located in the ninth level, relay 334 and magnet 331 are alternately operated and released to raise the brushes step by step until commutator brush 327 engages the ninth commutator segment. Relay 334 is then held operated to prevent further vertical movement, the circuit for holding relay 334 being traced through the back contact of rotary stepping magnet 332, lower winding of relay 335, brush 327 and ninth-level commutator segment, to ground at the inner right front contact of relay 306. Relay 335, operated by the energization of its lower winding, opens the operating circuit of the vertical-stepping magnet 331, and closes a circuit from battery through the winding of magnet 331, upper winding and upper front contact of relay 335 to ground at the upper front contact of relay 330. The current in this circuit is sufficient to hold relay 335 operated but is insufficient to hold the magnet 331 operated. With relay 335 operated, the stepping relay 334 assumes control of the rotary-stepping magnet 332. Since relay 335 is slow in operating, the brushes are properly centered before rotary motion is started by the operation of magnet 332. The operation of magnet 332 steps the brushes 321 to 326, inclusive, of switch F into engagement with the first set of terminals in the ninth level of the bank and moves the commutator brush 327 out of engagement with the commutator segment. Relay 334 releases when magnet 332 operates, and the release of relay 334 causes the release of magnet 332. Upon release of magnet 332 after its initial operation, the circuit for operating relay 334 is again closed through the back contacts of both of magnets 331 and 332. Relay 334 and magnet 332 are thereupon alternately operated and released to step the brushes from one set of terminals to the next until one of the three pairs of brushes encounters the set of terminals to which the connection in question is connected. When, in the case herein described, the brushes 325 and 326 engage the terminals to which connector C1 is connected, a circuit is closed for operating relay 338; this circuit is traced from battery through the winding of relay 338, middle upper back contact of relay 337, inner upper contact of relay 336, brush 326, over conductor 157 to ground at either relay 114 or relay 115 of connector C1. Were the connector in question connected to terminals with which brushes 321 and 322 engage, relay 336 would be operated instead of relay 338; and if the connector in question were connected to terminals with which brushes 323 and 324 engage, relay 337 would be operated instead of relay 338. The operation of any one of relays 336, 337 or 338 prevents further operation of stepping relay 334 and closes a circuit for operating relay 339; this circuit is traced from ground at the upper front contact of relay 330, uppermost back contact of relay 341, and upper front contact of relay 336 if relay 336 is operated, or through the uppermost back contact of relay 336 and the upper front contact of relay 337, if relay 337 is operated, or through the uppermost back contacts of relays 336 and 337 and the upper front contacts of relay 338 if relay 338 is operated. At its upper front contact, relay 339 connects interrupter 340 to the winding of the rotary-stepping magnet 350

of the timing switch TS, and at its lower front contact relay 339 connects its winding in series with the winding of relay 341 to ground at the lower front contact of relay 330. As long as the operating circuit for relay 339 remains closed, the winding of relay 341 is short-circuited and this relay cannot operate. Each closure of ground through interrupter 340 operates magnet 350 and advances the brush of switch TS one step. The number of steps taken before brush 351 encounters a grounded terminal and the frequency with which the interrupter closes its ground connection may be varied to measure any desired interval of time. Since the same supervisory condition exists in the connector on calls routed to an intercepting operator as when only one of the calling and called stations releases as above described, the common timing equipment is called in on intercepting calls and the switch TS should measure off a period longer than that required for the disposal of a call by an intercepting operator. Under such circumstances an interrupter which closes once every eighteen seconds will give an ample delay of three minutes before brush 351 engages terminal 10 at which time a circuit is closed from ground through brush 351, winding of relay 343, inner lower back contact of relay 341, lower front contact of relay 338, brush 325, conductor 158, thence through contacts 148 and the winding of release magnet 147 of the recording switch. Relay 343 and release magnet 147 operate, the recording switch being thereby restored to normal. The opening of off-normal contact 121 causes the release of relays 122, 123 and 136. When relay 122 releases, the ground on conductor 158 is connected to the winding of release magnet 134, but the resistance of the winding of relay 343 of the timing equipment is high enough to permit only the partial operation of magnet 134. Magnet 134 closes at its inner right front contact, a circuit through off-normal contact 133 for completing its energization and thereby causing the brushes and shaft of switch C1 to be restored to normal. With both the recording and connector switches restored to normal, the circuit over conductor 158 is opened and relay 343 releases.

If the timing equipment was called in because the called station was holding the connection, the forced release of relays 136 and 123 causes the release of relay 115 thereby disconnecting holding ground potential from terminal 113 and the preceding selectors are also returned to normal. In this case the called line 110 is connected to a first selector as for an originating call and a first-selector permanent-signal alarm will be operated after the lapse of a predetermined interval in usual manner. If, however, the timing equipment was called in because the calling station was holding the connection, relays 114 and 117 remain operated, after the called line has been freed by returning the switch C1 to normal, and ground is connected from the lowermost front contact of relay 117, through the upper back contact of relay 120, inner lower front contact of relay 117, inner lower back contacts of relays 122 and 120, to an alarm circuit; whereby, after an interval of from 22 to 44 minutes, a permanent-signal alarm is operated in the same manner as in the case of a first-selector permanent-signal condition. In either case the ground potential is disconnected from conductor 157 thereby causing the successive release of group relays 305 and 306 and the release of the operated one of relays 336, 337 and 338. The release of relay 306 disconnects ground from conductor 320 thereby opening the circuit through the winding of relay 330. Relay 330 releases unless some other group timing unit relay, such as relay 304, were operated, in which case relay 330 would be held operated. In any case, with all of relays 336, 337 and 338 released, the short circuit for the winding of relay 341 is opened; and relay 330, if not held operated, is slow in releasing, so that relay 341 is operated and relay 339 held operated to ground at the lower contact of relay 330. The operation of relay 341 causes the release of relay 330, if not already released, and the release of relay 330 causes the release of relay 335. The release of relay 330 closes a circuit through the normally open contact of the off-normal springs of switch TS, for operating the release magnet 352 of this switch, thereby restoring brush 351 to normal. The release of relay 335 and return of switch TS to normal, closes a circuit through its lowermost back contact and the lower contact of the vertical off-normal springs of switch F, the normally closed contact of the off-normal springs of switch TS, to ground at the back contact of relay 330; and the resulting operation of magnet 333 returns the shaft and brushes of switch F to normal. When the vertical off-normal springs are restored to normal, start relay 330 can be reoperated to start search for the terminals of some other connector which has been released by one but not both of two interconnected subscribers.

If a connector switch causes the operation of a set of group relays G1, G9 and the group relays are not released, due to failure of the finder switch or for any other reason, the group alarm relays 307 and 308 measure an interval of from 22 to 44 minutes and then close an alarm circuit. To this end the operation of any one of group relays 304, 306, et cetera connects ground to one side of the winding of relay 307; and, as soon thereafter as interrupter contacts 313 are closed, relay 307 operates and locks independent of the interrupter. If after a further lapse of 22 minutes, relay 307 has not yet released, the closing of interrupter contacts 314 causes the operation of relay 308. Relay 308 locks under control of relay 307 and closes an alarm circuit to light lamp 309 or operate any other alarm as desired.

If the finder switch F and timing switch TS are operated to free a called line as above described and, due to some trouble, switches TS and F are not restored to normal, ground through the front contact of relay 343 causes the operation of an alarm after the lapse of a predetermined interval such as 18 to 48 seconds; so that the trouble may be traced and the timing equipment released for use with other connectors.

Assume next that the subscriber's station A and line 100 have been extended by the operation of the line-finder LF and first selector S1 through terminals 161, 162 and 163 to the rotary connector C2. The line relay 201 of connector C2 is operated by the current in the circuit from battery through the lower winding of relay 201, inner lower back contact of relay 204, through terminal 162, middle brushes of switches S1 and LF, over the calling line 100 and through the telephone at station A, back through the upper brushes of switches LF and S1, terminal 161, inner upper back contact of relay 204 and through the upper winding of relay 201 to ground. Relay 201 closes the circuit for operating relay 202; and relay 202 connects ground through its lowermost

front contact, over sleeve conductor 220 to terminal 163 to hold the preceding switches in usual manner. When the subscriber at station A dials the next to the last digit of the number of a called station D, relay 201 is released by each interruption of the above traced circuit at the dial contacts. Relay 202 is slow in releasing and remains operated during the response of relay 201 to dial impulses. The first release of relay 201 closes a circuit from ground at the back contact of relay 201, upper front contact of relay 202, normally closed contact of the vertical off-normal springs 214, winding of relay 203 and through the winding of vertical stepping magnet 211 to battery. Relay 203 and magnet 211 are operated by the current in this circuit, the brushes of switch C2 being stepped up to the first level of the terminal bank by the operation of magnet 211. The vertical off-normal springs 214 are actuated when the shaft and brushes move out of normal position, the circuit for magnet 211 and relay 203 being thereby closed through the lower normally open contact of springs 214 and the front contact of relay 203 instead of through the normally closed contact of springs 214. Each succeeding release and reoperation of relay 201 causes a corresponding operation and release of magnet 211 thereby advancing the brushes to the required level of the bank. Being slow in releasing, relay 203 remains operated until all of the impulses in the train have been received by relay 201. The release of relay 203 at the end of the train prepare the rotary-stepping magnet 212 for response to the next train of impulses received by relay 201, which impulses are created by the dialing of the last digit of the number of the called station. The release of relay 201, in response to each of these impulses, closes a circuit for operating relay 205 and rotary-stepping magnet 212; this circuit is traced from ground at the back contact of relay 201, upper front contact of relay 202, lower normally open contact of springs 214, back contact of relay 203, upper back contact of relay 208, winding of relay 205, lower back contact of relay 210, and through the winding of magnet 212 to battery. The first operation of magnet 212 rotates the brushes into engagement with the first set of terminals in the selected level and each succeeding operation of this magnet advances the brushes one step, thereby selecting the set of terminals corresponding to the last digit of the called number. Being slow in releasing, relay 205 remains operated while the brushes are being advanced, the test brush 217 being connected through the lower front contact of relay 205 and inner upper back contact of relay 210 to the winding of busy test relay 208. The potential of the terminal with which brush 217 is in engagement indicates whether the line connected thereto is idle or busy; and, if busy, whether it is one of a group of trunks to a private branch exchange. If the line is idle, brush 217 encounters a battery potential; relay 208 does not operate; and, as soon as relay 205 releases, a circuit is closed for operating relay 210. The circuit for operating relay 210 is traced from the battery potential encountered by brush 217, through the inner lower back contact of relay 205, upper winding of relay 210, lower back contact of relay 208, to ground at the lowermost front contact of relay 202. Relay 210 is sufficiently energized by its upper winding to close a circuit through its lower winding and inner lower front contact, thence through the outer back contact of release magnet 213, to ground at the inner lower front contact of relay 202. Relay 210, completely operated by the energization of its lower winding, closes the ringing circuit from source 235, through the uppermost front contact of relay 210, upper winding and lower back contact of relay 206, middle lower front contact of relay 210, brush 216, over the called subscriber's line and through the ringer (not shown) at station D, back through brush 215, inner upper front contact of relay 210, and through the uppermost back contact of relay 206 to ground.

If the selected line is busy, the busy ground potential encountered by brush 217 causes the operation of test relay 208. Relay 208 is held operated, after relay 205 releases, through the inner upper back contact of relay 210, inner upper front contact of relay 208, upper back contact of relay 209, and the test brush 217. If the line to which the brushes connect is an individual line or the last trunk of a private branch exchange group, the terminal with which brush 217 engages is not strapped to the terminal which brush 218 engages; and the release of relay 205 closes a circuit from battery through the winding of relay 207, back contact of rotary-stepping magnet 212, back contact of relay 207, lowermost front contact of relay 208, lowermost back contact of relay 205, winding and upper back contact of relay 209, and through brush 217 to the busy potential. Relay 207, being marginal, does not operate, but relay 209 operates and closes a locking circuit through its inner upper front contact to ground at relay 202. With relay 209 operated, the locking circuit of relay 208 is traced through the inner upper front contact of relay 209 to ground at relay 202, instead of through the upper back contact of relay 209 to the test brush 217. At its uppermost front contact, relay 209 connects the busy tone source 231 over conductor 230, to the lower winding of relay 204, a busy tone being transmitted through condenser 242 to the calling station. The connection of ground through the lower winding of relay 204 to the busy tone conductor 231 also operates relay 232 to start the measurement of an interval of from 22 to 44 minutes; so that, if the connector C2 is not released by the calling subscriber within the measured interval, an alarm is operated.

If the selected line is one of a group of trunks to a private branch exchange and not the last one of the group, the terminals with which brushes 217 and 218 are in engagement are strapped together and the winding of relay 209 is short-circuited by a connection which includes its lower back contact, the inner lower front contact of relay 208, the inner back contact of release magnet 213, and brush 218. In this case relay 209 does not operate; but the marginal relay 207 operates and closes a locking circuit through its inner upper front contact to ground at relay 202. Relay 207 closes, at its outer upper front contact, a circuit for reoperating the rotary stepping magnet 212, thereby advancing the brushes to the next trunk in the group. The operation of magnet 212 releases relay 207. If the next trunk is idle, relay 208 releases and relay 210 operates as hereinbefore described; but if this trunk is busy and is not the last of the group relay 208 remains operated and relay 207 reoperates to cause the reoperation of magnet 212. When the brushes reach the last trunk in the group, relay 207 cannot again reoperate; if this trunk is busy, relay 208

remains operated and relay 209 operates to transmit a busy tone; or if this trunk is idle, relay 208 releases and relay 210 operates to close the ringing circuit as hereinbefore described.

When the called line is found idle and the ringing circuit closed, the energization of the upper winding of relay 206 is increased when the call is answered at the called station. Relay 206 thereupon closes at its inner lower front contact, a circuit for energizing its lower winding and thereby causing its complete operation. This circuit includes the outer back contact of release magnet 213 and the inner lower front contact of relay 202. At its outer front contacts, relay 206 connects the windings of supervisory relay 204 to the brushes 215 and 216, the talking current being transmitted through condensers 241 and 242. Relay 204 operates, to interchange the connections between terminals 161 and 162 and the windings of relay 201, and remains operated as long as the called line loop is closed at station D.

When the instrument at station A is restored to normal relay 201 releases and when the instrument at station D is restored to normal relay 204 releases. The release of relay 201 causes the release of relay 202; and the release of relay 204 restores the normal connections between terminals 161 and 162 and the windings of relay 201. With both of relays 201 and 204 released, relays 206 and 210 release closing a circuit from battery through the winding of release magnet 213, uppermost back contact of relay 210, upper contact of off-normal springs 214, uppermost back contact of relay 204, and back contacts of relays 202 and 201 to ground. Release magnet 213 operates thereby restoring the switch to normal in usual manner.

When either one of relays 201 and 204 are released and the other is held operated, conductor 257 is connected to ground to start the operation of the group timing relays 305 and 306. If relay 204 is held operated, this connection is traced through the upper outer front contact of relay 204 and the upper back contacts of relays 201 and 202; if relay 201 is held operated, this connection is traced through the inner upper front contact of relay 206, to ground at the lowermost back contact of relay 204. This supervisory ground is connected through conductor 257 and through individual resistor 302 to the winding of relay 305. If the operated one of relays 201 and 204 does not release before relay 306 operates, the finder F is started. When the brushes of switch F find the terminals of connector C2, relay 337 operates; and, when the timing switch TS has measured an interval of three minutes, ground is connected through brush 351, winding of relay 343, inner lower back contact of relay 341, lower front contact of relay 337, and brush 323, over conductor 258 to cause the partial operation of release magnet 213 of connector C2. The partial operation of magnet 213 actuates its contacts to cause the release of relays 206 and 210 without causing release of the shaft and brushes. Relay 204 then releases if not already released; in which case, relays 201 and 202 having been released, the circuit for causing complete operation of the release magnet is closed as hereinbefore described and the connector switch is restored to normal. If, however, the timing equipment was called in because the connection was being held by the calling subscriber, a circuit for operating relay 208 is closed through the front contact of release magnet 213, and relay 208 closes the circuit for operating relay 209. Relay 209 closes the busy tone circuit and causes the operation of relay 232; so that, if relay 201 is not released within the measured interval, an alarm will be operated in usual manner.

What is claimed is:

1. In a telephone system, subscribers' lines, connector switches for interconnecting calling and called lines, timing means for measuring a predetermined interval of time, a finder switch, and means for operating said finder switch to connect said timing means to any one of said connectors upon release of the connection by either one but not the other of two interconnected subscribers.

2. In a telephone system, subscribers' lines, connector switches, each interconnecting a calling line and a called line, a finder switch, an individual set of terminals in the bank of said finder switch for each of said connectors, means effective if one of two interconnected subscribers fails to replace the receiver within a predetermined interval of time after the other subscriber replaces the receiver for causing said finder switch to connect with the terminals of the connector switch through which the lines of said two subscribers are connected, and electromagnetic means effective if said one of the two subscribers fails to replace the receiver during a further predetermined interval of time for freeing the called line.

3. In a telephone system, a calling line, a called line, a numerical connector switch interconnecting said lines, and circuit means effective a predetermined interval of time after the release of the connection by either one but not both of the interconnected subscribers for freeing said called line from said connection.

4. In a telephone system, a calling line, a called line, a connector switch interconnecting said lines, a first supervisory relay, said relay controlled by the calling subscriber, a second supervisory relay, said second relay controlled by the called subscriber, a third relay, said third relay having contacts for connecting said last-mentioned supervisory relay to and through the brushes of the connector switch to the called line, a release magnet for said switch, means controlled by said supervisory relays and including a contact of said release magnet for holding said third relay operated, and circuit means effective a predetermined interval of time after the release of either one but not the other of said supervisory relays for partially energizing said release magnet to open said contact and release said third relay.

5. In a telephone system, lines, connector switches for completing connections between calling and called lines, each of said connectors comprising a first supervisory relay, a second supervisory relay, a third relay and a release magnet, said first supervisory relay controlled by the calling subscriber, said second supervisory relay controlled by the called subscriber, said third relay having contacts for connecting the windings of said second relay to and through the brushes of the connector to the called line, circuit means controlled by said supervisory relays and including a contact of said release magnet for holding said third relay operated, control means for use in partially energizing the release magnet of any one of said connectors to cause release of the third relay, switching means for connecting said control means to any one of said connectors, timing means for operating said switch-

ing means in the event that both of the supervisory relays of one of the connectors have not released within a predetermined interval after one of these supervisory relays releases, and timing means for rendering said control means effective to partially energize the release magnet of a connector a predetermined interval of time after the connection of the control means to said connector.

6. In a telephone system, subscribers' lines, connector switches for use in completing connections between calling and called lines, each of said connectors comprising a supervisory relay controlled by the calling line and a supervisory relay controlled by the called line and a release magnet, a finder switch, a set of terminals for each connector in the bank of said finder switch, said terminals being divided into groups, a group relay for each group of terminals and the corresponding group of connectors, individual resistors for connecting each of said connectors to the winding of the associated group relay, means in each of said connectors for operating the associated group relay in response to the release of one but not both of said supervisory relays, start relays, one for each of said group relays, for initiating the operation of said finder switch, means for operating any one of said start relays a predetermined interval of time after the operation of the associated group relay, means for stopping the operation of the finder switch when its brushes engage the terminals of a connector awaiting release of the second of its two supervisory relays, and circuit means effective a predetermined interval of time after the brushes encounter the terminals of such a connector for partially energizing the release magnet of said connector to free the called line.

7. In a telephone system according to claim 6, a signal, and means comprising a relay common to said group relays for operating said signal in response to the continued operation of a group relay for a predetermined interval of time.

8. In a telephone system according to claim 6, means operatively responsive to the partial energization of the release magnet of a connector by said control means for freeing said control means for use with another of said connectors.

9. In a telephone system according to claim 6, means responsive to the partial energization of the release magnet of a connector by said circuit means for restoring said circuit means to normal, and means for operating an alarm if said circuit means is not restored to normal within a predetermined interval after it becomes effective to cause partial energization of the release magnet of a connector.

10. In a telephone system, a calling line, a called line, a numerical connector switch interconnecting said lines and circuit means effective a predetermined interval of time after the release of the connection by either one but not both of the interconnected subscribers for returning said connector switch to normal.

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