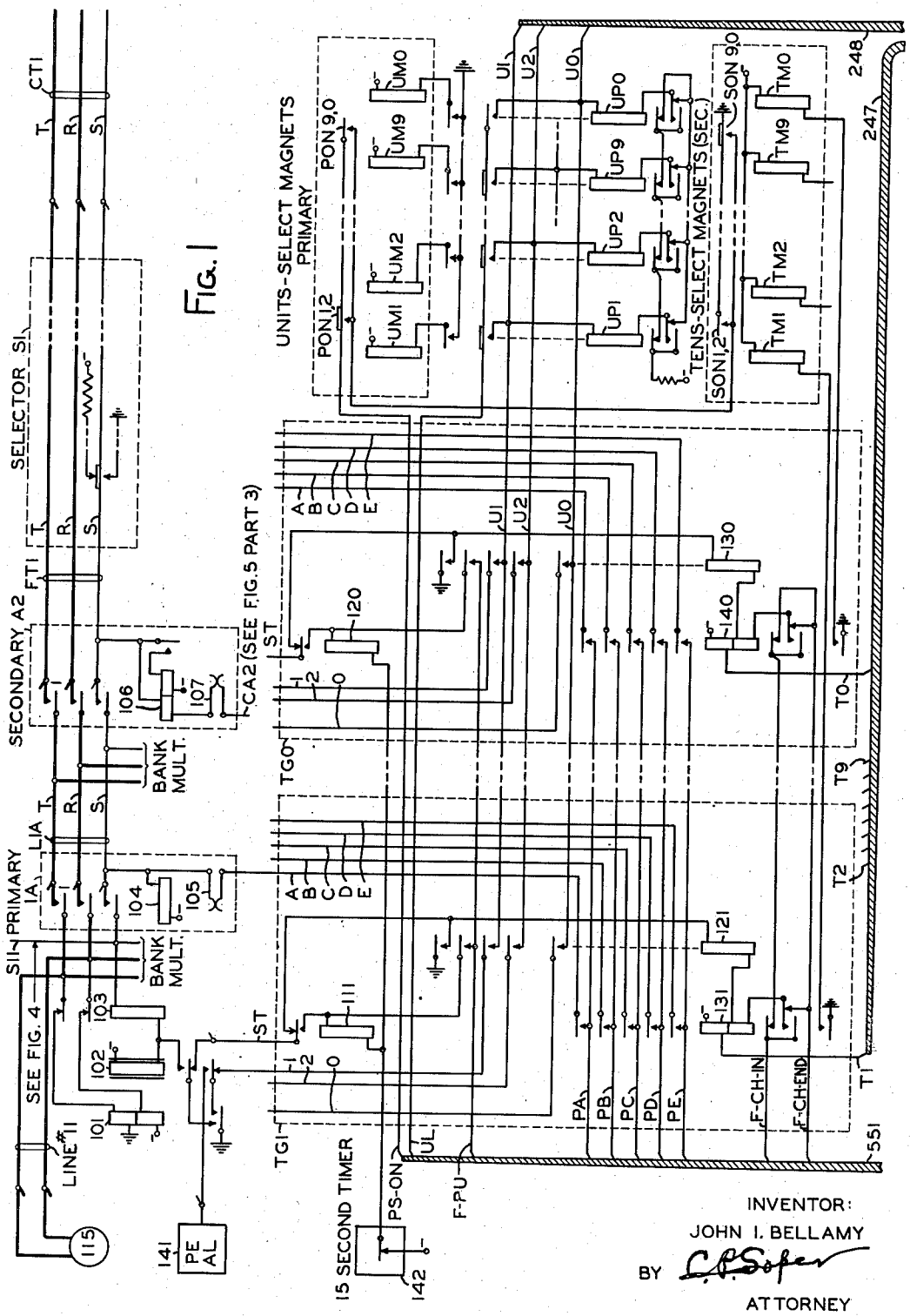
Nov. 13, 1951 J. I. BELLAMY 2,574,903

TRANSLATOR FOR SHIFTED LINES AND PARTIES

Filed April 8, 1948 12 Sheets-Sheet 1

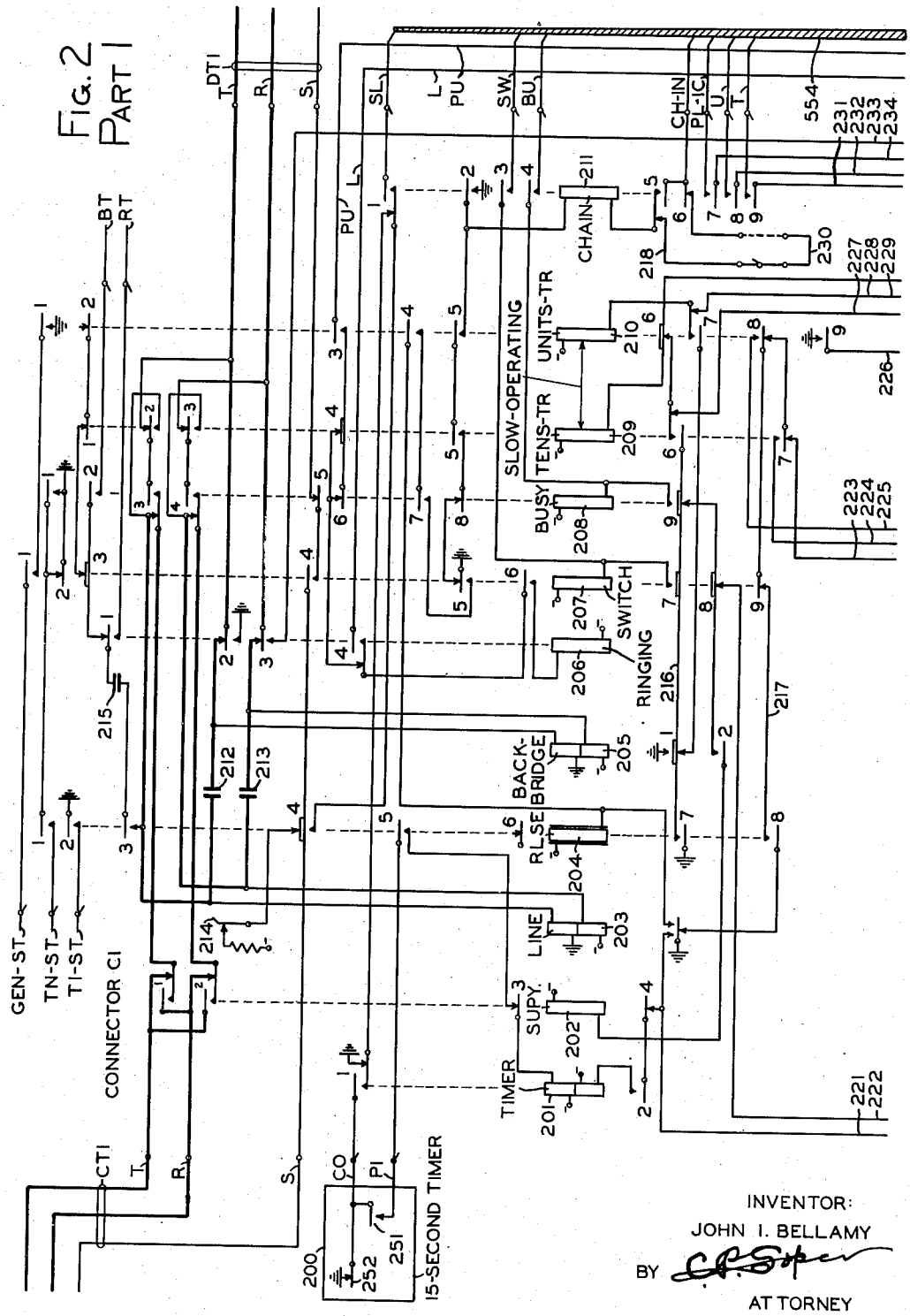


INVENTOR:
JOHN I. BELLAMY
BY C. P. Sofer
ATTORNEY

Nov. 13, 1951 J. I. BELLAMY 2,574,903

TRANSLATOR FOR SHIFTED LINES AND PARTIES

Filed April 8, 1948 12 Sheets-Sheet 2



INVENTOR:
JOHN I. BELLAMY
BY C. P. Spencer
ATTORNEY

Nov. 13, 1951 J. I. BELLAMY 2,574,903

TRANSLATOR FOR SHIFTED LINES AND PARTIES

Filed April 8, 1948 12 Sheets-Sheet 3

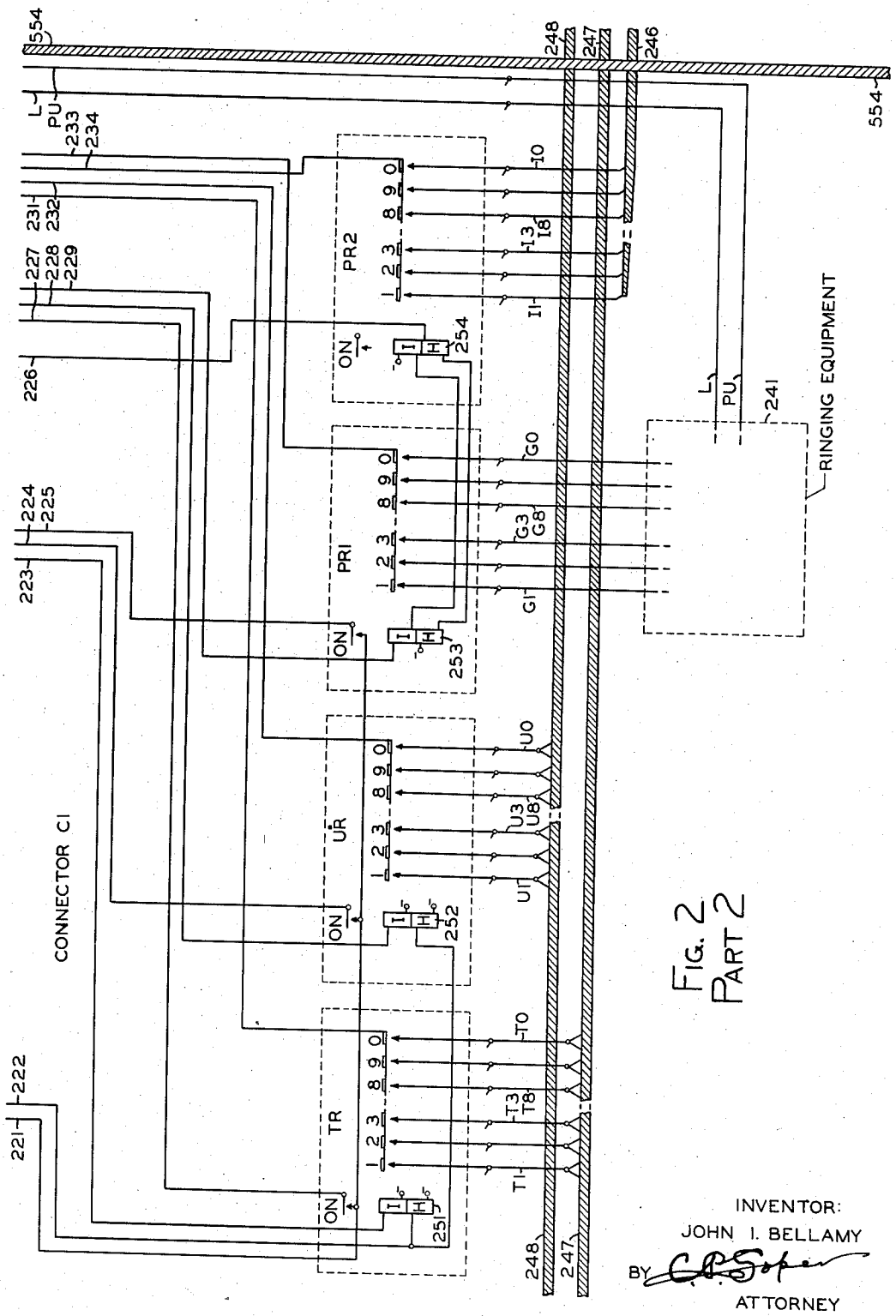


FIG. 2
PART 2

INVENTOR:
JOHN I. BELLAMY
BY C. P. Sopher
ATTORNEY

Nov. 13, 1951 J. I. BELLAMY 2,574,903

TRANSLATOR FOR SHIFTED LINES AND PARTIES

Filed April 8, 1948 12 Sheets-Sheet 4

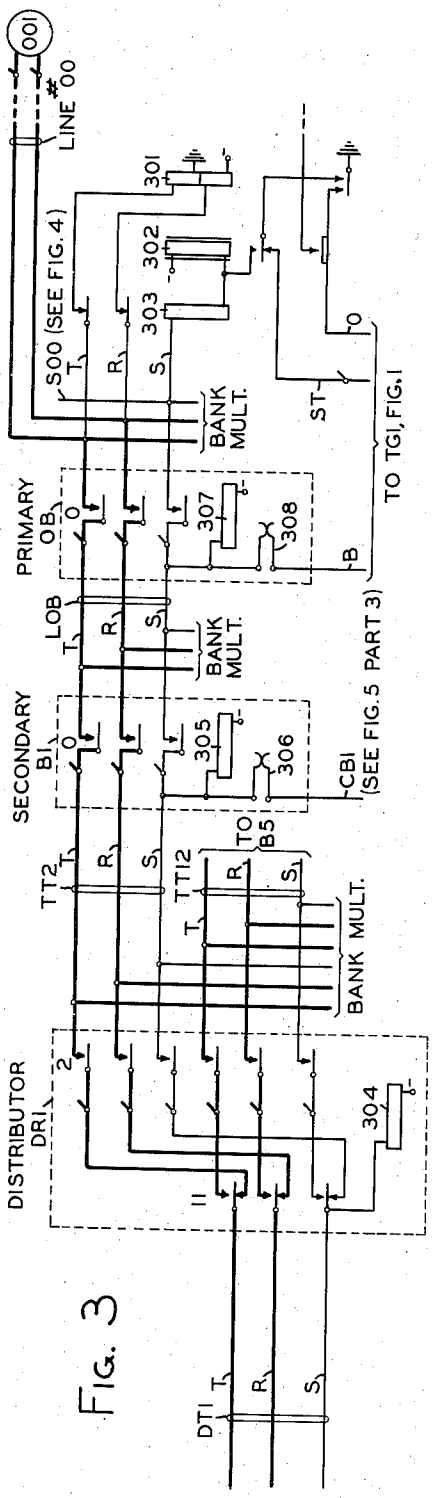


FIG. 3

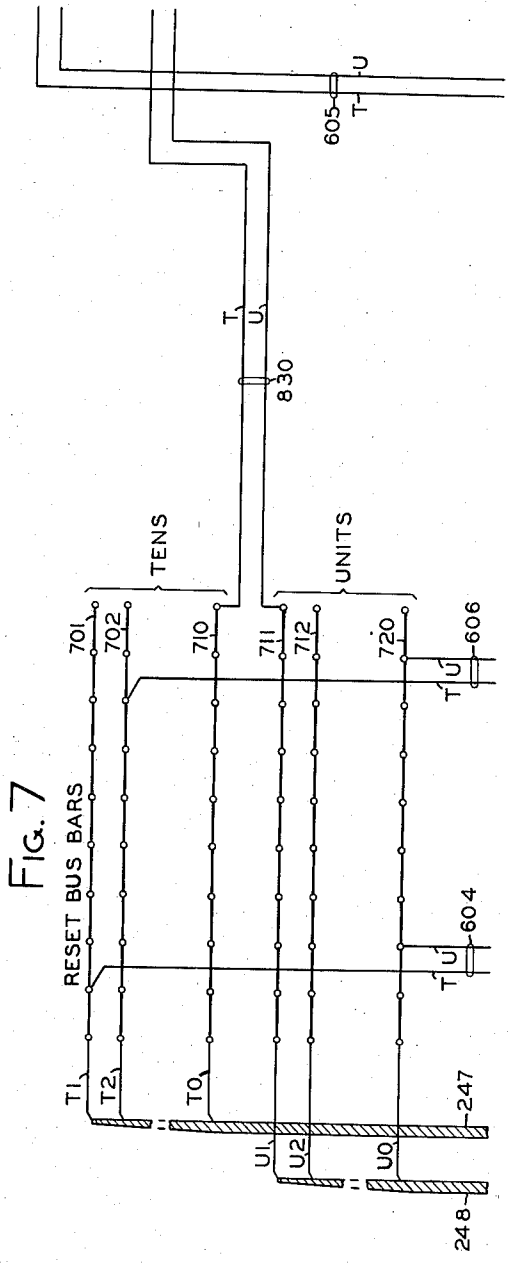


FIG. 7

INVENTOR:
JOHN I. BELLAMY
BY C. R. Soper
ATTORNEY

Nov. 13, 1951 J. I. BELLAMY 2,574,903

TRANSLATOR FOR SHIFTED LINES AND PARTIES

Filed April 8, 1948 12 Sheets-Sheet 5

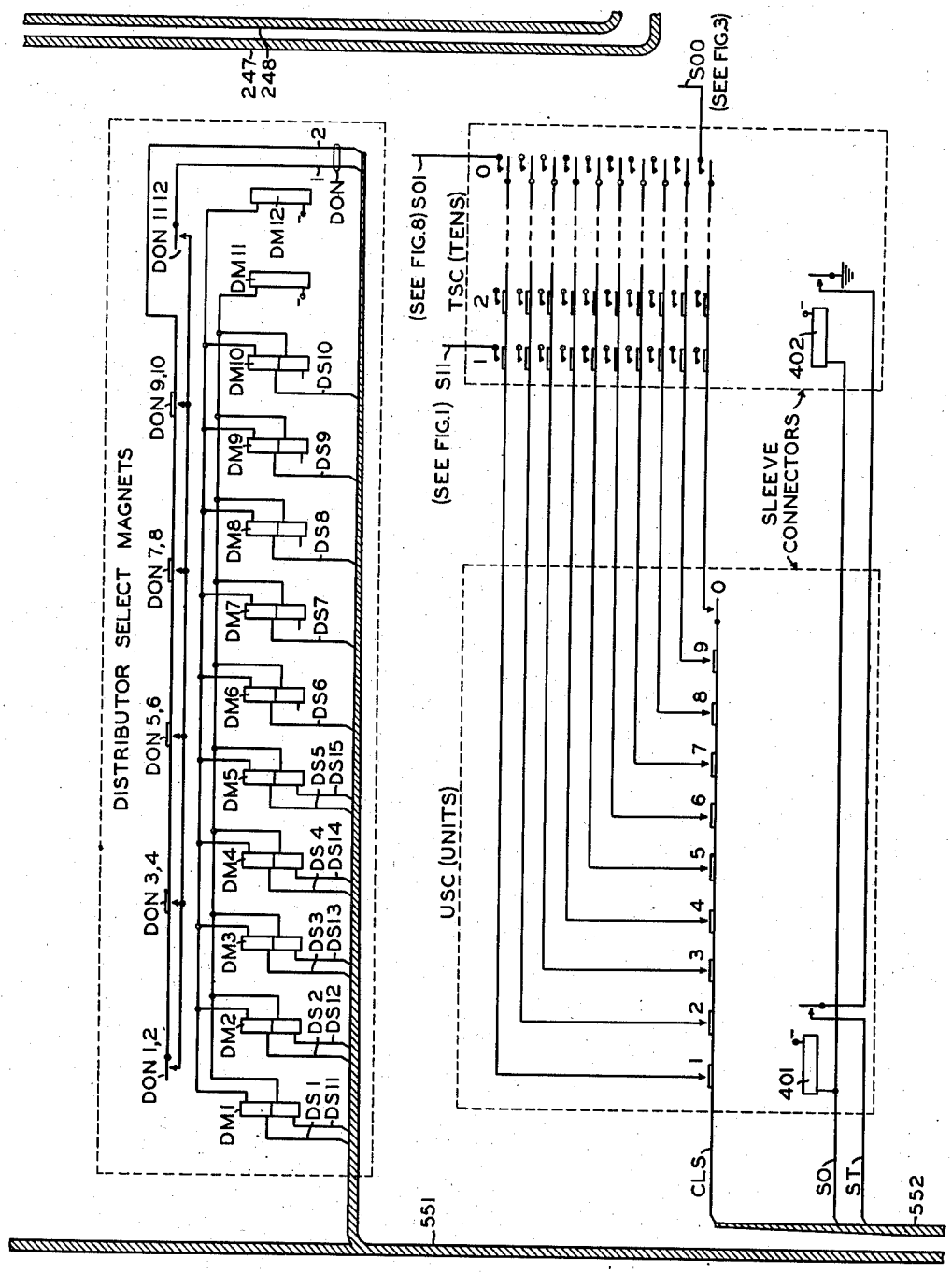


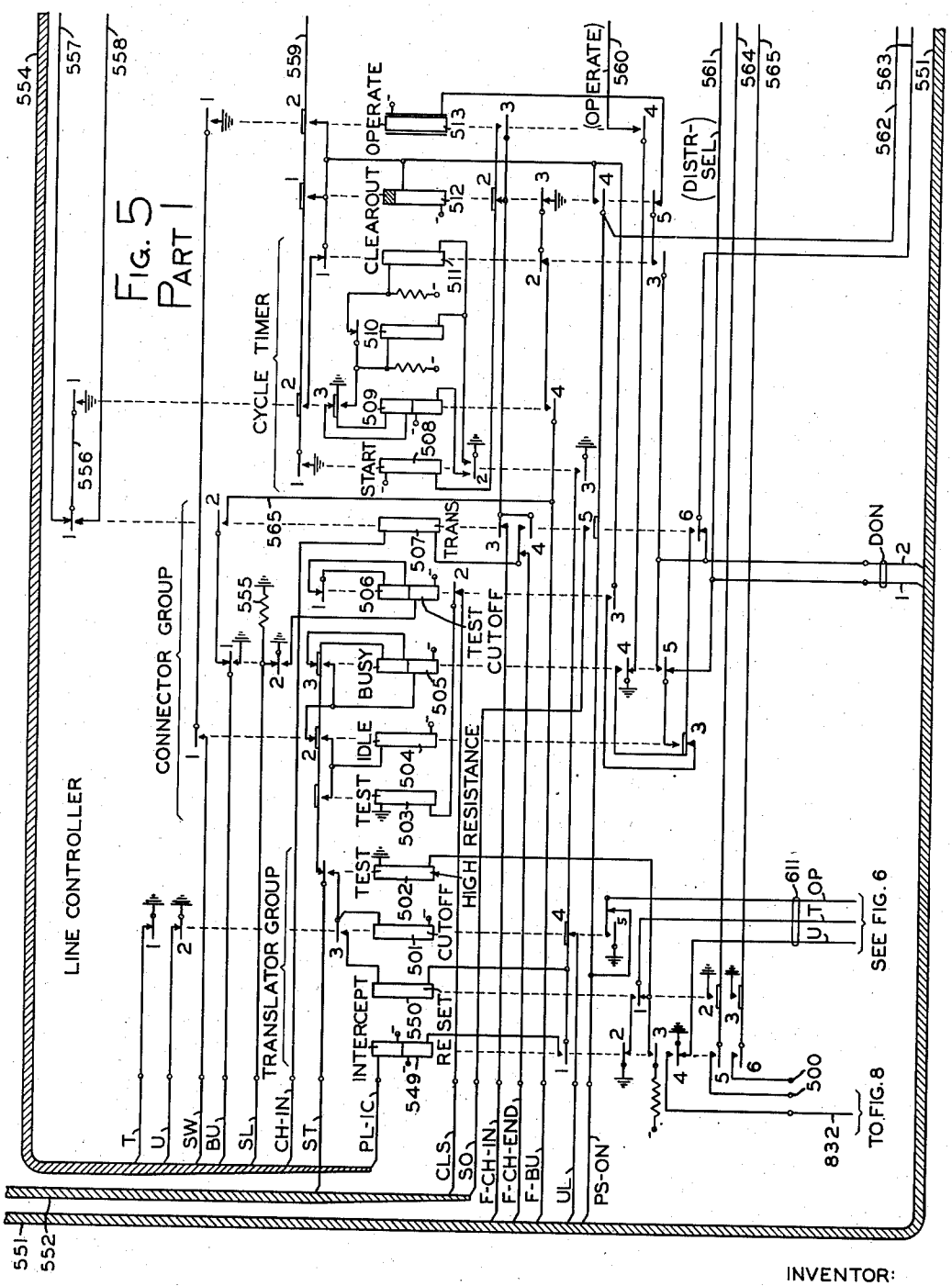
FIG. 4

INVENTOR:
JOHN I. BELLAMY
BY
ATTORNEY

Nov. 13, 1951 J. I. BELLAMY 2,574,903

TRANSLATOR FOR SHIFTED LINES AND PARTIES

Filed April 8, 1948 12 Sheets-Sheet 6



INVENTOR:
JOHN I. BELLAMY
BY C. R. Soper
ATTORNEY

Nov. 13, 1951 J. I. BELLAMY 2,574,903

TRANSLATOR FOR SHIFTED LINES AND PARTIES

Filed April 8, 1948 12 Sheets-Sheet 7

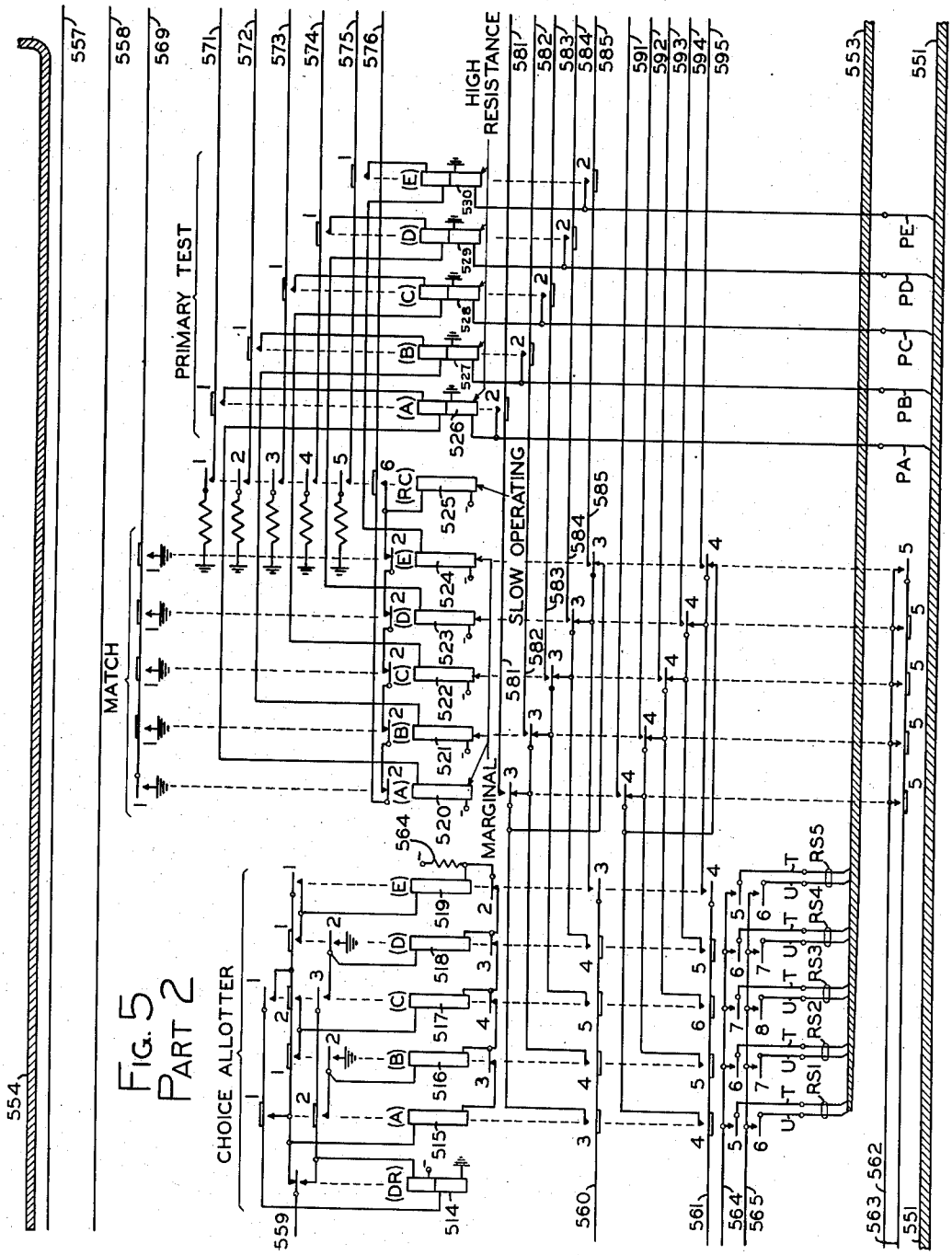


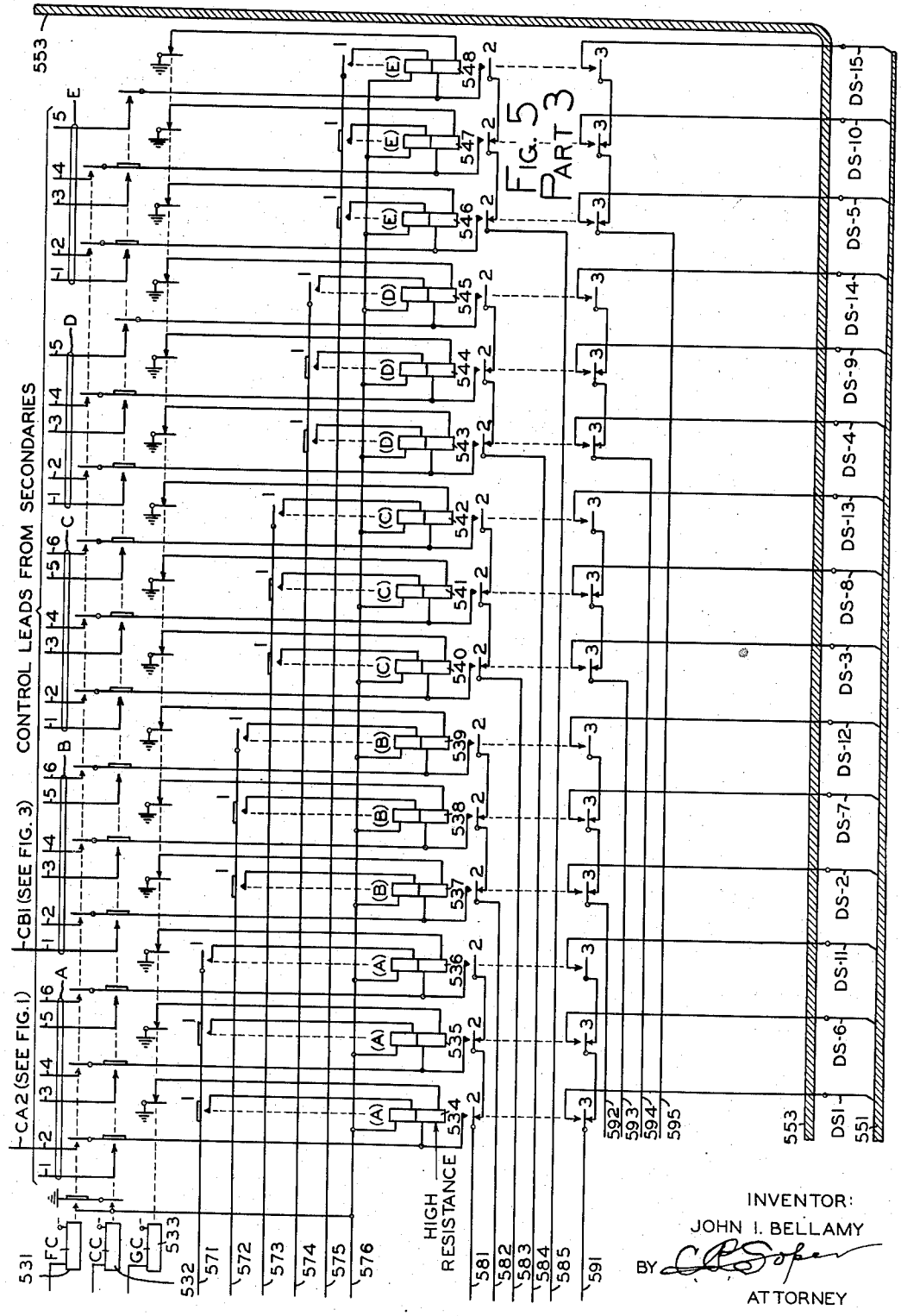
FIG. 5 PART 2

INVENTOR:
JOHN I. BELLAMY
BY C. P. Saper
ATTORNEY

Nov. 13, 1951 J. I. BELLAMY 2,574,903

TRANSLATOR FOR SHIFTED LINES AND PARTIES

Filed April 8, 1948 12 Sheets-Sheet 8



INVENTOR:
JOHN I. BELLAMY
BY
ATTORNEY

Nov. 13, 1951 J. I. BELLAMY 2,574,903

TRANSLATOR FOR SHIFTED LINES AND PARTIES

Filed April 8, 1948 12 Sheets-Sheet 9

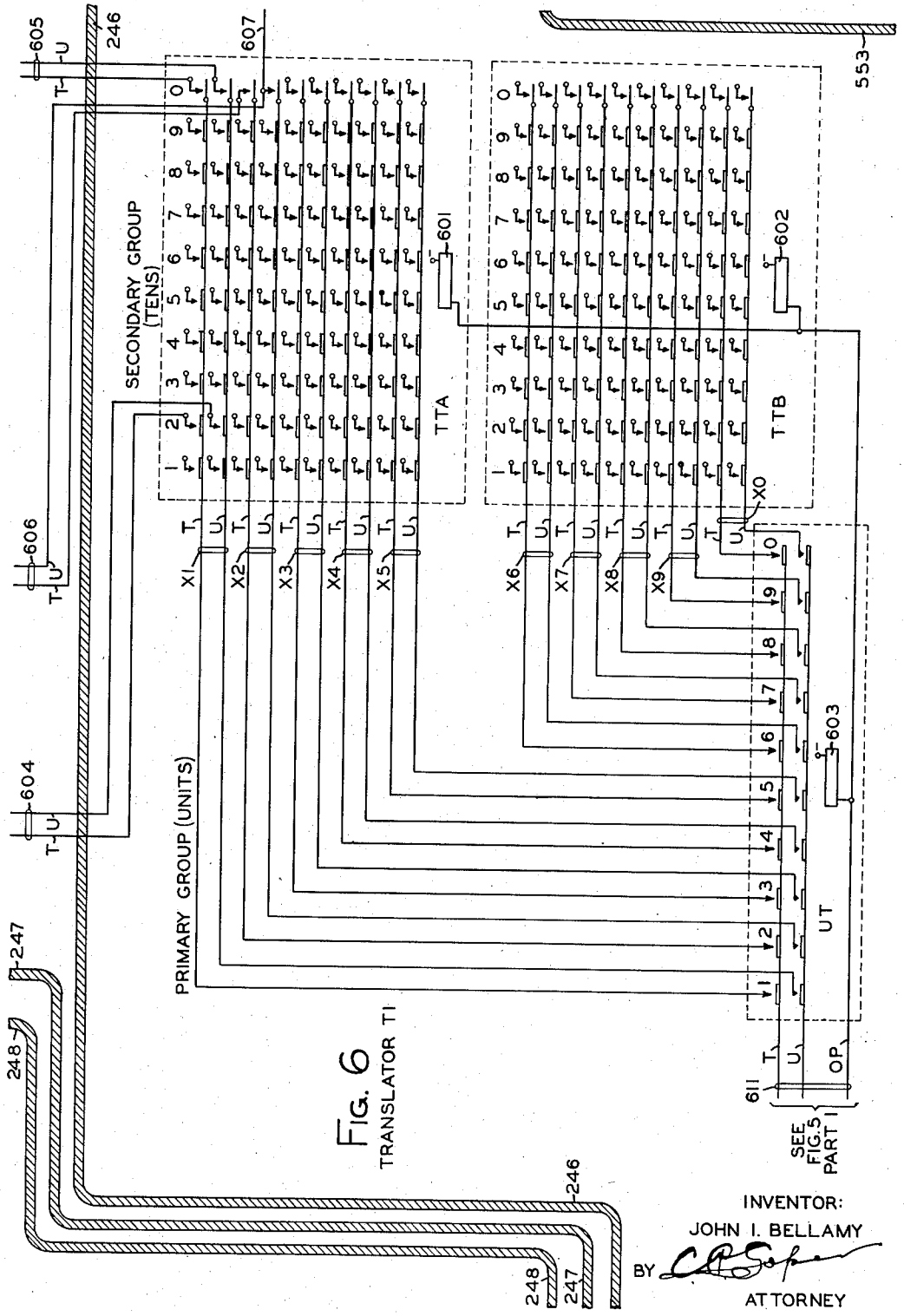


FIG. 6
TRANSLATOR TI

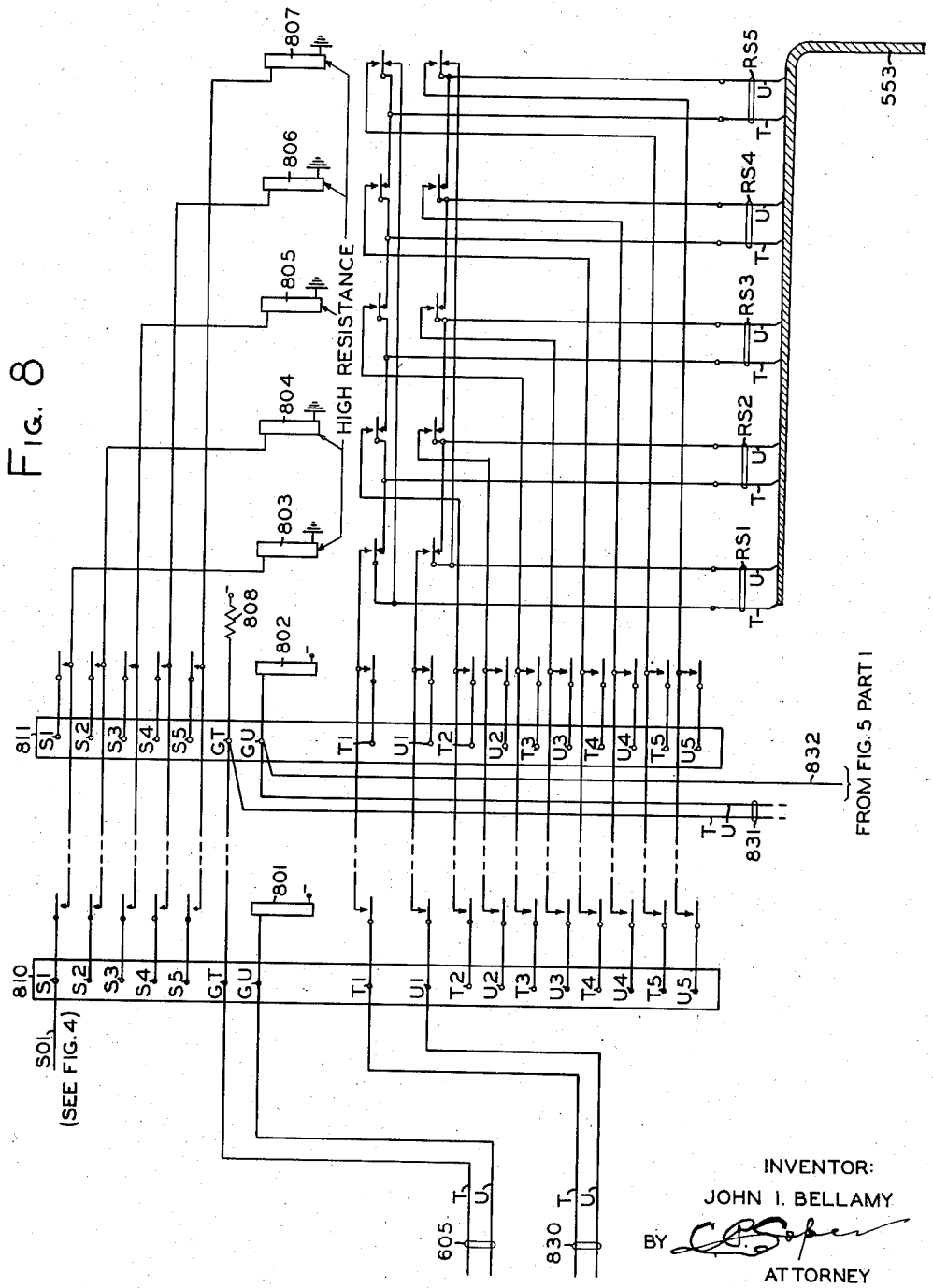
INVENTOR:
JOHN I. BELLAMY
BY
ATTORNEY

Nov. 13, 1951 J. I. BELLAMY 2,574,903

TRANSLATOR FOR SHIFTED LINES AND PARTIES

Filed April 8, 1948 12 Sheets-Sheet 10

FIG. 8



INVENTOR:
JOHN I. BELLAMY
BY
ATTORNEY

Nov. 13, 1951 J. I. BELLAMY 2,574,903

TRANSLATOR FOR SHIFTED LINES AND PARTIES

Filed April 8, 1948 12 Sheets-Sheet 11

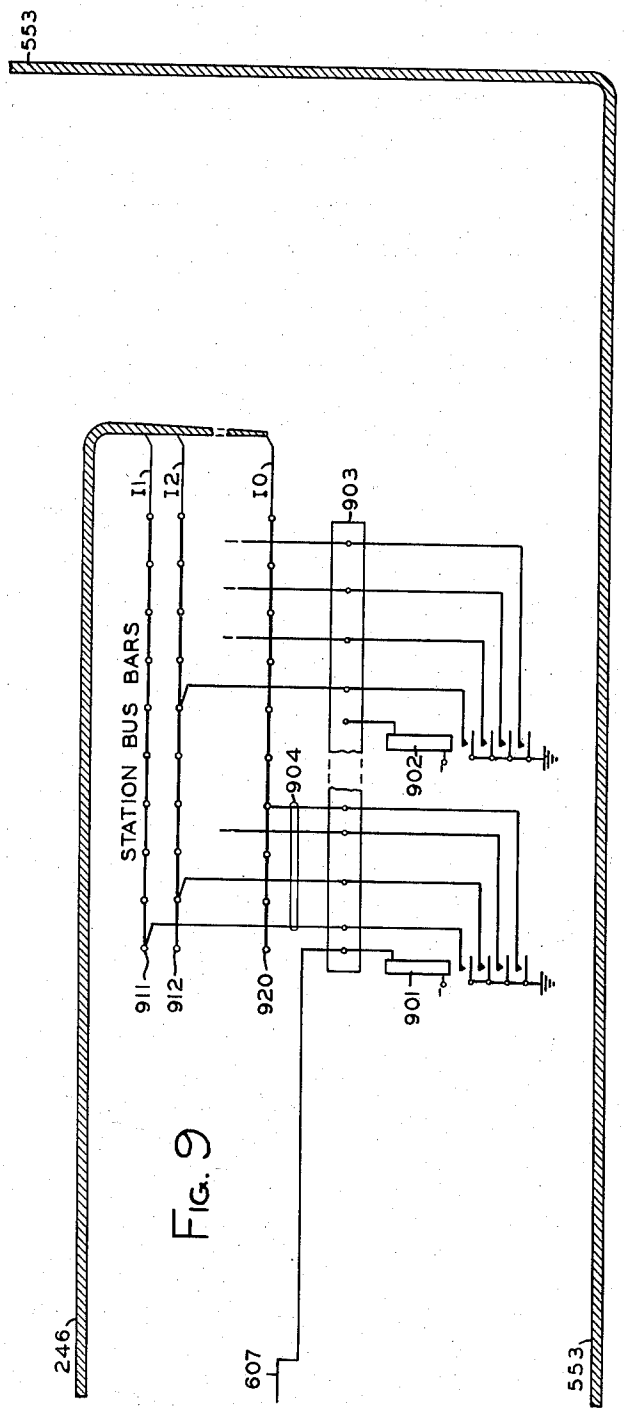


FIG. 9

FIG. 11

FIG. 1	FIG. 2 PART 1	FIG. 3 FIG. 7	FIG. 8
FIG. 4	FIG. 2 PART 2	FIG. 6	FIG. 9
FIG. 5 PART 1	FIG. 5 PART 2	FIG. 5 PART 3	

INVENTOR:
JOHN I. BELLAMY
BY
ATTORNEY

Nov. 13, 1951 J. I. BELLAMY 2,574,903

TRANSLATOR FOR SHIFTED LINES AND PARTIES

Filed April 8, 1948 12 Sheets-Sheet 12

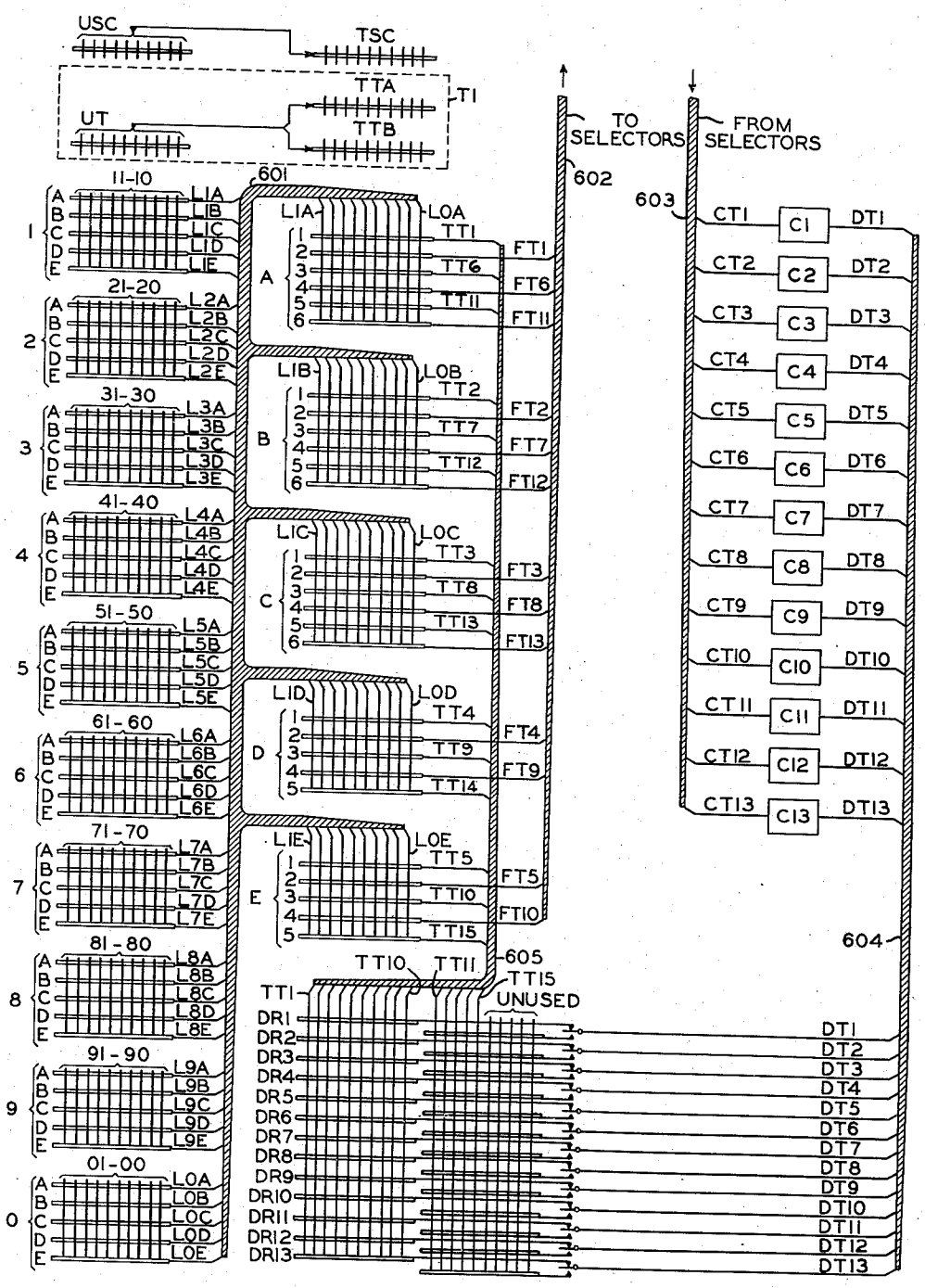


FIG. 10

INVENTOR:
JOHN I. BELLAMY
BY C. P. Soper
ATTORNEY

Patented Nov. 13, 1951

2,574,903

UNITED STATES PATENT OFFICE

2,574,903

TRANSLATOR FOR SHIFTED LINES AND PARTIES

John I. Bellamy, Antioch, Ill., assignor to Kellogg Switchboard and Supply Company, Chicago, Ill., a corporation of Illinois

Application April 8, 1948, Serial No. 19,766

6 Claims. (Cl. 179—18)

1

This invention relates to automatic telephone systems. The general object of the invention is the production of a new and improved line unit providing two-way service for a group of lines through tandem-related switching devices comprising primary and secondary subgroups interconnected by links spread among them.

A specific object is to provide a translator arrangement enabling any substantial traffic unbalance among the several primary subgroups to be corrected by an interchange among the primary subgroups of heavy-traffic and light-traffic lines, without requiring the respective call numbers of the interchanged lines to be changed.

Another specific object is to adapt the translator arrangement to handle intercept service for disconnected individual lines and for disconnected individual stations on party lines, and to control the handling of calls to P. B. X groups.

GENERAL DESCRIPTION

It has been chosen to illustrate the invention as applied to a line unit serving one hundred subscriber lines, including individual lines and ten-party lines, generally as disclosed in my co-pending application for Automatic Telephone Systems, Serial No. 564,293, filed November 20, 1944, now Patent No. 2,485,351, granted October 18, 1949. Such a line unit employs primary, secondary, and distributor groups of switching apparatus of the type disclosed in my co-pending application for Automatic Telephone Switches, Serial No. 524,816, filed March 1, 1944, now Patent No. 2,490,665, granted December 6, 1949.

The drawings

Of the accompanying drawings, Figs. 1 to 9 are circuit diagrams showing sufficient of the circuit arrangement of the improved 100-line unit to enable them to be understood;

Fig. 10 is a trunking diagram; and

Fig. 11 is a layout showing the way in which the sheets on which Figs. 1 to 9 are drawn should be assembled for a ready understanding thereof.

Figure 1

Fig. 1 shows one of the one hundred lines (#11) served by the unit, together with the individual line circuit of such line and switching apparatus which may be employed as line-finding apparatus to extend such line, when calling, to an idle finder trunk (FT1). Such finder trunk extends directly to a selector aparatus S1, which may be operated in the usual manner to select a numerical group of trunks, and an idle trunk therein, such as the connector trunk CT1.

2

The individual line circuit of the illustrated line #11 includes line relay 101, lockout relay 102, and cutoff relay 103.

Primary switch 1A is one of fifty line primary switches (see Fig. 10) comprising a group served by common select magnets and select shafts. It is one of a subgroup of five switches serving the first 10-line subgroup, lines 11 to 10. Primary switch 1A includes a hold magnet 104 and ten selective stackups of contacts, of which stackup 1 (through which the associated line #11 is reached) is one. The nine remaining selective stackups of the switch are omitted for simplicity.

Primary switch 1A is accessible to line-secondary switch A2, and the others in the same secondary subgroup, by way of the two-way line link L1A. Such link is reached through the illustrated stackup 1 of secondary A2, which has nine other selective stackups (not shown), each of which gives access to a line link extending to the corresponding one of the primary subgroups 2 to 0.

Fig. 1 shows also the first and last of ten subgroups of common equipment, TG1 and TG0. Subgroup TG1 serves the first ten-line subgroup (including the illustrated line #11), while subgroup TG0 serves the tenth subgroup of lines, including line #00; Fig. 3.

The equipment in subgroup TG1 includes subgroup lockout relay 111, which is operable as hereinafter explained to lock the associated ten lines temporarily out of finder service under certain conditions; connecting relay 121, operable only during line-finder action, for connecting the ten local units leads 1 to 0 of the first ten-line subgroup to the common units leads U1 to U0; tens-preference relay 131, which is operable both during line-finder action and during connector action to associate the five primary switches serving the associated ten-line subgroup with the line controller of Fig. 5, which controls the operation of the concerned switches during line-finder action and during connector action.

Fig. 1 also shows the units-select magnets, which control the primary select shafts serving the line primary group of switches. Only the first two and the last two (UM1 and UM2, UM9 and UM0) of the ten units-select magnets are illustrated in Fig. 1. These ten magnets are controlled over ten units leads U1 to U0, by ten units-preference relays UP1 to UP0, respectively.

Fig. 1 also shows the first two and the last two of the tens-select magnets TM1 to TM0, which control the select shafts of the secondary group of switches. They are controlled respectively by tens-preference relays 131 to 140.

Figure 2

Fig. 2, parts 1 and 2, shows the connector C1, to which the connector trunk CT1 extends, and from which the distributor trunk DT1 extends to the distributor DR1 of Fig. 3. Connector C1 is one of the thirteen connectors (C1 to C13) of Fig. 10.

Connector C1 includes equipment for supplying transmitter current to the calling line, equipment for recording the tens, units, and party digits in the number of the called line, and equipment for supplying ringing current and transmitter current to the called line.

The portion of connector C1, shown in part 1 of Fig. 2, includes control relays 201 to 211 and the so-called talking condensers 212 and 213, while the portion of the connector C1, shown in part 2 of Fig. 2, inculdes the tens, units, and party registers TR, UR, PR1, and PR2.

Of the control relays of connector C1, relay 201 is termed a timer relay, in that it cooperates with the common timer 200 to release the connector C1 at any time when such connector has been held for a predetermined interval (15 seconds, for example) during which no effective use is made thereof, such as dialing or conversation;

Relay 202 is a supervisory relay whose principal function is to reverse the direction of current flow over the incoming talking conductors when the call is answered;

Relay 203 is the line relay, being directly controlled over the calling line in the manner common to connectors;

Relay 204 is the slow-restoring release relay, controlled by line relay 203 to prepare the connector for operation and to maintain the connection;

Relay 205 is the so-called back-bridge relay, being controlled directly over the called line when the call is answered;

Relay 206 is the so-called ringing relay, which is operated under control of a ringing interrupter (which is part of the ringing equipment 241, Fig. 2, part 2) at the beginning of a ringing cycle to place the connector in ringing condition, and which is restored during the so-called silent interval to permit back-bridge relay 205 to respond when the call is answered;

Relay 207 is the so-called switching relay, being controlled from the line controller of Fig. 5 to effectuate the completion of the connection and to prepare for the ringing of the called line, in the event that the called line has been found to be idle and an idle connection path thereto exists;

Relay 208 is the so-called busy relay, being controlled from the line controller of Fig. 5 to place the connector in busy condition and return a busy-tone signal to the calling line if the called line is busy or if, for any reason, a connection thereto must be denied;

Relay 209 is the so-called tens-transfer relay, being arranged to operate following the transmission and termination of the impulses, constituting the tens digit to prepare for the reception of the units digit;

Relay 210 is the so-called units-transfer relay, in that it is arranged to operate upon the termination of the units digit to transfer the circuits into condition for the reception of the party digit;

Relay 211 is a so-called chain relay, being included in the preference chain passing through contacts of similar relays of the other connectors. It is arranged to operate at the termination of the party digit to temporarily individualize the connector C1 with the line controller of Fig. 5.

Digit registers TR, UR, and PR1 and PR2 (part 2, Fig. 2) are controlled over impulse conductors 223, 224, 225 to record the tens, units, and party digits in the called number. Each of these registers is preferably an electromagnetic counting device of the type disclosed in my co-pending application for Electromagnetic Counting Devices, Serial No. 493,312, filed July 2, 1943, being illustrated as of the type shown in Figs. 21 to 25 thereof, wherein a single control magnet is provided with a hold winding (H), and with an impulse winding (I) effective to cause the counting contacts to close successively in a wave-like operation responsive to the successive impulses of a series. Obviously, the true party registers PR1 and PR2 may be replaced by a single register of the above type having two independent sets of contacts.

Figure 3

Fig. 3 shows switching apparatus which may be employed to extend a connection, by connector action, from connector C1 of Fig. 2 over a certain one of several paths to one of the one hundred lines (such as #00) as a called line.

The distributor DR1 of Fig. 3 is one of the thirteen distributors of Fig. 10 (DR1 to DR13). Each such distributor is a three-wire, twenty-point switch of the type disclosed in my previously noted application for Automatic Telephone Switches. Each such switch has eleven selectively operable stackups of contacts, of which stackups 2 and 11 are shown in Fig. 3. For selecting any one of the first ten outlets of the distributor DR1, the corresponding one of its stackups 1 to 10 is operated without operation of stackup 11. When any one of the eleventh to twentieth outlets of distributor DR1 is to be selected, the concerned one of the stackups 1 to 10 is actuated, along with stackup 11.

The distributor DR1 has access to secondary switch B1 by way of terminating trunk TT2. Through its illustrated stackup 0, secondary switch B1 has access to primary switch OB, by way of the associated line-link LOB. Through its illustrated stackup 0, primary switch OB has access to line #00.

Line, lockout, and cutoff relays 301, 302, and 303 of the line circuit associated with line #00 correspond respectively to relays 101 to 103 of line #11 (Fig. 1).

Figure 4

Fig. 4 shows the twelve distributor select magnets DM1 to DM12 comprising six pairs which respectively control the six select shafts (not shown) of the group distributors of Fig. 10. Magnets DM1 to DM10 correspond respectively to the stackups 1 to 10 of any of the distributors, such as DR1; magnet DM11 corresponds to the eleventh or switching stackup of any one of the distributors; and magnet DM12 is an additional magnet employed to rotate the sixth selecting shaft of the distributor group in the opposite direction to that in which it is rotated by magnet DM11. Magnet DM12 is a magnet not disclosed in my previously noted application for Automatic Telephone Switches. It may be located immediately to the right of magnet DM11 in Fig. 1 of such application, to cause the sixth selecting shaft to be rotated in the opposite direction at any time when selection of the eleventh stackup is not to occur. The utility of this arrangement is to secure invariably

the closure of the distributor off-normal contacts DON 11, 12 associated with the sixth shaft of the mechanism. Off-normal contacts DON 1, 2; DON 3, 4; DON 5, 6; DON 7, 8; and DON 9, 10 are associated respectively with the first five selecting shafts of the distributor group. The off-normal contacts of Fig. 4 are interconnected with conductors 1 and 2 in distributor pair DON to cause such conductors to be joined only when one or another of the first five shafts has been moved off-normal, along with the sixth shaft of the distributor group. This provision is utilized in the control of the circuit operations in a manner to be pointed out subsequently.

Fig. 4 further shows the circuit arrangement of the units-sleeve connector USC and of the tens-sleeve connector TSC of Fig. 10. These two sleeve connectors cooperate, during the setting up of a connection from any connector to the called line, to connect incoming conductor CLS in cable 552 to the sleeve conductor of the called line, such as conductor S11 or S00 the sleeve conductor of lines #11 and #00, respectively. The hold magnet of USC is shown at 401, while the hold magnet of TSC is shown at 402. These magnets are operated over conductor S0 in cable 552 only when the connection being handled by the line controller of Fig. 5 is one involving connector action, as distinguished from one involving line-finder action.

The selective action of sleeve connectors USC and TSC is automatically controlled in accordance with the designation of the called line, for sleeve connector USC is an additional switch in the line-primary group, and sleeve connector TSC is an additional switch in the line-secondary group, as indicated in Fig. 10.

Figure 5

Fig. 5, consisting of parts 1, 2 and 3, shows the line controller previously referred to. The line controller is temporarily called in for finder action by any ten-line subgroup containing a calling line. It makes the necessary tests, and determines which switches are to be operated to extend the calling line to an idle finder trunk. It is also temporarily called in for connector action by any connector at which the called number has been completely dialed. It then makes the necessary tests, and directs the extension of a connection to the called line. It does this either with or without assistance from the translator T1 of Figs. 6 and 10 and related equipment, depending upon whether or not there are translator jumpers in place for the called number.

Through conductors in cables 551 to 554, the line controller is connected as required with the other equipment. Certain other conductors connect the line controller with certain of the items of other equipment as shown.

The line controller of Fig. 5 consists principally of fifty relays, 501 to 550. Of these, relays 549, 550, 501, and 502 comprise the translator group, employed to control translation service; relays 503 to 507 comprise the connector group, being operative during each connector action handled by the line controller, but not during finder action; relay 508 is the common start relay for finder action and for connector action; relays 509 to 511 comprise a cycle timer, which is operated each time start relay 508 operates; relays 512 and 513 are the clearout and operate relays used during finder action and connector action; relays 514 to 519 comprise the choice allotter, which responds to each operation of start relay 508 to shift the choice to the next succeeding one of the secondary subgroups A to E; relays 520 to 525 comprise the matching group, of which relays 520 to 524 control the matching in secondary subgroups A to E respectively, and reserve control relay 525 operates to reserve one idle secondary switch of each category in a subgroup until required for a connection; relays 526 to 530 are primary test relays, corresponding respectively to switches A to E in any primary subgroup; relays 531 to 533 are test-control relays, which act to control the secondary-switch test leads; relays 534 to 548 are the secondary test relays, comprising five groups of three relays, one for each secondary subgroup A to E.

Figures 6 and 7

Figs. 6 and 7 show the translator T1 and the reset bus bars respectively. Translator T1 comprises a single units translator switch UT, and two tens translator switches, TTA and TTB.

Units translator switch UT (Fig. 6) is an additional switch in the line-primary group, as shown in Fig. 10, which also shows that the tens translator switches TTA and TTB of Fig. 6 are additional switches in the line-secondary group. Magnets 601, 602, and 603 are the hold magnets of translator switches TTA, TTB, and UT, respectively.

The reset bus bars of Fig. 7 comprise ten tens bus bars 701 to 710, and ten units bus bars 711 to 720, connected respectively to tens conductors T1 to T0 and units conductors U1 to U0. The switches of the translator act to extend a two-wire connection to any one of one hundred pairs of terminals, one such pair for each of the one hundred line numbers.

Figure 8

Fig. 8 shows the equipment for providing group service of the type commonly referred to as P. B. X service. This equipment includes a separate group-connect such as, 801 and 802 relays, and an associated pin-terminal block, such as 810 and 811, for each group of lines, such as P. B. X lines. The equipment includes allotter relays 803 to 807 common to all the groups of lines.

Figure 9

Fig. 9 shows the equipment used to provide individual station intercept service for party lines. It includes ten station bus bars 911 to 920 connected to the party register PR2 (Fig. 2, part 2), and a separate relay, such as 901 and 902 for each party line requiring station intercept service.

Figure 10

As shown in Fig. 10, a combined trunking and cabling diagram of the disclosed line unit includes a group of fifty line-primary switches divided into ten primary subgroups designated 1 to 0; a group of twenty-eight secondary switches divided into five subgroups designated A to E; thirteen connectors C1 to C13 (of which the connector C1 is shown in Fig. 2); and a group of thirteen distributor switches DR1 to DR13. The fifty primary switches are served in common by select magnets UM1 to UM0, Fig. 1, through five select shafts (not shown) extending across the group; the twenty-eight secondary switches are similarly served by select magnets TM1 to TM0, Fig. 1; and the distributors DR1 to DR13 are served by select magnets DM1 to DM12, Fig. 4.

As indicated by their location in Fig. 10, the switches USC and UT of Figs. 4 and 6, respectively, lie physically in the primary group of switches, and they are controlled in the manner of any primary switch by the common select shafts and select magnets of the primary group. Fig. 10 further shows that switch TSC of Fig. 4 and switches TTA and TTB of Fig. 6 lie physically in the secondary group, and are controlled in the manner of any secondary switch by the common select shafts and select magnets of the secondary group.

Each primary subgroup contains five primary switches A to E, and serves a separate ten-line subgroup of the 100-line group served by the disclosed improved line unit. For example, lines 11 to 10 are served by primary subgroup 1; lines 21 to 20 are served by primary subgroup 2; and so forth. The ten vertical lines shown extending across the five switches A to E of any primary subgroup represent the ten subscriber lines in the corresponding ten-line subgroup.

As shown in Fig. 1 and in Fig. 3 (for primary subgroups 1 and 0, respectively) the conductor pair representing any line may be attached to the appropriate contact terminals of the first primary switch in a subgroup, being connected through the vertically extending, bare-wire bank multiple to the corresponding contact terminals of the other primary switches in the same subgroup.

Line-link cable 601 carries fifty two-way line links between the respective primary switches and the bank multiples of the subgroups A to E into which the twenty-eight line secondary switches are divided. There are five line links for each primary subgroup of switches, one such line link for each switch. These line links are designated L1A to L1E for primary subgroup 1; L2A to L2E for primary subgroup 2; and so forth, to L0A to L0E for primary subgroup 0. The usual primary-secondary spread is employed between the primary and secondary switches. Accordingly, the ten links L1A to L0A, extending to the "A" primary switches in the ten primary subgroups, are reached through secondary subgroup A; the ten line links L1B to L0B, extending to the "B" switches in the ten primary subgroups, are reached from secondary subgroup B; and so forth, to the ten line links L1E–L0E, extending to the "E" switches in the ten primary subgroups, which are reached from the switches comprising secondary subgroup E.

Any primary switch, together with its associated line link, is employed both for finder action and for connector action. On the other hand, each secondary switch is definitely assigned to either finder action or connector action. The assignment arrangement selected is such that the odd-numbered secondary switches in any subgroup are employed for connector action, while the even-numbered secondary switches are employed for finder action. The first five finder trunks FT1 to FT5 extend from secondary switch 2 in the respective subgroups A to E; the second five finder trunks FT6 to FT10 extend respectively from secondary switch 4 in the respective secondary subgroups A to E; while the final three finder trunks FT11 to FT13 extend respectively from secondary switch 6 in subgroups A to C.

Since the unit disclosed is merely one of a number of similar units of the exchange, one or more stages of selectors are employed through which originated calls are routed to one or another of the line units according to the destination of the call. Cable 602 carries the thirteen finder trunks FT1 to FT13 to a corresponding number of selectors, while cable 603 carries thirteen connector trunks (CT1 to CT13) incoming from the selectors to the connectors. The unit herein disclosed is particularly adapted to cooperate with an installation employing one or more selector switching stages of the type disclosed in my patent for Selector Switching Systems, No. 2,400,530, issued May 21, 1946.

From the connectors C1 to C13, thirteen distributor trunks DT1 to DT13 extend, by way of cable 604, to distributors DR1 to DR13, respectively. As previously noted in connection with Fig. 3, each of the distributors is a three-wire twenty-point switch, having access to twenty three-wire outlets. Of the twenty outlets of the distributor group, numbers 1 to 15 are employed, numbers 16 to 20 being unused.

The distributors have access in common to fifteen terminating trunks TT1 to TT15, extending by way of cable 605 to the respective odd-numbered secondary switches in sub-groups A to E. The assignment of the terminating trunks is such that terminating trunks TT1 to TT5 extend respectively to secondary switches 1 in subgroups A to E; terminating trunks TT6 to TT10 extend respectively to secondary switches 3 in subgroups A to E; and terminating trunks TT11 to TT15 extend respectively to secondary switches 5 in subgroups A to E.

Calls extended to the terminating trunks are completed, through the operation of the secondary switches to which such terminating trunks extended, and thence to the respective called lines, by way of line links in cable 601, and primary switches in the concerned subgroups.

Detailed description

A detailed description will now be given of the operation of the illustrated apparatus in establishing and clearing out connections.

A. *Line #11 calls line #00*

Operations involved in a call from line #11, as shown in Fig. 1, to line #00, as shown in Fig. 3, will now be described. Each of the illustrated lines #11 and #00 is shown as a party line by the conventionally indicated common connections extending from the conductors thereof. One of a possible ten substations on line #11 is shown at 115, and one substation on line #00 is shown at 001. To make a call, a subscriber at a substation, such as 115 on line #11, removes his receiver; waits for dial tone; and then dials the desired three-digit member such as number 7001.

A1. *Marking the calling line*

When the receiver (not shown) is removed at calling substation 115, the usual direct-current bridge is closed across the conductors of the calling line, operating line relay 101 through contacts of cutoff relay 103. Line relay 101 grounds the associated start conductor ST, common to the ten lines of the first subgroup, and it also grounds the associated units conductor U1 individual to the calling line.

A2. *Tens selection*

Assuming that the line controller of Fig. 5 is idle, the grounding of start conductor ST associated with tens subgroup TG1 of Fig. 1, closes a circuit for tens subgroup relays 121 and 131 and start relay 508 in series, as follows; from ground on start conductor ST in tens subgroup

TG1, through contacts of relay 111, the winding of relay 121, lower winding of relay 131, normally closed contacts of relay 131, the chained inner-lower contacts of the ten relays 140 to 131, finder-chain-in conductor F–CH–IN in cable 551, chain contacts 3 of transfer relay 507, contacts 2 of clearout relay 512, and thence to battery through the winding of start relay 508. Relays 121, 131, and 508 operate in series over the above-traced circuit. Start relay 508 starts the line controller into operation with results to be hereinafter described.

At its middle lower armature, relay 131 locks its lower winding directly to conductor F–CH–IN to maintain the above-traced circuit intact after the control chain is broken at its lower contacts. The chain-end conductor F–CH–END is now isolated to temporarily preclude operation of any further tens subgroup relays, or of relay 507.

Relay 131 connects common control conductors PA to PE in cable 551 to control conductors A to E in the tens subgroup TG1, being the respective control conductors of the primary switches 1A to 1E in the first primary subgroup. This permits test relays 526 to 530 in the line controller to operate in accordance with the busy or idle condition of the respective concerned primary switches. Additionally, relay 131 closes a circuit for the associated tens magnet TM1, to effect tens selection in the secondary group of switches, wherein the first primary subgroup is thereby selected.

A3. *Units selection*

When relay 121 operates over the above-traced circuit, it connects the ten units conductors 1 to 0, associated respectively with the ten lines of the first subgroup, to the common units conductors U1 to U0, which extend respectively to units preference relays UP1 to UP0. With units conductor 1 in tens subgroup TG1 grounded, units-preference relay UP1 is operated over conductor U1 through the illustrated preference chain circuit. Upon operating, relay UP1 closes a locking circuit for itself independent of the remaining relays in the chain, and opens the preference chain to preclude operation of any further relays thereof for the time being. This arrangement prevents two or more units selections from being made in case two or more lines in the same tens subgroup are calling at the same time. At its upper contacts, relay UP1 closes a circuit for units-select magnet UM1, causing units selection to be accomplished in the primary subgroup of switches, wherein line 1 of the calling subgroup is thereby selected.

A4. *Tens and units selections locked*

The effected tens and units selection are locked in independent of the continued energization of line relay 101, partly as an aid to further operations, and partly to prevent false or partially completed finder actions resulting from momentary bridging or grounding of the line.

The tens selection is locked in at the upper contacts of relay 121, which ground the associated start lead ST independent of line relay 101. The units selection is locked in at the inner, upper contacts of unit-preference relay UP1, which lock the relay to units-lock conductor UL in cable 551, grounded by contacts 3 of start relay 508.

A5. *Finder switch operation*

As soon as the described tens and units selections have been accomplished, ground is extended to off-normal conductors PS–ON in cable 551 (through off-normal contacts SON 1, 2 and PON 1, 2) to inform the line controller of Fig. 5 that tens and units selections have been made.

Assuming that primary switch 1A and secondary switch A2 shown in Fig. 1 are both idle, these two switches may now be operated by the line controller of Fig. 5 (in a manner to be hereinafter explained) to extend calling line #11 to finder trunk FT1.

The operating circuit for primary switch 1A is from ground applied to conductor PA in cable 551 by the line controller, and thence through contacts of relay 131, primary conductor A of subgroup TG1, make-busy contacts 105, and thence to battery through the winding of hold magnet 104 of primary switch 1A.

Units-select magnets UM1 having been operated, the operation of hold magnet 104 results in the closure of the illustrated stackup 1 of switch 1A to extend the tip, ring, and sleeve conductors of the calling line to the corresponding conductors of the line link L1A. The initial operating ground potential for hold magnet 104 is now applied, through the sleeve contacts of stackup 1 of primary switch 1A, to sleeve conductor S of the multiple associated with the calling line, thereby closing an operating circuit for cutoff relay 103 in series with lockout relay 102. Relays 103 and 102, accordingly operate, whereupon line relay 101 restores because it is disconnected by cutoff relay 103. The associated conductors ST and 1 are thereby ungrounded, but this causes no immediate response, for ground is maintained in each of these conductors (by relays 121 and UP1) by the above-described selection-locking connections.

The operating circuit for hold magnet 106 of secondary switch A2 is as follows: from ground on the associated control conductor CA2 (ground by the line controller as will be hereinafter explained) through make-busy contacts 107, left-hand winding of hold magnet 106, sleeve conductor S of finder trunk FT1, back and thence to battery through the illustrated contacts and resistor of the selector apparatus S1. Tens-select magnet TM1 having been operated, the operation of hold magnet 106 results in the closure of the illustrated stackup 1 of switch A2, to extend the conductors of line link L1A respectively to the tip, ring, and sleeve conductors of finder trunk FT1.

A moment later, holding ground is placed on the sleeve conductor of the established connection in the usual manner by the selector apparatus S1, providing a holding circuit for relays 102 and 103, and for magnets 104 and 106. Such holding circuit maintains the connection after the line controller clears out, in a manner to be hereinafter described. The clearing out of the line controller causes relays 121, 131, and UP1, and magnets TM1 and UM1 to restore. The holding circuit for secondary switch A2 is from the ground on the sleeve conductor of the established connection, through the locking contacts of magnet 106 (the so-called off-normal stackup of the switch), the right-hand winding of magnet 106, to battery.

A6. *Selecting the called group*

Dial tone may now be returned to the calling line in the usual manner, through selector apparatus S1, informing the calling subscriber that he may commence to dial.

Upon the dialing of the hundreds digit 7 of the assumed number (7001) indexing the disclosed

100-line unit, the selector mechanism S1 operates in the usual manner to select the corresponding group of trunks, and to select an idle trunk therein, such as trunk CT1, extending to connector C1 of Fig. 2. Trunk CT1 is normally marked idle by the resistance battery connection to the sleeve conductor S thereof through make-busy contacts 214 and the back contact of armature 4 of relay 204.

A7. *Preparing connector C1 for operation*

When the connection is extended to connector C1, line relay 203 (connected to the incoming tip and ring conductors, through normally closed contacts of busy relay 208 and of supervisory relay 202) operates over the called line and closes an operating circuit for release relay 204.

At its contacts 8, release relay 204 prepares an impulse circuit for the digit registers, while at its contacts 7, release relay 204 applies ground potential to local conductor 216, thereby preparing locking circuit for relays 207 to 210, closing a holding circuit for registers TR and UR. At armature 4, relay 204 disconnects the associated idle-indicating battery-supply resistor and applies the holding ground potential to the incoming sleeve conductor S in trunk CT1, such potential being obtained through normally closed contacts of chain relay 211 and of timer relay 201. The holding potential replaces the one removed a moment later by selector S1 in the usual course of its operation, and serves to maintain the connection intact.

A8. *Setting tens register TR*

When the calling subscriber dials the second digit of the desired number (tens digit 0) line relay 203 is restored ten times momentarily. Release relay 204, being slow-restoring, remains operated during dialing.

Each time it restores incidental to the dialing of a digit, line relay 203 applies ground potential, through contacts of release relay 204, to impulse conductor 217. During the dialing of the tens digit 0, conductor 217 extends, through contacts 9 of relay 207, and contacts 8 and 7 of relays 210 and 209, to branch conductor 223, extending to the impulse winding I of magnet 251, of tens register TR, which receives ten impulses. Recording contacts 1 to 0 of register TR close successively as the impulses arrive, each preceding contact pair opening on receipt of the next succeeding impulse. Accordingly, contacts 0 of register TR are closed at the end of the tens digit 0, contacts 1 to 9 having reopened successively.

Off-normal contacts ON of register TR close upon the delivery of the first impulse and remain closed until the register is cleared out. The closure of contacts ON of register TR occurs with line relay 203 in restored condition during the delivery of the first impulse of the series. Each time line relay 203 reoperates thereafter during the dialing of the tens digit, a circuit is momentarily closed as follows for tens-transfer relay 209; from ground through left-hand front contact of line relay 203, conductor 221, off-normal contacts ON of register TR, conductor 227, normally closed contacts controlled by armature 6 of relay 209, contacts 6 of relay 210, and thence to battery through the winding of relay 209. Relay 209 is preferably slow-operating by virtue of the comparatively heavy spring load carried thereby, and by virtue of a comparatively inductive winding. As a result, relay 209 cannot operate during the delivery of a series of impulses, for line relay 203 remains operated only momentarily between impulses of a series.

When line relay 203 comes to rest in an operated condition at the conclusion of the dialing of the tens digit, tens-transfer relay 209 operates over its above-traced circuit. Upon so doing, it closes a local locking circuit for itself at its contacts 6, at the same time opening its initial circuit. At its armature 7, relay 209 disconnects impulse conductor 217 from branch conductor 223 of register TR and transfers it to the similar conductor 224 extending to register UR.

A9. *Setting units register UR*

When the units digit is dialed, the impulses delivered to impulse conductor 217 pass over branch conductor 224 (through armature 7 of relay 209 and its front contact), wherefore units register UR responds as noted in connection with tens register TR to record the units digit 0.

When line relay 203 comes to rest in an operated condition at the termination of the dialing of the units digit, units transfer relay 210 (similar to relay 209) operates over the following circuit: from ground on conductor 221, off-normal contacts ON of units transfer UR; conductor 228, normally closed contacts controlled by armature 7 of relay 210, and thence to battery through the winding of relay 210. Upon operating, relay 210, at its armature 7 and associated contacts, locks itself to local conductor 216 independent of conductor 228; at armature 8, it disconnects impulse conductor 217 from units branch 224 and transfers it to party conductor 225, extending to party registers PR1 and PR2. At its contacts 9, relay 210 applies ground potential to holding conductor 226 local to party registers PR1 and PR2, registers TR and UR being held over branch 222 of grounded conductor 216. At its contacts 6, units-transfer relay 210 open-circuits and restores the locked tens-transfer relay 209, so as to enable the latter relay to be reoperated as a party-transfer relay.

A10. *Setting party registers PR1 and PR2*

When the final digit, party digit 1, of number 7001 is dialed, the single impulse thereof is delivered over branch conductor 225 to the magnets of party registers PR1 and PR2 in series. Contacts ON and 1 close at each such register.

At the termination of the party digit, tens-transfer relay 209 is reoperated as a party-transfer relay over the following circuit: from ground on conductor 221, off-normal contacts ON of party transfer PR1, conductor 229, and thence to battery through the winding of relay 209. Upon reoperating, relay 209 does not lock operated, as its locking circuit through armature 6 and associated contacts has been interrupted at contacts 6 of relay 210.

A11. *Calling in the line controller*

The line controller of Fig. 5 is now called in responsive to the closing of a circuit for chain relay 211 of the connector through contacts 5 of transfer relays 209 and 210, subject to the line controller being currently in idle condition. This circuit is as follows: from ground through contacts 5 and 8 of relays 207 and 208, contacts 5 of relays 209 and 210, winding of chain relay 211, normally closed contacts controlled by armature 5 thereof, chain-end conductor 218 (common to all connectors), chain contacts on the chain relays of all connectors, including contacts 6 of

relay 211, chain-in conductor CH–IN of cable 554, winding of transfer relay 507 of line controller, normally closed contacts controlled by armature 4 of relay 507, conductor F–CH–END of cable 551, chain contacts of relays such as 140 and 131, conductor F–CH–IN in cable 551, contacts 3 of transfer relay 507, contacts 2 of clear-out relay 512, and thence to battery through the winding of start relay 508. Relays 211, 507, and 508 operate in series over the above circuit.

At its armature 4 and associated contacts, relay 507 locks itself to the origin point of the chain (through contacts 2 of relay 512 and winding of relay 508) independent of conductors F–CH–END and F–CH–IN in cable 551, while at its contacts 3, it disconnects conductor F–CH–IN to preclude the operation of any of the finder control relays 131 and 121 (Fig. 1) for the time being.

At its contacts 1, relay 507 adapts the line controller for connector action, while start relay 508 initiates the required cycle of operations.

In the connector C1, chain relay 211, on operating, locks itself to the associated chain-in conductor CH–IN at armature 5 and its front contacts, at the same time isolating its winding and chain-in conductor CH–IN from local chain-end conductor 218 to preclude the operation for the time being of the chain relay in any other connector. At its contacts 2, relay 211 locks ground on its upper winding terminal independent of contacts of relays 209 and 210 to insure that relay 211 remains operated until restored by the line controller; at its armature 1 and associated contacts, it disconnects the normally applied source of holding ground potential from the incoming sleeve conductor and substitutes ground potential over sleeve lead SL in cable 554, having to do with reverting-call busy test; at its contacts 3 and 4, it connects switching and busy relays 207 and 208 respectively to switching and busy lead SW and BU in cable 554; at contacts 7, it connects conductor PL–IC and branch conductor 234, having to do with party-line intercept service; and at contacts 8 and 9, it connects grounded conductor T and U in cable 554 to branch conductors 231 and 232 of the tens and units register TR and UR, and thereby grounds the selected one of the tens conductors in cable 247 and the selected one of the units conductors in cable 248.

A12. *Tens and units selection*

In the assumed example, the grounded potential applied to conductors 231 and 232 (through contacts 8 and 9 of relay 211, conductors T and U in cable 554, thence to ground through contacts 1 and 2 of relay 591) is extended through the closed contacts 0 of tens and units registers TR and UR to tens conductor T0 in cable 247, and to units conductor U0 in cable 248. Units-preference relay UP0 operates over conductor U0 to cause the tenth units-select magnet UM0 to operate. The upper winding of the tens-preference relay 140 is operated without the accompanying operation of relay 130. Relay 140 connects common primary control conductors PA to PE to control conductors A to E of the tenth primary subgroup TG0; and at its lower contacts, it closes an operating circuit for tens-select magnet TM0.

A13. *The called line is busy*

If the called line #00 of Fig. 3 is busy when called, such fact is determined by the line controller of Fig. 5, which thereupon grounds conductor BU in cable 554, closing a circuit through contacts 4 of relay 211 for busy relay 208. Thereupon, relay 208, at its armature 9, removes ground from holding conductor 222 to permit registers TR and UR to clear out, and closes a self-locking circuit to conductor 216, and at 8, it opens the initial energizing ground connection to chain relay 211, leaving such relay locked through its contacts 2.

A moment later, when the line controller opens, conductor CH–IN in cable 554 incidental to its clearing out operation, chain relay 211 is open-circuited and restored. With contacts of busy relay 208 now open, relay 211 cannot reoperate when conductor CH–IN is reclosed at the line controller. Since switching relay 207 has not operated, no operating ground potential has been extended to the sleeve conductor S of the distributor trunk DT1, wherefore there has been no forward extension of the connection from the connector C1 toward the called line.

At its contacts 2, busy relay 208 connects the common busy-tone lead BT through back contacts of relay 206, condenser 215 and contacts 3 of relay 204 to the tip talking conductor, thereby transmitting a busy signal back to the calling line. The calling subscriber is now expected to replace his receiver to permit the established connection to clear out.

A14. *The called line is idle*

If the line #00 of Fig. 3 is idle when called, the line controller of Fig. 5 proceeds to match a path thereto from any of the terminating trunks such as TT2 and TT12 of Fig. 3, and to set the distributor select magnets shown in Fig. 4 in accordance with which of the paths has been matched. Assuming that the matched path is by way of terminating trunk TT2 and line link L0B, the distributor selection is such as to cause the illustrated stackup 2 of DR1 (Fig. 3) to be selected.

A15. *Connector switching operation*

When the necessary connections have been effected by the line controller, control conductors CB1 and B of the switches B1 and 0B (Fig. 3) are grounded along with switching conductor SW in cable 554.

The grounding of conductor B associated with primary switch 0B closes a circuit, through make-busy contacts 308, for holding magnet 307, whereupon the illustrated stackup 0 of such switch is closed, having been selected by magnet UM0 (Fig. 1).

Responsive to the placing of ground potential on control conductor CB1, a circuit is closed, through contacts 306, for hold magnet 305, whereby the illustrated stackup 0 of switch B1 is closed, having been selected by magnet M0 (Fig. 1).

Responsive to the grounding of conductor SW in cable 554, switching relay 207 operates, through contacts 3 of relay 211. It closes a self-locking circuit to conductor 216 at its contacts 7; it ungrounds conductor 222 at its contacts 8 to permit registers TR and UR to clear out; it prepares a circuit for ringing relay 206 at its contacts 6; it opens a point in the initial circuit of chain relay 211 at its back contact 5; and at its contacts 4, it extends the grounded incoming sleeve conductor, through contacts 5 of busy relay 208, to sleeve conductor S in distributor trunk DT1, thereby closing a circuit for hold magnet 304. Hold magnet 304 now closes the selected stackup 2 of the distributor DR1, thereby extending conductors T, R, and S of trunk DT1, through the back contacts of stackup 11 and through the three upper

pairs of stackup 2 of the distributor, to the selected terminating trunk TT2, whence the connection extends, as illustrated, to the called line. The ground potential on sleeve conductor S of distributor trunk DT1 is now effective to hold magnets 304, 305, and 307 operated, as well as to hold operated cutoff and lockout relays 303 and 302 of the called line circuit, such relays having previously been operated over the associated sleeve conductor S00 by the line controller.

A moment later, chain relay 211 restores responsive to the temporary removal of energizing potential from conductor CH–IN in cable 554, incidental to the clearing out of the line controller. With back contact 5 of relay 207 maintained open, relay 211 cannot reoperate when conductor CH–IN subsequently recloses.

A16. *Ringing the called substation*

Following the described operation of switching relay 207, as soon as common pick-up lead PU is momentarily grounded (by the usual ringing interrupter in common ringing equipment 241), at the beginning of the ringing cycle, a circuit is closed for ringing relay 206 from lead PU, through contacts 3 of units-transfer relay 210, contacts 6 of busy relay 208, normally closed contacts controlled by armature 4 of relay 206, and contacts 6 of switching relay 207. Upon operating, ringing relay 206 locks itself to the normally grounded locking conductor L in substitution for pick-up lead PU, remaining locked over conductor L through the remaining portion of the ringing cycle, at the end of which conductor L is temporarily ungrounded to permit ringing relay 206 to restore temporarily before the next ringing cycle starts. If no response is obtained before the next succeeding ringing cycle begins, ringing relay 206 is operated again when pick-up lead PU next becomes grounded.

As the principal result of its operation, ringing relay 206 disconnects conductors T and R in distributor trunk DT1 from talking condensers 212 and 213, and from the windings of back-bridge relay 205, and connects them to the ringing circuit. The tip conductor T is thereby connected directly to ground, while the ring conductor R is connected, over conductor 233, and the closed contacts 1 of party register PR1, to the selected coded generator leads G1 of the ringing equipment 241. After each ringing cycle, battery potential is impressed on the selected generator lead (by ringing equipment 241), consequently on ringing lead 233, and thence to the ring conductor R of distributor trunk DT1 and the called line. Any potential difference, due to the condenser, in the ringing circuit (not shown) at the substations of the called is dissipated.

When ringing relay 206 is restored at the end of any ringing cycle, it transfers the tip and ring conductors of the called line back from the ringing circuit to talking condensers 212 and 213, and to the windings of back-bridge relay 205 to permit the ringing operation to be tripped responsive to the call being answered.

A17. *Answering*

When the call is answered, the resulting closure of the usual direct-current bridge across the conductors of the called line permits back-bridge relay 205 to energize over the called line, through the back contacts of armatures 2 and 3 of the restored ringing relay 206. At its back contacts 1, relay 205 open-circuits and restores units-transfer relay 210. At its contacts 3, units-transfer relay disconnects pick-up lead PU to prevent subsequent reoperation of ringing relay 206, and at its contacts 9, it ungrounds hold conductor 226 permitting party registers PR1 and PR2 to clear out. The opening of off-normal contacts ON of party register PR1 open-circuits and restores tens-transfer relay 209.

As a further result of its operation, back-bridge relay 205, at its contacts 2, operates supervisory relay 202, through contacts 9 of busy relay 208 and contacts 7 of release relay 204. Upon operating, relay 202, at its armatures 1 and 2 and associated contacts, reverses the direction of flow over the talking conductors of trunk CT1 for whatever purpose may be desired. This operation is utilized in many systems to operate call meters, to give supervision at the switchboard of a calling operator, and the like.

A18. *Clearing out the established connection*

When the conversation is terminated, and the subscribers have replaced their receivers, the established connection is cleared out as will now be described.

It may be assumed that the called subscriber replaces his receiver first, whereupon back-bridge relay 205 restores and permits supervisory relay 202 to restore.

When the receiver is replaced on the calling line, line relay 203 restores, followed a moment later by the restoration of release relay 204. Release relay 204 is adjusted to restore reliably in spite of the self-locking circuit through 217 and contacts 7 of such relay, as previously discussed. At its armature 7, relay 204 removes ground potential from the local holding conductor 216, thereby permitting switching relay 207 to restore. At the front contact of its armature 4, relay 204 disconnects ground potential from the sleeve conductor S of the established connection, thereby clearing out selector apparatus S1 in the usual manner, and deenergizing the cutoff relays (103 and 303) and lockout relays (102 and 302) of the calling and called lines, and hold magnets 104, 106, 304, 305, and 307. By these operations, the entire connection is broken down. The connector C1 is again marked as idle by battery potential applied to the incoming sleeve conductor thereof through make-busy contacts 214, and back contacts 4 of the release relay 204.

B. *Reverting call on party line #11*

The way in which reverting calls are made on party lines will now be described. It will be assumed that the subscriber at substation 115 (substation 5 on line #11) desires to call another substation on the same line, substation 0, for example. For this purpose, the subscriber at substation 115 removes his receiver; waits for dial tone; and dials the directory number (7110) assigned to the desired substation; replaces his receiver upon hearing the busy tone which is returned by the connector C1; waits a sufficient interval to permit the called substation on the same line to be signalled; and then removes his receiver for conversation with the called subscriber.

It may be assumed that, responsive to the removal of the receiver to initiate the call, a connection is extended as previously described from the calling line #11 through primary and secondary switches 1A and A2 of Fig. 1 selector apparatus S1, and that the connection is extended (on dialing hundreds 7) to the connector C1 (Fig. 2), in which connector, relays 203 and 204 operate as previously described.

When the tens, units, and party digits (1, 1,

and 0) in called number are dialed, tens and units registers TR and UR and party registers PR1 and PR2 respond as previously described. Contacts 1 are closed in registers TR and UR and contacts 0 are closed in registers PR1 and PR2. It will be recalled that relays 209 and 210 are energized successively, relay 209 at the end of the tens digit and relay 210 at the end of the units digit; that relay 209 is restored by relay 210 and reoperates under the control of contacts ON of register PR1 at the end of the dialing of the party digit.

The reoperation of relay 209, with relay 210 operated, results in the described operation of chain relay 211 to call in the line controller of Fig. 5. At this time, the test connection to the called line is made over test conductor S11 in Fig. 1. By operations to be described in detail hereinafter, the line controller of Fig. 5 recognizes the called line as being also the calling line, wherefore it fails to bring about the operation of a secondary and primary switch to forward a call to the called line. In a reverting call, the line controller grounds busy lead BU in cable 554, and follows by grounding switching lead SW in such cable. As a result, busy and switching relays 208 and 207 are operated successively. Each of the relays 208 and 207, on operating, locks itself to the grounded local conductor 216. Contacts 5 of busy relay 208 prevent contacts 4 of relay 207 from operating distributor DR1.

When the line controller clears out, chain relay 211 is restored as described. The relays now operated in the connector C1 are line and release relays 203 and 204, switching and busy relays 207 and 208, and transfer relays 209 and 210.

At contacts 2 of busy relay 208, the described busy-tone connection is made to the calling line to prompt the calling subscriber to replace his receiver to permit ringing to occur.

B1. *Inverting the connector C1*

With switching and busy relays 207 and 208 both operated, the connector C1 is conditioned for reverting-call action, and to become inverted (when the calling subscriber replaces his receiver) so that ringing current will be transmitted back over the tip and ring conductors in connector trunk CT1. Preparation for this inversion is made by armatures 3 and 4 of busy relay 208 and their associated contacts, along with armatures 2 and 3 of tens-transfer relay 209 and their associated contacts. The connection from the tip conductor T of connector trunk CT1 to line relay 203 and talking condenser 212 now includes the front contact of armature 3 and the said armature of relay 208, armature 2 of relay 209 and its front contact. Similarly, the connection from the ring conductor of such trunk to the lower winding of line relay 203 and condenser 213 now includes front contacts 4 and 3 of relays 208 and 209. That is, so long as tens-transfer relay 209 remains operated, the operation of armatures 3 and 4 of busy relay 208 makes no immediate change in the connections between the incoming talking conductors and the windings of line relay 203.

When the calling subscriber replaces his receiver, line relay 203 immediately restores and remains restored thereafter until the connection has been cleared out. Release relay 204, however, does not restore at this time as it is held operated in a local circuit, including front contacts 5 of relay 207, and contacts 7 and 4 of relays 208 and 210. The immediate result of the restoration of line relay 203 is the opening of the circuit of tens-transfer relay 209, which has been held operated following the dialing of the party digit through contacts ON of party register PR1 and the left-hand front contact of line relay 203. Upon restoring, with busy relay 208 in operated condition, relay 209, at its armatures 2 and 3, disconnects the incoming tip and ring conductors from the windings of line relay 203 and the left-hand terminals of talking condensers 212 and 213, and transfers them to the tip and ring conductors of the distributor trunk DT1, over which ringing current is to be applied. Back-bridge relay 205 is now in position to be energized over the calling line when the calling subscriber or called subscriber thereon removes the receiver.

B2. *Signalling the called substation*

Upon the described restoration of tens-transfer relay 209, pick-up lead PU is extended through contacts 3 of relay 210 and contacts 4 of the restored relay 209 to the winding of ringing relay 206. Relay 206 is operated over lead PU as previously described, to transfer the outgoing talking conductors (and at this time also the incoming talking conductors) of the connector to the ringing circuit for the duration of the ensuing ringing cycle.

Since the party digit 0 has been dialed in the assumed example, contacts 0 of register PR1 are closed, and ringing current is transmitted to the line from ringing equipment 241, over the #10 coded generator lead G0, contacts 0 of register PR1, conductor 233, front contact 3 of ringing relay 206, back contact 3 of relay 209, and front contact 4 of busy relay 208. A return path to ground for such ringing current is through front contact 3 of busy relay 208, back contact 2 of relay 209, and front contact 2 of relay 206.

Keeping in mind that ringing relay 206 is temporarily restored at the end of each ringing cycle as previously noted, the removal of the receiver at either of the concerned stations (calling or called) on line 11 causes energization of back-bridge relay 205 to occur, either immediately, or responsive to the next succeeding restoration of ringing relay 206. The circuit of relay 205 includes back contacts 2 and 3 of ringing relay 206. The circuit of relay 205 includes back contacts 2 and 3 of ringing relay 206, back contacts 2 and 3 of relay 209, and front contacts 3 and 4 of busy relay 208. The closing of contacts 2 of relay 205 does not at this time cause supervisory relay 202 to respond, as its circuit is held open at back contact 9 of relay 208.

Units-transfer relay 210 performs its described ring-cutoff operation by restoring responsive to the opening of back contact 1 of back-bridge relay 205. At its contacts 4, relay 210 opens the previously established direct holding circuit for release relay 204. Line relay 203 being in restored condition, release relay 204 now restores. At its contacts 7, release relay 204 removes the normal ground connection from holding conductor 216, but such conductor is maintained grounded temporarily through front contact 1 of relay 205. At its front contact 4, release relay 204 removes ground potential from the incoming sleeve conductor, thereby clearing out the connection between line 11 and the connector C1, switches 1A and A2 releasing, and apparatus S1 clearing out. Responsive to this operation, back-bridge relay 205 restores, removing ground potential from holding conductor 216 at its con-

tacts 1, whereupon connector C1 clears out completely and immediately.

B3. *Reverting-call lockout*

Upon the described removal of ground potential from the sleeve conductor of the connection previously established from line #11 to connector C1, cutoff relay 103 associated with the calling line restores immediately, but slow-restoring lockout relay 102 remains operated momentarily. With a direct-current bridge now across the conductors of line #11, line relay 101 immediately reoperates, through contacts of the restored cutoff relay 103, and closes a locking circuit for lockout relay 102. Relay 102 is accordingly held operated so long as line relay 101 remains operated. With relay 102 operated, no ground potential is extended to the associated conductors ST and 1 in TG1, wherefore no finder action is initiated. The calling and called subscribers may now converse over the line #11 as desired, transmitter current being supplied through the windings of line relay 101.

When the receiver is subsequently replaced at both substations, line relay 101 restores, permitting relay 102 to restore, returning the line circuit to normal condition.

C. *Subgroup line-finder lockout*

In Fig. 1, arrangements are provided for locking a subgroup of ten lines temporarily out of line-finder service, responsive to the encountering of a busy condition of the finder paths with respect to such subgroup. These provisions include the ten relays 111 to 120, a separate such lockout relay for each ten-line subgroup. When line-finder action is initiated at any such subgroup, the concerned one of the ten connecting relays 121 to 130 is operated to connect lead F–BU in cable 551 to the right-hand terminal of the concerned one of the relays 111 to 120. If lead F–BU is then grounded by the line controller, responsive to a finder-busy condition, the concerned one of the relays 111 to 120 operates and locks, through contacts of the fifteen-second timer 142, disconnecting the associated lead ST from the associated one of the connecting relays 121 to 130. By this arrangement, the concerned ten-line subgroup is locked out of finder service until the contacts of timer 142 next open, freeing the line controller for other finder calls, and for connector calls.

D. *Permanent timing*

So-called permanent timing is employed at each of the connectors, being controlled by timer 200 (Fig. 2). Each connector has a timer relay such as relay 201 of connector C1. The timer 200 is more or less arbitrarily indicated as a fifteen-second timer.

Whenever the connector C1 is taken for use, the closing of contacts 5 of release relay 204 associates the upper winding of timer relay 201 with pick-up lead P1 of the timer 200. Such lead is arranged to be momentarily grounded, through contacts 251 and 252 of timer 200, at the beginning of each fifteen-second cycle thereof, while cutoff lead C0 is arranged to be ungrounded momentarily at the termination of such cycle.

With relay 204 operated, the next grounding of pick-up lead P1 results in the energization of the upper winding of timer relay 201. Relay 201 thereupon operates and locks itself, at its contacts 2, through contacts 4 of relay 202, to the left-hand front contact of the operated line relay 203. At its armature 1 and associated contacts, timer relay 201 disconnects the holding ground locally supplied to the front contact of armature 4 of release relay 204 and substitutes ground on cutoff lead C0 through contact 252. If nothing occurs to restore timer relay 201 before the end of the current cycle of timer 200 is reached, the opening of contacts 252 removes holding ground from the incoming sleeve conductor S of connector trunk CT1, clearing out the connection from the calling line to the connector. This clearing out causes the associated line circuit to assume a lockout condition, as described hereinbefore for line 11, Fig. 1, in connection with reverting calls. At this point, it may be noted that permanent alarm device 141 may be provided common to all the lines of the unit, to give a suitable alarm signal provided it is energized continuously, for a period of an hour or more, for example.

Ordinarily, the calling subscriber begins to dial the number promptly following the extension of the connection to the connector. In the connector C1, when line relay 203 restores, responsive to the beginning of dialing, if relay 201 is operated, the locking circuit thereof is opened, whereupon the relay restores. Relay 201 thereafter remains restored until the beginning of the next ensuing cycle of timer 200, whereupon it again operates, provided supervisory relay 202 is not in operated condition. The disclosed arrangement provides for a similar delay following the dialing of each of the digits of the number.

The timer arrangement remains effective until the call is answered, whereupon the windings of relay 201 are disconnected at contacts 3 and 4 of supervisory relay 202, remaining disconnected during conversation.

If the called subscriber replaces his receiver at the end of conversation, before the calling subscriber replaces his receiver, the timing arrangement again becomes effective responsive to the restoration of supervisory relay 202. Then, if the calling subscriber does not cause the connection to clear out before the timer 200 has finished its next complete cycle of operations, contacts 252 separate with relay 201 operated, causing the connection to be cleared out as previously noted.

E. *Miscellaneous connector provisions*

Certain miscellaneous provisions of the connectors will now be described.

E1. *Start leads*

Start leads GEN–ST, TN–ST, and TI–ST are provided in common to all the connectors. Throughout the time connector C1 is in use, release relay 204 maintains lead TI–ST grounded to maintain timer 200 in operation.

At its contacts 1, release relay 204 grounds lead TN–ST, so as to start the tone-supply apparatus into operation to deliver appropriate tone current to common lead BT. This start lead remains grounded until switching relay 207 operates to open its contacts 2, at which time it becomes ungrounded unless busy relay 208 is operated to close its contacts 1, which condition obtains, as described, when a reverting call is made.

Upon the operation of switching relay 207, its contacts 1 ground lead GEN–ST, through contacts 1 of the then operated units-transfer relay 210. This lead is employed to start ringing equipment 241 into operation. When units-transfer relay 210 is restored, by back-bridge relay 205, lead GEN–ST is ungrounded at contacts 1 of relay 210.

E2. *Tone leads*

As previously noted, at its contacts 2, busy relay 208 applies busy-tone current to the calling line from common lead BT. During a reverting call, busy relay 208 remains in operated condition until after the call has been answered, and continuously applies busy-tone current to the calling line throughout the ringing operation, except that back contact 1 of ringing relay 206 opens the busy-tone circuit during each ringing cycle to prevent the joining together of common leads BT and RT. It may be noted that the presence or absence of a tone on the calling line during reverting-call ringing is immaterial, since no one is listening on the line at that time.

At its front contact 1, ringing relay 206 connects ringing-tone lead RT to the calling line as an indication that the called substation is being signalled. The current applied to ringing-tone lead RT may be obtained from the ringing equipment 241.

F. *Line controller—Finder calls*

The operation of the line controller of Fig. 5 in handling finder calls will now be described. It has been previously described that start relay 508 operates on the initiation of each call within the 100-line unit, whether such call be a finder call or a connector call. If the call is a finder call, transfer relay 507 is not operated, the latter relay operating only on connector calls.

F1. *Starting the cycle timer*

At its contacts 1, start relay 508 grounds conductor 559 to prepare a circuit for clearout relay 512 and to control the choice allotter. Relays 510 and 511 immediately operates through the right-hand front contact of relay 508. At the left-hand contact of the same armature, relay 508 operates relay 509. The operation of relay 509 is delayed slightly by its normally short-circuited upper winding, to give relays 510 and 511 time to operate first.

Upon operating, relay 509 removes the short circuit around its upper winding at back contact 3, to render the relay fast-releasing. At its front contact 3, a short-circuiting ground potential is applied to the left-hand terminal of relay 510, so as to cause the relay to restore as a slow-acting relay. It will be noted that relay 510 upon restoring, extends short-circuiting ground potential to the left-hand terminal of relay 511, causing the latter to restore as a slow-acting relay. The restoration of relay 511 completes this timing cycle and operates the clearout relay 512 (through contacts 2 of relay 509 and contacts 1 of relay 511) to clear out the line controller by opening its contacts 2. This clearing-out operation is sufficiently delayed by the slow action of relays 510 and 511 to permit the completion of the regular operation of the line controller, as will be described.

F2. *Setting the secondary test relays*

At its contacts 1, the relay 509 of the cycle timer applies ground potential to conductor 557 through the back contacts 1 of transfer relay 507, to operate finder call connecting relay 531. Upon operating, relay 531 grounds conductor 576, and connects the even conductors 2, 4, and 6 in the associated conductor subgroups A, B, and C, and conductors 2 and 4 in subgroups D and E respectively, to the high-resistance lower windings of secondary test relays 534 to 544, 546, and 547. Each of the above-mentioned

leads is the control from a separate one of the thirteen finder-action secondary switches. Of these leads, secondary control lead CA2 is shown in Fig. 1, being the control lead of secondary switch A2. For example, if the secondary switch A2 (Fig. 1) and associated trunk FT1 are idle, secondary test relay 534 operates over the following circuit: from ground, through contacts of relay 533, high-resistance lower winding of relay 534, contacts of relay 531, secondary control lead CA2, make-busy contacts 107, left-hand winding of hold magnet 106 of secondary A2, sleeve conductor S in trunk FT1, illustrated contacts of equipment S1, and through the associated resistor to battery.

Since relay 534 has a high-resistance lower winding (as has each of the relays 535 to 548), the flow of test current through the left-hand winding of hold magnet 106 in the above-traced circuit is insufficient to effectively energize such hold magnet.

At its armature 2, each operated one of the secondary test relays 534 to 548 prepares to place ground on the associated secondary control lead, in shunt of its own high-resistance lower winding, to operate its associated secondary switch, preparatory to the matching operation to be described.

F3. *Setting the primary test relays*

As previously described, the energization of any of the ten relays 131 to 140 (Fig. 1), connects the five primary leads PA to PE respectively to the local control leads A to E of the concerned one of the tens subgroup TG1 to TG0. Leads PA to PE are connected to ground respectively through the high-resistance lower windings of primary test relays 526 to 530 in the line controller. Accordingly, each of the relays 526 to 530 now operates, subject to the primary switch with which it is currently associated being idle. For example, if the finder call being handled involves a line in the first ten-line subgroup, line 11, Fig. 1, for example, relay 131 is energized, wherefore, if primary switch 1A and associated link L1A are idle, relay 526 is energized over the following circuit: from ground, through the high-resistance lower winding of relay 526, conductor PA in cable 551, contacts of relay 131 in tens subgroup TG1, local conductor A of this tens subgroup, make-busy contacts 105, and thence to battery through the winding of hold-magnet 104. Hold-magnet 104 is not effectively energized over this circuit because of the high resistance of the lower winding of relay 526.

Each operated one of the primary test relays 526 to 530, at its contacts 2, prepares an operating ground potential to the associated one of the primary control conductors PA to PE in shunt of its own lower winding, preparatory to the matching operation to be described.

F4. *The matching operation*

The matching operation is performed by marginal matching relays 520 to 524, which control matching in secondary subgroups A to E, respectively.

Matching relay 520 to 524 being marginal, the operation of any one of them is subject to ground potential being applied to the concerned one of the conductors 571 to 574 through the upper winding of at least two secondary test relays. Considering secondary subgroup A, for example, if all three secondary test relays 534 to 536 are operated, indicating that all three finder-action

switches are idle, ground potential from conductor 576, grounded by relay 531, is applied to conductor 571 through all three upper windings of relays 534 to 536, through contacts 1 of such relays. Then, if primary test relay 526 is operated, indicating that the "A" primary switch in the calling primary subgroup is idle, relay 520 operates through contacts 1 of primary test relay 526, in series with the upper winding thereof. Relay 520 operates if two or three of the test relays 534 to 536 are operated. On the other hand, if only one of the relays 534 to 536 is operated, relay 520, being marginally adjusted, will not operate.

For the present example, it may be assumed that all of the finder-action secondaries in all subgroups are idle, in which case each of the secondary test relays employed for finder action operates. In this event, ground potential is applied to each of the conductors 571 to 573 through three windings, while ground potential is applied to conductors 574 and 575 through two windings each. Assuming further that each of the primary test relays 526 to 530 operates, each of the matching relays 520 to 524 operates, indicating a match in each secondary subgroup.

At its contacts 2, each of the relays 520 to 524 disconnects reserve-control relay 525 from grounded conductor 576, wherefore relay 525 is prevented from operating. At its contacts 3, each of the matching relays 520 to 524 extends a partial connection to the associated one of the operating conductors 581 to 585, in preparation for the operation of a primary switch and a secondary switch over one of the matched paths. At its contacts 5, each of the relays 520 to 524 joins conductors 562 with conductor 563, as an indication that the matching has been completed.

F4a. *Locking the matched condition*

At its contacts 1, each matching relay 520 to 524 grounds conductor 569, thereby operating ground-control relay 533 to disconnect test potential (ground potential) from the lower winding of each secondary test relays 534 to 548. This operation is performed on each matching operation, regardless of how many of the matching relays, 520 to 524, operate. From this point, no further secondary test relays can operate, and the continued operated condition of any one of the secondary test relays 534 to 548 is dependent on the flow of locking current through the upper winding of such relay, and locking contacts 1 thereof, which current flow obtains only if contacts 1 of the corresponding one of the primary test relays 526 to 530 are closed.

In the assumed example (wherein all primary test relay and all secondary test relays concerned with finder action were operated) all operated secondary test relays remain locked operated notwithstanding operation of relay 533. For example, relays 534 to 536 remain locked operated in the following circuit: from ground placed on conductor 576 by relay 531, upper windings of relays 534 to 536, contacts 1 of such relays, conductor 571, contacts 1 and upper winding of primary-test relay 526, and thence to battery through the winding of matching relay 520. The upper winding of any primary or secondary test relay is effective to hold such relay operated independent of other current flow through the lower winding thereof.

F5. *Choice allotter*

Assuming that, on seizure of the line controller the choice allotter, comprising relays 514 to 519, is in the illustrated condition, with all relays restored, as it normally is on seizure in five, the above described grounding of conductor 559 by start relay 508 closes a circuit through the back contact of the armature of driver relay 514, for the first counting relay 515, by way of chained contacts of counting relays 516 to 519, and battery-supply resistor 564. Relay 515 thereupon operates. At its upper contacts, it locks itself in series with the lower winding of driver relay 514. Such winding does not energize immediately, being short circuited by ground potential maintained on conductor 559. At its inner upper contacts, relay 515 prepares a circuit for the second counting relay 516, which cannot be closed until driver relay 514 operates. At its inner lower contacts, relay 515 connects operate conductor 560 to armature 3 of the first matching relay 520, whereby secondary subgroup A, which matching relay 520 represents, is given first choice at this time by the choice allotter. If this occurs at a time when matching relay 520 does not operate, the ground potential extended to armature 3 of relay 520 passes through the back contact thereof to the armature 3 of the second match relay 521, and so on down the chain to the armature 3 of the first operated match relay encountered.

As fully described in my previously cited application for Automatic Telephone Systems, the choice allotter is so arranged that the grounding of conductor 559, incidental to a finder call or to a connector call, causes the next succeeding one of the relays 515 to 519 (considered as endless chain) to operate and extend first choice to the concerned one of the match relays 520 to 524, whose armatures 3 and back contacts are connected in an endless chain.

F6. *Closing the operating circuits*

From the preceding description, it will be recalled that, when the primary and secondary select-magnet action has occurred, ground potential is extended, through one or another of the five secondary off-normal contact pairs of Fig. 1, in series with one or another of the five primary off-normal contact pairs, to conductor PS–ON in cable 551. With this having occurred, as soon thereafter as the described matching operation has occurred, if it has not already done so, operate relay 513 of the line controller is operated over the following circuit: from ground on conductor PS–ON in cable 551, conductor 562, contacts 5 of one or another of the matching relays 520 to 524, conductor 563, back contact 6 of transfer relay 507, contacts 3 of operated cycle time relay 511, contacts 5 of clearout relay 512, and thence to battery through the winding of operate relay 513. Upon operating, relay 513, at its contacts 4, applies ground potential to operate conductor 560, through back contact 4 of busy relay 505.

In the assumed example, the choice allotter is now in its "A" position (relay 515 operated, and relays 516 to 519 restored); each of the matching relays 520 to 524 is operated; each of the primary test relays 526 to 530 is operated; and each of the secondary test relays associated with finder action is operated. Accordingly, the grounding of conductor 560 operates the "A" switch in the calling primary subgroup, and the first finder-action switch (A2) in the secondary subgroup A.

The operating circuit for switch A2 is as follows: from ground on operate conductor 560, contacts 3 of the operated choice-allotter relay 515, armature 3 of matching relay 520 and its

front contact, conductor 581, armature 2 of secondary test relay 534 and its front contacts, contacts of the operated finder-control relay 531, secondary conductor CA2, and thence to battery as previously traced, through the left-hand winding of hold magnet 106 of the secondary switch A2. Such secondary switch is operated over this circuit to the exclusion of all other secondary switches.

Assuming the call to be from a line in the first ten-line subgroups, the operating circuit of the "A" primary switch is as follows: from ground, as previously traced, to conductor 581, and thence through contacts 2 of the operated primary-test relay 526, primary conductor PA in cable 551, contacts of relay 131, conductor A in TG1, and thence to battery through the winding of hold magnet 104 of primary switch 1A.

F7. *Clearing out the line controller*

In addition to closing the operate circuits as previously described, relay 513 initiates the clearing-out operation by closing a circuit, at its contacts 2, for clearout relay 512, from grounded conductor 559. Upon operating, relay 512 locks itself to conductor 559 at its contacts 1; opens its contacts 2, without immediate effect because contacts 3 of operated relay 513 are closed; opens its contacts 3 to prevent application of ground potential to finder-busy conductor F-BU in cable 551, in case cycle-timer relay 511 restores prior to the restoration of operate relay 513; at its contacts 4, it further locks itself to conductor PS-ON in cable 551; at its contacts 5, it open-circuits relay 513. Relay 513 remains operated for a momentary interval, being a slow-restoring relay. It therefore maintains operate conductor 560 grounded at its contacts 4, to maintain closed the operating circuits of the matched primary and secondary switches, long enough to permit holding ground to be applied to the established connection, as hereinbefore described.

When operate relay 513 subsequently restores, it disconnects ground from operate conductor 560, at its contacts 4; and at its contacts 3, it disconnects start relay 508 (clearout relay 512 being in an operated condition), causing the operated tens subgroup relays such as 131 and 121 (Fig. 1) to restore.

In the line controller, the disconnected start relay 508 now restores, whereupon the cycle timer, comprising relays 509 to 511, immediately clears out. The removal of ground potential from conductor 559, in addition to permitting the operation (restoration or release, as the case may be) of driver relay 514 of the choice allotter, open-circuits the operated clearout relay 512. As is indicated by the shaded upper portion thereof, relay 512 is slightly slow-operating, and is somewhat slow-releasing. The slow-releasing characteristic keeps relay 512 operated long enough to insure that the concerned tens subgroup of Fig. 1 is cleared out before clearout relay 512 restores, to reclose the control chain at its contacts 2. Additionally, with its contacts 4 closed, clearout relay 512 cannot restore until restoration of the primary and secondary off-normal contacts (Fig. 1) has occurred to unground conductors PS-ON in cable 551.

The restoration of the operated tens subgroup relay 131 disconnects the primary control conductors PA to PE in cable 551 from the control conductors of the associated primary switches, rendering primary test relays A to E dependent on current flow through their upper locked windings. The opening of contacts 1, of cycle timer relay 509, permits the operated connector relay 531 to restore. Ground is thereby removed from conductor 576, unlocking and restoring relays 520 to 524, 526 to 530, and all operated ones of the relays 534 to 548.

Upon restoration of relay 512, the line controller is entirely cleared out, and its start chain is reclosed at contacts 2 of relay 512, to permit another call (either a finder call or a connector cal) to be received.

F8. *Alternative matching*

With further reference to the matching operation previously described, it will be apparent that when matching has occurred in secondary subgroup A (involving secondary test relays 534 to 536), if the first-choice secondary switch in the group is busy, secondary test relay 534 remains in a restored condition. Then, the described placing of an operating ground potential on conductor 581 extends ground potential through the back contact 2 of relay 534, to armature 2 of the second-choice relay 535. If such relay is in operated condition, the corresponding secondary switch is chosen. On the other hand, if relay 535 then is in restored condition, the ground potential is further extended through back contact 2 thereof, to armature 2 of the then necessarily operated relay 536, causing the third-choice secondary switch within the subgroup to be operated.

F9. *Reserve matching*

As previously noted, each of the match relays A to E is a marginal relay, so adjusted as to operate only when the current supplied thereto is equal to that obtainable through the upper windings of at least two secondary test relays. Matching relay 520, for example, cannot operate, even though primary test relay 526 is operated, if none of the associated secondary test relays 534 to 536 is operated, nor if only one of such relays is operated. If one or another of these conditions obtains with respect to each of the secondary subgroups, none of the relays 520 to 524 operates initially, wherefore the circuit of slow-operating reserve-control relay 525 remains intact. Under this condition, relay 525 soon operates responsive to the grounding of conductor 576. At its contacts 6, reserve-control relay 525 locks itself directly to conductor 576, and, at its contacts 1 to 5, it applies ground potential to each of the conductors 571 to 575. Each such application of ground potential is by way of a resistor having a reistance similar to that of the upper winding of any secondary test relay, each such resistor being associated with a separate secondary subgroup. Considering secondary subgroup A, for example, if there is no idle secondary switch in such subgroup, none of the relays 534 to 536 is operated, and the ground-supply resistor connected to conductor 571 by relay 525 is the only circuit path effective to supply current to marginal matching relay 520, wherefore relay 520 still fails to operate. On the other hand, if any one of the relays 534 to 536 is operated, ground potential is now supplied to conductor 571 through two similar resistance paths, permitting matching relay 520 to operate, to render available the final, reserve secondary (in the concerned category, finder or connector action) in the group.

F10. *All-finders-busy operation*

In the preceding description, it was noted that the operation of relay 513 during finder action

to extend ground potential to operate conductor 560 is dependent, among other things, upon the energization of one or another of the matching relays 520 to 524 to join conductors 562 and 563. If no idle path can be matched between a calling line in the concerned tens subgroup and an idle finder trunk, none of the matching relays 520 to 524 can operate, either during the time allotted to the regular matching operation or to the reserve matching operation. In this event, the previously traced circuit for relay 513 remains open, wherefore such relay does not operate pursuant to the normal disposition of the call. In this event, the previously described operation of the cycle timer (comprising relays 509 to 511) proceeds to completion with relay 513 still unoperated. It will be recalled that the final step in the operation of the cycle timer is the restoration of relay 511, responsive to being short-circuited upon the restoration of relay 510. Upon restoring under the condition noted, relay 511 disconnects the unoperated relay 513 at its contacts 3, while at its contacts 1, it closes a circuit for clearout relay 512, through contacts 2 and 1 of relays 509 and 508. Clearout relay 512 is a slow-operating relay, as previously noted. During the interval required for relay 512 to operate after its circuit is closed, ground potential is momentarily applied to finder-busy conductor F-BU through contacts 3, 2, and 4 of relays 512, 511, and 509, respectively. This application of ground potential suffices to operate the concerned one of the subgroup-lockout relays 111 to 120 for the previously described purpose.

With operate relay 513 not in operated condition, relay 512, on operating, immediately initiates the clearing-out operation by opening its contacts 2, such clearing-out operation then proceeding as previously described.

G. *Line controller—Connector calls*

The operation of the line controller shown in Fig. 5 in handling connector calls will now be described.

G1. *Seizure*

As previously described, when the line controller is seized, or called in, for a connector call, the operation in a connector of a chain relay (such as 211 of connector C1) is accompanied by the previously described operation of transfer and start relays 507 and 508 of the line controller. At its armatures 3 and 4 and their associated contacts, transfer relay 507 locks itself to the control chain independent of the finder branch thereof, and isolates the end of the finder chain conductor F-CH-END in cable 551. At its remaining contacts, transfer relay 507 makes the necessary circuit alterations to adapt the line controller for handling connector calls as distinct from handling finder calls.

G2. *Secondary test*

With transfer relay operated, the grounding of conductor 556 at contact 1 of relay 509 results in the closure of a circuit, through the front contact 1 of relay 507, and over conductor 558, for the connector-call connecting relay 532. Relay 532 connects the odd-numbered secondary-switch control leads to secondary test relays 534 to 548 respectively, all fifteen such relays being employed for connector calls, for there are fifteen connector-action (terminating) secondary switches. The secondary test relays accordingly now set themselves in accordance with the busy or idle condition of the connector-action secondary switches and associated terminating trunks. For example, if secondary switch B1 (Fig. 3) to which terminating trunk TT2 extends, is idle, secondary test relay 537 now energizes over the following circuit: from ground through the contacts of ground-control relay 533, lower winding of relay 537, contacts of connecting relay 532, winding of relay 537, contacts of connecting relay 532, control conductor CB1, make-busy contacts 306, and thence to battery through the winding of hold magnet 305. Magnet 305 is not effectively energized over the above-traced circuit, because of the high resistance of the lower winding of relay 537, but relay 537 operates as described in connection with finder calls.

G3. *Primary test*

As previously noted, the operation of a chain relay such as 211 of connector C1 is followed immediately by the operation of one or another of the tens relays 131 to 140, depending upon the value of the tens digit which has been dialed. Such relay connects the common primary control lead PA to PE respectively to the control conductors of the associated subgroup of primary switches, causing the primary test relays 526 to 530 to set themselves according to the idle or busy condition of such primary switches.

G4. *Matching*

The primary and secondary testing operations result in the operation of one or more of the matching relays 520 to 524, as described in connection with handling of finder calls. Thereupon, ground-control relay 533 is operated to terminate the secondary-testing operation as described.

G5. *Testing the called line*

As soon as the tens and units selection have been accomplished, by the described operation of one or another of the tens-select magnets TM1 to TM0 (Fig. 1), and the operation of one or the other of the units-select magnets UM1 to UM0, an operating circuit is completed: from ground on conductor PS-ON in cable 551, through contacts 5 of transfer relay 507 and over sleeve-operate conductor S0 in cable 552 for hold magnets 401 and 402 of sleeve connectors USC and TSC (Fig. 4). As shown in Fig. 10, USC is a switch in the primary group, and TSC is a switch in the secondary group. As a result, one or another of the stackups of contacts is closed in each sleeve connector, connecting called-line-sleeve conductor CLS in cable 552 to the sleeve conductor of the currently called line, such as sleeve conductor S11 (Fig. 1) or sleeve conductor S00 (Fig. 3).

By this operation, the sleeve conductor of the called line is connected, through contacts 2 of test-cutoff relay 506, to the winding of ground-connected test relay 503 in the connector group of the line controller. With hold magnets 401 and 402 both in an operated condition, a series ground connection is made through contacts controlled by such magnets, to test-start conductor ST in cable 552, thereby closing a circuit for lower winding of busy relay 505 through back contacts 2 of idle relay 504. The testing of the called line is thereby started, the result of the test being determined by whether or not test relay 503 operates during either of the two successive operating intervals hereinafter discussed. The first interval is the one following the operation of the sleeve connectors, but preceding the

operation of busy relay 505, while the second interval is the one following the operation of busy relay 505 (if it occurs), but preceding the operation of test-cutoff relay 506. Each of the relays 505 and 506 is arranged to be slow-operating, by virtue of its normally short-circuited upper winding, but to be fast-restoring because each such relay opens the short-circuit upon operating.

G6. *The called line is idle*

If the called line is idle, test relay 503 now operates over the sleeve conductor thereof, in series with the attached relays, such as 303 and 302. Upon operating, relay 503 closes an operating circuit for idle relay 504, from ground on the associated conductor ST. In this event, relay 504, at its back contacts 2, disconnects busy relay 505 before the latter relay has had time to operate. At its contacts 2, relay 504 locks itself to the associated conductor ST; prepares, at its contacts 1, to ground switching conductor SW in cable 554; and, at its front contacts 3, prepares a circuit over distributor-select conductor 561 to operate the distributor-select magnets of Fig. 4 in accordance with which terminating trunk is to be selected by the distributor group.

G7. *Called line tests busy initially*

Assume now that the called line tests busy initially; that is, that test relay 503 fails initially to operate because the sleeve conductor of the called line is grounded. In this event, idle relay 504 does not initially operate, permitting busy relay 505 to operate after a short interval. At the front contacts of its armature 1, busy relay 505 grounds lead BU in cable 554, thereby immediately operating the busy relay 208 of the connector C1.

G8. *Reverting-call test*

At its back contacts 2, busy relay 505 removes the shunt from around sleeve resistor 555, and closes a circuit for the operate winding of slow-operating test-cutoff relay 506, thereby initiating the reverting-call test. In explanation of this test, it may be assumed that the calling line is line #11, and that it has been extended by way of switches 1A and A2 and selector apparatus S1 (Fig. 1) to the connector C1 (Fig. 2). In this event, the sleeve conductor being tested by relay 503 is conductor S11 (Fig. 1), to which ground potential is applied (over the sleeve conductor S of the established connection) through front contacts 4 of release relay 204. With chain relay 211 operated in the connector C1, the front contact 4 of relay 204 connected, through front contact 1 of chain relay 211, to sleeve conductor SL in cable 554, which is then the sole supply of sleeve ground potential for the established connection. Prior to the operation of busy relay 505, ground potential is connected directly to sleeve conductor SL in cable 554, through back contact 2 of relay 505. Following the operation of relay 505, the sole supply of ground potential to the sleeve conductor of the established connection is through resistor 555. The potential drop through resistor 555 is insufficient to cause the release of operated relays such as 102 and 103, or of hold magnets such as 104 and 106, but is sufficient to cause an idle-indicating battery potential to appear on sleeve conductor S11 of the calling line. Since test relay 503 is now connected to such sleeve conductor (through USC and TSC, Fig. 4), test relay 503 operates in parallel with resistor 555, subject to the called line being also the calling line; that is, subject to the currently handled connector call being a reverting call. If it operates at this time, relay 503 brings about the operation of idle relay 504, and the latter relay locks operated. Relay 506 operates shortly following the operation of relay 505, disconnecting test relay 503 to terminate the testing operation.

It will be understood, of course, that the described line testing-operations proceed while the described switch-testing and matching operations are occurring.

G9. *Distributor selection*

If the call being handled is not a reverting call, and is directed to an idle line to which an idle switching path can be matched, distributor selection is effected over the following circuit: from ground on conductor PS–ON in cable 551 (grounded only after tens and units selection have been effected), conductor 562, contacts 5 of one or more of the matching relays 520 to 524, conductor 563, front contact 6 of transfer relay 507, front contacts 3 of idle relay 504, back contacts 5 of busy relay 505, distributor-select conductor 561, contacts of one or another of relays 515 to 519 and of 520 to 524, one or another of conductors 591 to 595, contacts of one or another of relays 534 to 548, and thence to battery over one or another of the distributor select leads DS–1 to DS–15 in cable 551 and the associated magnet windings shown in Fig. 4. For example, if the B-choice relay 516 in the choice allotter is currently operated, and if B-match relay 521 and secondary-test relay 537 are operated, the distributor select ground on conductor 561 extends through the contacts 5 of relay 516, front contacts 4 of matching relay 521, conductor 592, front contacts 3 of secondary-test relay 537, to distributor lead DS–2, closing a circuit for the upper winding of distributor-magnet DM2 (Fig. 4) in series with distributor-magnet DM12. Magnets DM2 and DM12 are thereby energized to perform their respective functions. As explained in my previously noted application for Automatic Telephone Systems, select magnet DM11 selects the eleventh (switching) stackup in the distributors, while magnet DM12 performs no direct selective function, but secures the closure of distributor-offnormal contacts DON 11, 12. Magnet DM2 effects selection of the second stackup in the several distributors, also causing distributor-offnormal contacts DON 1, 2 to close.

G10. *Closing the operating circuits*

During a connector call, the closing (over operate conductor 560) of the operating circuits is effected, if at all, only after the distributor select magnets have been operated, whereupon the ground potential on distributor-select lead 561, to which conductor 1 of pair DON in cable 551 is connected, is extended through distributor-offnormal contacts DON 11, 12 (Fig. 4), one or another of the remaining off-normal contacts of the distributor, conductor 2 in pair DON, contacts 3 of cycle timer relay 511, back contacts 5 of clearout relay 512, and thence to battery through the winding of operate relay 513. With busy relay 505 not operated, relay 513, at its contacts 4, applies ground potential to operate conductor 560. With relays 516, 521, and 537 in operated condition as previously assumed, the ground potential on conductor 560 is extended through contacts of relays 516, armature 3 and front contact of relay 521, to conductor 582. One branch circuit extends through contacts 2

of relay 527, to primary control conductor PB, to operate the "B" switch in the concerned primary subgroup, while another branch extends through front contact 2 of relay 537, and contacts of connecting relay 532 to secondary-control lead CB1, to operate secondary switch B1 (Fig. 3).

At its contacts 1, relay 513 applies ground potential to conductor SW in cable 554, by way of contacts 1 of idle relay 504. If the calling connection is in connector C1, switching relay 207 now operates, and closes the previously described operating circuit for magnet 304 of distributor DR1, completing connection through the upper three pairs in stackup 2 of such distributor and by way of terminating trunk TT2 to the operated secondary switch B1.

G11. *Clearing out*

Additionally, relay 513 operates relay 512 to cause the line controller to clear out as described in connection with the handling of finder calls, relays 513 and 512 restoring successively for this purpose. At its contacts 5, transfer relay 507 removes ground from conductor S0 in cable 552, permitting sleeve connectors USC and TSC (Fig. 4) to clear out. Any operated ones of relays 503 to 506 responsively restore, as conductor CLS in cable 552 is disconnected and conductor ST in such cable is ungrounded.

G11*a*. *Regular-busy clearout*

As described, if the called line is regularly busy (not busy merely because it is the calling line), busy relay 505 operates, and idle relay 504 remains restored. With busy relay 505 operated, ground potential cannot be extended to distributor-select conductor 561, whereby distributor selection is not effected. With idle relay 504 not operated, operate relay 513 cannot be operated to ground conductor SW in cable 554.

When test-cutoff relay 506 operates, following operation of busy relay 505, a circuit is closed: from ground through front contact 4 of relay 505, back contact 3 of idle relay 504, contacts 3 of test-cutoff relay 506, to battery through the winding of clearout relay 512. Operate relay 513 being in restored condition, the opening of contacts 2 of clearout relay 512 immediately restores relays 508 and 507, and the concerned connector chain relay, such as 211.

When ground potential is removed, as described, from conductor ST in cable 552, relays 505 and 506 restore successively. The initial circuit of clearout relay 512 is thereby opened, permitting such relay to restore along with the other relays in the line controller.

G11*b*. *Reverting-call clearout*

If the previously described testing operation determines that the call being handled is a reverting call, the operation of busy relay 505 is followed by the operation of idle relay 504. The opening of contacts 4 of busy relay 505 precludes grounding of operate conductor 560 by operate relay 513, while the operation of armature 5 of busy relay 513 (preceding the operation of relay 504) precludes the application of ground potential to distributor-select conductor 561. Operate relay 513, under these conditions, is operated over the following circuit path: from ground, through front contacts 4 of relay 505, front contacts 3 of relay 504, front contacts 5 of relay 505, front contacts 3 of relay 51, back contacts 5 of relay 512, and thence to battery through the winding of relay 513. Relay 513, besides initiating the clear-out operation as previously described, ground conductor SW in cable 554 so as to bring about the operation of a switching relay such as 207 in the calling connector, the busy relay 208 in such connector having been previously operated by busy relay 505.

G11*c*. *Lost-connector-call clearout*

As previously noted, when the called line tests regularly idle (relay 504 operating and relay 505 remaining restored), the closure of a circuit for operating relay 513 is dependent upon the closure of contacts 5 of one or another of matching relays 520 to 524. If none of these relays is able to operate by the time the cycle timer (comprising relays 509 to 511) completes its cycle of operations, relays 512 and 513 are still in restored condition when cycle-timer relay 511 restores. Under this condition, ground potential is applied to conductor 565, through contacts 3 of relay 512, contacts 2 of relay 511 and contacts 4 of relay 509. Under the assumed conditions, the grounding of conductor 565 applies ground potential to lead BU in cable 554 through contacts 2 of relay 507, and back contact 1 of relay 505, to operate busy relay 208 of the calling connector, to cause the return of a busy signal to the calling line as a notification that the desired connection cannot be completed. The line controller then clears out responsive to the operation of clearout relay 512 by cycle timer relay 511.

H. *Translator arrangement*

The translator arrangement, in its simplest illustrated aspect, includes the translator group of relays (549, 550, 501, and 502 in the line controller, Fig. 5, part 1), the translator T1 of Figs. 6 and 10, and the reset bus bars 701 to 720, Fig. 7. This apparatus suffices to supply what is herein termed number-transfer service, through which (*a*) a call for a disconnected line is transferred to a predetermined line of the group assigned to the intercept operator, and (*b*) calls are transferred to compensate for shifts in line locations which may be made from time to time to balance the traffic through the several primary subgroups. Such rerouting (or call-transfers) eliminates the necessity, which would otherwise arise, of assigning a new number to any line shifted from one primary subgroup to another.

The apparatus of Fig. 8, operating in conjunction with the above-noted translator group of relays in the line controller, and in conjunction with the apparatus of Figs. 6 and 7, provides for the economical handling of calls to groups of lines, such as P. B. X groups. The apparatus of Fig. 8 further provides for the routing of intercepted calls to the intercept operator over one or another of a group of lines assigned to such service.

The apparatus of Fig. 9, operating in conjunction with the translator apparatus of Figs. 5, 6, and 7, as well as with the party registers such as PR2 (Fig. 2, part 2) of connector C1, provides intercept service with respect to any disconnected station on a party line.

Referring now to Figs. 6 and 10, it will be observed that the units translator switch UT of translator T1 is an additional switch in the primary group. Stackups 1 to 0 of switch UT, therefore, correspond respectively to units-select magnets UM1 to UM0 of Fig. 1.

Each of the translator switches TTA and TTB

(Figs. 6 and 10) is an additional switch in the secondary group. The ten stackups 1 to 0 in either of the switches TTA and TTB, therefore, correspond respectively to the units-select magnets TM1 to TM0 of Fig. 1.

Any stackup 1 to 0 of translator switch TTA contains ten pairs of contact elements arranged to extend the five pairs of conductors X1 to X5 (controlled respectively by stackups 1 to 5 of switch UT) to five pairs of translator terminals. Each of the stackups 1 to 0 of the similar translator switch TTB is arranged to extend the five pair of conductors X6 to X0 (corresponding respectively to stackups 6 to 0 of units translator switch UT) to five pairs of terminals. Accordingly, the upper contact terminals of the contact pairs of switches TTA and TTB comprise one-hundred pairs of translator terminals corresponding respectively to the one-hundred line numbers of the unit. For example, considering stackup 1 of the switches TTA and TTB, reading from top to bottom, the ten terminal pairs represented by the upper elements, elements of the contact pairs, reading from top to bottom, correspond respectively to line numbers 11 to 10, normally assigned to the lines served by the first primary subgroup of Fig. 10. Stackups 2 to 0 in the two switches TTA and TTB correspond respectively to number groups of ten normally assigned respectively to primary subgroups 2 to 0 of Fig. 10, and each such stackup of the translator switch provides ten pairs of translator terminals corresponding respectively to the ten line numbers within the group of ten.

H1. *Number-transfer service*

When the unit is initially installed, the illustrated translator terminals (the terminal ends of the upper contact members of the respective contact pairs of switches TTA and TTB) are ordinarily left unconnected, except for jumper connections such as those installed for a group of lines (such as a P. B. X group) having a common call number.

It may frequently happen that the five line links serving a primary subgroup are overloaded because the primary subgroup contains more than its share of high-traffic lines, while the line links of other primary subgroups within the unit are underloaded. The unbalanced traffic condition among the several primary subgroups can be substantially eliminated by interchanging high-traffic lines of one subgroup with low-traffic lines of another subgroup. The required interchanging of lines may be made conveniently at the usual main distributing frame (M. D. F.), not shown herein. When such an interchange in line locations has been made, jumper pairs can be installed between the translator T1 of Fig. 6 and the reset bus bars of Fig. 7 to correspondingly reroute calls for the shifted lines, to the end that calling the original number of any such shifted line results in the rerouting (or transfer) of the connection to the line at its shifted location.

H1a. *Translating line No. 21 to line No. 10*

It will now be assumed that one or more lines have been interchanged between the first and second subgroups, and that these shifted lines are to retain their original numbers. By way of example, it will be assumed that the line bearing the initially assigned line number 21 has been shifted from the second primary subgroup to the first, and that it replaces the line therein to which the line number 10 was initially assigned. Calling the original number 21 of this shifted line results in the establishment of a connection thereto provided a two-conductor jumper is attached to the terminal pair 21 of the translator which corresponds to the initial number of the shifted line, and is extended to the reset bus bars (701 and 720) which correspond to the tens and units designation of the line in its shifted location. Such a jumper is shown at 604, Figs. 6 and 7, comprising a tens conductor T and a units conductor U. With conductor 604 in place, calling a telephone number (such as 7211) containing line number 21 results in rerouting (or transfer) operations now to be described.

It may be assumed that the dialing of the hundreds digit 7 results in the extension of a connection as hereinbefore described to the connector C1 of Fig. 2. In this event, the dialing of the line number (the tens and units digits 2 and 1 in the assumed telephone number) causes the tens and units registers TR and UR, Fig. 1, part 2, of the connector C1 to be positioned according to the digits 2 and 1, respectively. The dialing of the station suffix digit causes the party registers PR1 and PR2 to be positioned accordingly, following which chain relay 211 of the connector C1 operates, and the line controller of Fig. 5 is called in for connector action as hereinbefore described.

With registers TR and UR positioned respectively in accordance with tens digit 2 and units digit 1, the grounding of conductors 231 and 232 by chain relay 211 energizes tens conductor T2 in cable 247 and units conductor U1 in cable 248 to cause the second tens select magnet TM2 and the first units select magnet UN1 of Fig. 1 to be operated as hereinbefore described. The second tens group (the second primary subgroup) is responsively selected in the secondary switch group shown in Fig. 10, and the first line in any primary subgroup is selected in the group of primary switches. Except for the presence of the conductors T and U comprising jumper 604 of Figs. 6 and 7, the resultant action of the line controller of Fig. 5, and of the sleeve connectors USC and TSC of Figs. 4 and 10 would cause the connection to be extended to the line now connected to the switchboard terminals to which line #21 was originally assigned (the first line position in the second primary subgroup of lines), if idle. This, however, is prevented by translator action, now to be described, which causes the line number 21 received by the connector C1 to be erased, and causes the translated line number 10 to be substituted.

The operation of the above-noted primary and secondary select magnets of Fig. 1 results in the previously-described application of ground potential to conductor PS–ON in cable 551. The grounding of this conductor closes the previously-described circuit, through contacts 5 of transfer relay 507 and conductor SO in cable 552, for operating hold magnets 401 and 402 of sleeve connectors USC and TSC of Fig. 4. At the same time, the ground potential on conductor PS–ON is further extended, through normally closed contacts controlled by armature 5 of cut-off relay 501 in the translator group, to operate lead OP, extending to hold magnets 601 to 603 of translator switches TTA, TTB, and UT.

Since the selecting apparatus of the secondary group of switches is set in accordance with the dialed tens digit 2 (tens magnets TM2 of Fig. 1 being energized), and since the selecting appara-

tus of the primary group of switches is set in accordance with the units digit 1 (units magnet UM1 of Fig. 1 being energized), the operation of magnets 601 and 602 results in the closure of the second stackup of tens translator switches TTA and TTB, and the operation of hold magnet 603 results in the closure of the first stackup of units translator switch UT. With the translator apparatus set as described, the tens and units conductors T and U in group 611 (Figs. 5 and 6) are extended, through the closed contacts of the first stackup of switch UT, over conductors T and U in group X1 to the terminals of the uppermost pair of make contacts in stackup 2 of translator switch TTA. With jumper 604 installed as illustrated, the above-noted conductors in group 611 are further extended, over conductors T and U of jumper 604, to the first tens bus bars 701 and the tenth units bus bar 720, respectively.

In the translator group of the line controller (Fig. 5, part 1) conductor U of group 611 is normally grounded through back contact 4 of intercept relay 549, wherefore a ground potential is extended over the above-traced units conductor path to the tenth units bus bar 720, thereby grounding the tenth units conductor U0 in units cable 248, preparatory to operating units-preference relay UP0 of Fig. 1. Relay UP0 does not operate for the time being, as the units-preference chain (for relays UP1 to UP0) is currently open at the inner lower contacts of the operated units-preference relay (UP1).

Conductor T in group 611 is normally connected, through back contact 1 of reset relay 550, to ground through the winding of high-resistance translator-test relay 502. With jumper 604 in place, the described setting of the translator closes a circuit from ground through the winding of relay 502, and thence over the previously-traced path (including tens conductor T in jumper 604) to tens bus bar 701, and thence over conductor T1 in tens cable 247, to battery through the upper winding of tens relay 131, Fig. 1. Test relay 502 operates over the above-traced circuit in series with relay 131, but the latter relay does not operate for the time being because of the high resistance of relay 502.

On operating, relay 502 disconnects start conductor ST in cable 552, from the relays of the connector group, thereby preventing testing of the sleeve conductor with which sleeve connectors TSC and USC (Fig. 4) have made connection. Relay 502 also transfers the grounded conductor ST to the winding of cutoff relay 501, thereby operating the latter relay.

At its contacts 3, cutoff relay 501 locks itself to ground through the winding of reset relay 550 and contacts 3 of start relay 508, but no current flows over this locking circuit so long as the initial circuit of relay 501 is maintained. At its contacts 4, relay 501 disconnects ground from units-lock lead UL to permit the operated units-preference relay (UP2) to restore when its initial circuit is opened.

At its armature 5 and associated contacts, relay 501 applies ground potential directly to lead OP in group 611, to maintain the hold magnets of the translator of Fig. 6 operated after the initial selection in the primary and secondary groups has been cleared out to unground conductor PS–ON in cable 551. At the same time, the concerned conductors (PS–ON and OP) are isolated from each other.

At its contacts 1 and 2, cutoff relay 501 disconnects ground from tens and units conductors T and U in cable 554, thereby disconnecting ground potential from contacts 8 and 9 of chain relay 211 of connector C1, and thereby from conductors 231 and 232 leading to the contact mechanism of tens and units registers TR and UR of Fig. 2, part 2. By this operation, the previously-existing marking potential is removed from the associated tens connector T2 in cable 247 and the associated units conductor U1 in cable 248, thereby restoring the operated tens relay (#2, not shown, similar to 131 or 149) to restore tens select magnet TM2, and restoring the operated units-preference relay UP1 to restore the operated units select magnet UM1.

Upon the restoration of relay UP1, the operating chain for relays UP1 to UP0 is reclosed at the inner lower contacts of relay UP1, whereupon relay UP0 operates over the ground potential extended over the above-described path to conductor U0 in cable 248, which path includes conductor U in group 611, contacts in the translator of Fig. 6, and conductor U in jumper 604. Units select magnet UM0 now operates.

As a result of the restoration of the previously-operated select magnets, ground potential is removed from conductor PS–ON in cable 551, and consequently from conductor S0 (an extension of it through contacts 5 of relay 507), thereby restoring magnets 401 and 402 to clear out the sleeve connectors. This operation removes ground potential from conductor ST in cable 552, thereby opening the initial circuit of cutoff relay 501 of the translator group. Relay 501 remains operated, and reset relay 550 now operates, in the locking circuit of relay 501, which includes the contacts 3 thereof, the winding of relay 550, and contacts 3 of start relay 508.

At its contacts 1, reset relay 550 disconnects tens conductor T in cable 611, from the winding of high-resistance test relay 502 and transfers it to ground through contacts 2 of intercept relay 549. Test relay 502 accordingly restores, and the first tens relay 131 (which failed to operate previously because of the high resistance of relay 502) now operates to call in the switches of the first tens group (first primary subgroup), and to operate tens select magnet TM1 to select the first primary subgroup.

As soon as the concerned tens and units select magnets (TM1 and UM0 of Fig. 1) have operated to impart the reset selection to the secondary and primary switch groups dictated by the connections made through jumper 604 to reset bus bars, conductor PS–ON in cable 551 is again grounded, to again ground conductor S0 in cable 552, whereupon magnets 401 and 402 are reoperated to impart a new setting to the sleeve connectors USC and TSC, according to the reset condition of the secondary and primary select magnets. Stackup 0 is closed in switch USC and stackup 1 is closed in switch TSC to thereby extend conductor CLS in cable 552 to sleeve conductor 10 (not shown) extending to the corresponding line circuit to which the called line No. 21 has been transferred.

Magnets 401 and 402 reground conductor ST in cable 552 to restart the relays of the connector group to test the called line. If such line is idle, connection is made thereto, at its transferred location, by operations as hereinbefore described.

The cycle timer, comprising relays 509 to 511, provides enough margin of time, a second or two, to permit all the foregoing operations to occur before it completes its cycle-timing operations.

H2. *Single-trunk intercept service*

The service through which a call for a disconnected line or station reaches an operator, to enable the calling subscriber to be informed that the called line or station has been disconnected, is termed intercept service. Intercept service may be provided for the disclosed 100-line unit over a single line or trunk, connected in place of one of the subscriber lines, or such service may be provided over a group of such lines or trunks, as the necessity may arise. It may be assumed that intercept service is provided for the disclosed unit over a single line, termed an intercept trunk.

H2*a*. *Line intercept*

Under the assumed conditions, if a line over which service has been given is disconnected (as when the subscriber moves to another locality) a jumper similar to **604** may be extended from the corresponding terminals of one or another of the translator switches TTA and TTB of Fig. 6 to the concerned ones of the tens and units reset bus bars **701** to **720**. With this jumper in place, the calling of the number of the disconnected line causes reset operations to be controlled thereover as described hereinbefore for jumper **604** to transfer the call to the line used as an intercept trunk. This causes the described cancellation of the original setting of the primary and secondary select magnets after the record of such setting is locked in on the translator apparatus of Fig. 6, and causes the select-magnet apparatus of the primary and secondary groups to be reset in accordance with the above-noted intercept jumper connections. The connection is extended in accordance with the resetting, all as hereinbefore described.

H2*b*. *Individual station intercept*

If one or more individual stations on a party line are disconnected, leaving the line in use for other stations still connected thereto, calls to the line in question are to be intercepted subject to being also for a station which has been disconnected therefrom. The distinction between a call for a disconnected station on a line and for some other station thereon is made through the use of a second party register for each connector (such as register PR2, Fig. 2, part 2, for the connector C1), in conjunction with the apparatus of Fig. 9.

Referring to Fig. 9, a suitable number of party-line relays, such as **901** and **902**, is provided according to the maximum number of party lines likely to require individual station intercept service at any one time. When any party line requires individual station-intercept service, a jumper such as **607** is extended from the corresponding units terminal in one or another of the translator switches TTA and TTB to block **903**, and is connected to the terminal therein of the concerned party-line relay, such as **901** or **902**. An associated terminal in block **903** is jumper-connected (as by one of the jumpers **904**) to the station bus bar **911** to **920** which corresponds to the station digit assigned to the station which has been disconnected from the line. For example, if line #02 is a party line from which station 1 has been disconnected, jumper **607** and the first jumper in group **904** are installed. The installation of the illustrated jumper **607** results in the closure of the following circuit path when the tens and units digits (0 and 2) designating the party line in question have been dialed, and the select-magnet and translator apparatus have been positioned in accordance therewith: from ground through back contact **4** of intercept relay **549**, units conductor U in group **611**, the lower contact pair in stackup **2** of units translator UT, conductor U of group X2, a closed contact pair in stackup **0** of tens translator switch TTA, jumper **607**, to battery through the winding of relay **901**. Relay **901** now operates to ground each associated jumper terminal in block **903**, but without effect unless a station bus bar (**911** to **920**) to which one such jumper extends has been rendered effective by the second party register of the connector through which the line controller of Fig. 5 has been called in.

Assuming that the connector of Fig. 2 is the one associated with the line controller, and that the disconnected station 1 on the called line #02 has been called, the operation of relay **901** closes an operating circuit for the upper winding of intercept relay **549** from ground over the first jumper **904**, station bus bar **911**, conductor I1 in cable **246**, the closed first contact pair of party register PR2, conductor **234**, contacts **7** of the operated chain relay **211**, conductor PL–IC in cable **554**, to the upper winding of relay **549**. Upon operating, relay **549** closes a locking circuit for its lower winding, through its own contacts **1** and contacts **3** of start relay **508** so as to remain operated after its initial circuit has been opened. At its contacts **2** and **4**, relay **549** disconnects conductors T and U in group **611**, thereby rendering ineffective the translator apparatus of Fig. 6, open-circuiting and restoring the operated intercept relay **901**. This operation opens the initial circuit of relay **549**, but leaves it locked operated through its lower winding.

At its front contact **4**, relay **549** grounds conductor **832**, but this conductor is a jumper which is installed only when intercept service is provided over more than one line, a case to be hereinafter considered.

At its contacts **5** and **6**, relay **549** prepares to extend a connection to terminals **500**, but this connection remains open at the contacts of relay **550** for the time being.

At its contacts **3**, intercept relay **549** closes a local circuit for test relay **502** which thereupon operates with results as hereinbefore described. These results include the operation of cutoff relay **501** to cancel the initial primary and secondary select-magnet setting. Following this, the sleeve connectors of Fig. 4 clear out, and reset relay **550** operates in the self-locking circuit of relay **501**, followed by the restoration of test relay **502** to reactivate the testing apparatus of the associated connector group of relays when the selecting apparatus has been reset.

With relay **549** operated, the operation of reset relay **550** applies ground potential to each of the terminals of pair **500**. A two-wire jumper (not shown) similar to jumpers **604** and **606** is extended from terminal **500** to the reset bus bars of Fig. 7 corresponding to the line used as an intercept trunk. The consequent grounding of such bus bars causes reset operations as hereinbefore described to occur to complete the call to the line assigned to the intercept operator.

It will be evident that calls to any one of several stations that have been disconnected from the same party line may be independently intercepted, one for each jumper such as **904**.

Referring again to Figs. 6 and 7, it will be observed that the translator pair of terminals of

the party-line line number (02) last considered has the two-wire jumper 606 extending therefrom to reset bars 702 and 720. Jumper 606, in combination with jumper 607, illustrates a condition wherein a line may be shifted from one tens group to another (from the second line location in the tenth tens group to the tenth line location in the second tens group) and still have normal station intercept service. With jumper 606 in place, a call to line #02 causes circuits to be closed over conductors T and U in jumper 606 to result in operations similar to those hereinbefore described to transfer the call to line terminals 0 in primary subgroup 2. With intercept jumper 607 in place, and if the call for the shifted party line P2 is for a disconnected station thereon, the described operation of relay 901 over jumper 607, and the resulting operation of station-intercept relay 549 to disconnect translator conductors T and U in group 611, cancels the effect of jumper 606, but leaves relay 549 locked operated as hereinbefore described to transfer the call to the intercept operator rather than to the called line in its shifted location.

H3. *Common-number groups*

As previously noted, the apparatus of Fig. 8 operates in conjunction with other disclosed apparatus to provide service to common-number groups of lines, such as a P. B. X. group. When the number of any such group of lines is called, an operation must occur to direct the extension of the connection to an idle line of the group. The apparatus of Fig. 8 is used to call in the lines of any called group for test and to control the extension of the connection to an idle one thereof. This apparatus includes as many connecting relays such as 801 and 802 as there are separate groups of lines employing respective call numbers, and as many test relays 803 to 807 as there are lines in the largest group.

Relays 801 and 802 comprise the first and the last of a group of connecting relays, of which the intermediate relays are omitted. Five test relays 803 to 807 are illustrated. This number, however, can be increased as desired, to ten or fifteen for example, where groups are encountered comprising more than five lines each.

Each connecting relay 801 or 802 has a terminal block 810 or 811 associated therewith to the terminals of which jumpers can be connected as required. Each such terminal block includes five sleeve terminals S1 to S5 which may be extended by jumper wires to the sleeve conductors of the concerned lines, similar to the sleeve conductor S11 of Fig. 1, or the sleeve conductor S00 of Fig. 3.

Each terminal block 810 or 811, includes a call-number pair of terminals GT and GU, to which the tens and units conductors of a jumper, such as 605, may be extended from the translator apparatus to call in the group of lines responsive to the calling of the common call number assigned thereto.

Each block 810 or 811 includes five terminal pairs T1, U1 to T5, U5 for respective jumpers, such as 830, to be extended to the reset bus bars of Fig. 7. One or another of these terminal pairs is rendered effective, to transmit marking potential to the reset bus bars, depending upon the setting of the test relays 803 to 807 when the group is called in, and upon the order of preference according to the current position occupied by the choice allotter of Fig. 5, part 2.

Preferably, each line of a common-number group is located in a separate primary subgroup to maintain a better condition of traffic balance among the primary subgroups.

The installation of the illustrated jumper 605 assigns line-number digits 0 and 1 to the group of lines identified with connecting relay 801 and terminal block 810. Since hundreds digit 7 is assigned to the 100-line unit, the assignment of an arbitrary station-suffix digit 1 completes the common call number as 7011.

It may be assumed that the connector C1 of Fig. 2 has been seized as hereinbefore described responsive to the hundreds digit 7, and that the tens, units and stations digits 0, 1 and 1 have been dialed and recorded in the registers of Fig. 2, part 2, and that chain relay 211 has operated incidental to the calling in of the line controller of Fig. 5. The secondary and primary selecting apparatus is accordingly set in accordance with the tens and units digits 0 and 1, the sleeve connectors of Fig. 4, and the translator switches of Fig. 6, are set in accordance therewith, as hereinbefore described. When this occurs, connecting relay 801 is energized by the ground potential extended through the translator apparatus over conductor U in jumper 605, and the high-resistance test relay 502 in the translator group of the line controller is operated over conductor T in jumper 605, in series with resistor 808 common to the several connecting blocks. Relay 502 operates relay 501 as hereinbefore described to clear out the primary and secondary select magnets and the sleeve connectors, whereupon reset relay 550 operates as described to commence the resetting operation.

Upon operating, relay 801 connects the sleeve terminals S1 to S5 respectively to the windings of test relays 803 to 807, and it connects the five pairs of reset terminals (T1, U1 to T5, U5) respectively to test relays 803 to 807, preparatory to resetting the secondary and primary select magnets under the control of the test relays and the preference allotter of the line controller.

If the group of lines associated with relay 801 and terminal block 810 contains five lines, each of the sleeve terminals S1 to S5 in block 810 is jumpered to a sleeve conductor of a separate line of the group. If the group contains fewer than five lines, one or more of the sleeve terminals is left unjumpered.

Each of the relays 803 to 807 for which a sleeve jumper is in place for the called group operates, subject to the line with which it is associated being idle. For example, if line #01 corresponding directly to the call number (7011) is idle, test relay 803 operates through the upper contacts of relay 801, sleeve terminal S1 in block 810, over the illustrated jumper extending therefrom, and in series with the relays (such as 303 and 302) connected to the sleeve of line #01. The latter relays do not operate at this time because of the high resistance of the winding of test relay 803. It will be understood, of course, that relay 803 does not operate if the associated line is busy, as the ground potential then maintained on the sleeve conductor shunts operating current away from the test relay.

Upon operating, relay 803 disconnects tens and units reset conductors RS1 in cable 553 from the contacts of the next succeeding test relay and transfers them to terminals T1 and U1 in block 810, by way of contacts of the operated connecting relay 801. Operation of any one of the remaining test relays 804 to 807 performs a similar

operation with respect to the associated one of the reset conductor pairs RS2 to RS5 in cable 553.

When reset relay 550 operates as hereinbefore described, it grounds reset conductors 564 and 565 to thereby ground one or another of the five pairs of reset conductors RS1 to RS5 in cable 553, depending upon the current setting of the choice allotter (relays 514 to 519). In the present example, it may be assumed that the choice allotter is in its first position (relay 515 operated and relays 516 to 519 restored), in which case conductors RS1 in cable 553 are grounded, giving first choice to the line with which the first test relay 803 is currently associated. In this event, with test relay 803 operated as described, the ground potential on conductors RS1 is further extended, through contacts of relay 801, to the conductors in jumper 830, thereby applying reset potential to bus bars 710 and 711. The grounding of these bus bars causes the secondary and primary selecting apparatus to be reset for the corresponding line selection, whereupon the connection is extended to the line corresponding to the reset selection.

From an inspection of Fig. 8, it will be apparent that (under the assumed conditions) if the first line is busy (relay 803 not operating) the resetting ground potential on conductors RS1 is extended to the contacts of the second test relay 804. If the associated line is idle, relay 804 is operated and the ground potential on conductors RS1 is extended to terminals T2 and U2 in block 810, by way of contacts of relay 801. The reset jumper (not shown) extending from these terminals to the reset bus bars of Fig. 7 is thus rendered effective to direct the connection according to the tens and units location of the second line of the group.

In a similar manner, if the group contains additional lines, the connection may be completed to any succeeding line of the group. For example, it may be completed to the fifth line of the group responsive to the ground potential on conductors RS1 being extended through back contacts of relays 803 to 806 and front contacts of relay 807 to terminals T5 and U5. If no line of the group is idle, none of the relays 803 to 807 operates, wherefore no reset connection is established. In this event, relays 509, 511, and 512 of the cycle timer cooperate to ground busy lead BU in cable 554 to cause a busy signal to be returned to the calling line as described.

It is to be understood that, by the action of the choice allotter of Fig. 5, part 2, the preference may stand at any one of the five test relays 803 to 807 when a call is made to a group of lines, and that therefore, the line associated with any one of the five test relays may have the preference to receive the call if it is idle. In this regard, it will be observed that the armatures and back contacts of relays 803 to 807 are interconnected in an endless chain.

One advantage of the illustrated and described arrangement for shifting the preference from line to line of a group is that the traffic load of a group is thereby distributed more evenly over the lines thereof, and consequently more evenly to the concerned primary subgroups. A resultant advantage over the usual fixed-choice arrangement is that a defect in no single line can block the eventual effective extension of a connection to a line of the group. For example, if a call is made to the group and the line first reached is defective, the likelihood is great that a replacement of the call will result in an extension of the connection to a different line of the group.

It will be understood that the calling of another group of lines will result in the operation of another connecting relay similar to 801 or 802 to connect the test relays 803 to 807 with the sleeve jumpers and reset jumpers of the lines of such other group, wherefore the test relays 803 to 807 are used in common by all such groups.

H4. *Plural-trunk intercept service*

It is sometimes highly desirable to extend two or more lines (usually termed intercept trunks) from the disclosed line unit to the station of the intercept operator, and to make arrangements for the extension of a connection to the intercept operator over any idle one of such lines. In Fig. 8, connecting relay 802 is illustrated as allotted to a group of lines extending from the disclosed line unit to the station of the intercept operator. When relay 802 and its associated terminal block 811 are used for this purpose, the previously described jumpers (not shown) connected to terminals 500 are removed; jumper 832 is installed to associate station-intercept relay 549 with group relay 802, and jumpers such as 831 are installed for calling in relay 802 in response to a call to a disconnected line. Additionally, the sleeve and reset terminals in block 811 are jumper-connected to the concerned sleeve conductors and reset bus bars as described in connection with relay 801 and terminal block 810.

With jumper 832 in place, the previously described operation of intercept relay 549, responsive to the calling of a disconnected station on a party line, results in the grounding of jumper 832 at front contact 4 of relay 549 to operate connecting relay 802. This relay makes appropriate connections to the windings and contacts of test relays 803 to 807 to cause the lines of the intercept group to be tested and to cause the selecting apparatus to be reset to direct the connection to an idle one of them.

When a call is made to a disconnected line, a jumper such as 831 is thereby connected up through the translator apparatus of Fig. 6 to operate connecting relay 802, along with test relay 502 in the translator group, thereby directing the connection to an idle line leading to the station of the intercept operator rather than to the terminals of the disconnected line.

I claim:

1. In an automatic telephone system, a switchboard including a group of sets of line terminals divided into similar subgroups, a group of line links for serving lines connected respectively to said sets of terminals, said line links being divided into corresponding subgroups each containing sufficient links to serve the lines connected to the corresponding subgroup of terminals provided the subgroups connected lines are generally in balance from the standpoint of the traffic thereover, trunks serving said lines through the medium of said links, switching apparatus for interconnecting any set of line terminals and connected line with any idle line link in the corresponding subgroup and for interconnecting the line links with said trunks, the sets of line terminals having telephone numbers assigned respectively thereto, normal means responsive to the extension of a connection to an idle one of said trunks and to the transmission thereover of sets of digit impulses in accordance with the telephone number of any said set of line terminals for operating said switching apparatus to extend the connection to

such line terminals and connected line by way of an idle line link in the concerned subgroup, said lines being connectable to said sets of terminals and being thereafter capable of being shifted from subgroup to subgroup to balance the traffic among subgroups, and overriding means responsive to the extension of a connection to an idle one of said trunks and to the transmission thereover of sets of digit impulses in accordance with the telephone number of any said set of line terminals from which the line has been shifted for disabling said normal means and for individually translating the called telephone number into the telephone number assigned to any one of said sets of line terminals to which such line may have been shifted, said automatic switching apparatus being thereupon responsive to the translated number, rather than to the disabled said normal means, to extend the connection to the shifted line in its new location.

2. In an automatic telephone system as set forth in claim 1, with the overriding means recited therein being herein termed first overriding means, second overriding means effective when a station has been disconnected from a called party line for translating the number of the disconnected station into a number for routing the call to a line of the group assigned to serve as an intercept trunk, and means giving said second overriding means preference over said first overriding means when both apply to the same called telephone number.

3. In a switching system, a group of selective primary switches and a group of selective secondary switches serially related for the extension of connections, separate multi-position selecting apparatus for each group, any switch in either group being operable to complete any one of a number of connections, depending upon the position currently occupied by the associated selecting apparatus, sets of translator terminals, each said group including at least one switch common to the remaining switches thereof, means effective when a desired connection is to be completed for correspondingly setting the selecting apparatus of each group and for operating a common switch of each group to complete a series connection through a common switch of the other group to a set of translator terminals determined jointly by the setting of the selecting apparatus of the two groups, sets of reset bus bars associated with the two groups of switches respectively, said reset bus bars and said translator terminals being adapted to terminate conductors comprising relatively temporary connections between them, means for energizing a bus bar in each set over the said connection dependent on concerned ones of said relatively temporary connections having been previously extended respectively thereto from the connected translator terminals, and means responsive to such energization for canceling the initial setting of the selective apparatus of the two groups of switches and for resetting such selective apparatus in accordance with the energized bus bars.

4. In a switching system, (*a*) a group of separately numbered sets of line terminals, lines bearing similar respective call numbers and normally connected respectively to said terminal sets, sets of translator terminals also bearing similar respective call numbers, reset conductors connectable to any set of translator terminals in accordance with the shifted location of any line which has been shifted from one terminal set to another, (*b*) a group of primary switches and a group of secondary switches serially related for the extension of connections to said sets of line terminals, each switch group further including a sleeve-connector switch, the sleeve-connector switch of either group being serially related with the one in the other group for the extension of preliminary test connections to the sets of line terminals, each switch group further including a translator switch, the translator switch of either group being serially related with the one in the other group for extending connections to the sets of translator terminals, (*c*) separate multi-position selecting apparatus for each switch group, any switch in either group being operable to make any one of a number of connections depending upon the position currently occupied by the associated selecting apparatus, (*d*) means responsive to the calling of the number assigned to a desired line for setting the selecting apparatus of the said groups in accordance with such number, (*e*) means for thereupon operating the sleeve-connector switches to make a test connection to the set of line terminals bearing the called number, means normally controlled over such test connection for operating a switch of each group to complete a connection to the called line by way of the last-named set of line terminals subject to such line being idle and to the sleeve-connector switches remaining operated, (*f*) means for operating the translator switches along with the said operation of the sleeve-connector switches to extend a connection to the set of translator terminals bearing the called number, (*g*) means controlled over the reset conductors through the connected set of translator terminals when the number called is that of a shifted line for restoring said selecting apparatus and for resetting it in accordance with the number assigned to the set of line terminals to which the called line has been shifted, (*h*) and means for restoring the sleeve-connector switches and for reoperating them in accordance with the reset condition of the selecting apparatus while maintaining the translator switches operated, the said switch-operating means then becoming effective to operate a switch of each group to complete a connection to the called line in its shifted location.

5. In a switching system, (*a*) a group of separately numbered sets of line terminals, lines bearing similar respective call numbers and normally connected respectively to said sets, translator terminals also bearing similar respective call numbers, reset conductors selectively connectable to the translator terminals in accordance with the shifted location of any line which has been shifted from one terminal set to another, (*b*) a group of switches for extending connections to said sets of line terminals, said switch group further including a sleeve-connector switch for extending preliminary test connections to the sets of line terminals, said switch group further including a translator switch for extending connections to the sets of translator terminals, (*c*) multi-position selecting apparatus common to all the switches of the group, (*d*) means responsive to the calling of the number assigned to a desired line for setting the selecting apparatus in accordance therewith, (*e*) means for thereupon operating the sleeve-connector switch to make a test connection to the set of line terminals bearing the called number, means normally controlled over such test connection for operating a switch of the group to complete a connection to the called line by way of the last-named set of line terminals subject to such line being idle and to the sleeve-

connector switch remaining operated, (*f*) means for operating the translator switch along with the said operation of the sleeve-connector switch to extend a connection to its set of terminals bearing the called number, (*g*) means controlled over a reset conductor through the connected translator terminal when the number called is that of a shifted line for restoring said selecting apparatus and for resetting it in accordance with the number assigned to the set of line terminals to which the called line has been shifted, (*h*) and means for restoring the sleeve-connector switch and for reoperating it in accordance with the reset condition of the selecting apparatus while maintaining the translator switch operated, the said switch-operating means then becoming initially effective to operate a switch of the group to complete a connection to the called line in its shifted location.

6. In a switching system, a group of separately numbered sets of line terminals, lines bearing similar respective call numbers and normally connected respectively to said sets, a translator having sets of terminals also bearing similar respective call numbers, reset conductors connectable to any set of translator terminals in accordance with the shifted location of any line which has been shifted from one terminal set to another, switching apparatus for extending connections to said sets of line terminals, a sleeve connector for extending a preliminary test connection to any set of line terminals, selecting apparatus, means responsive to the calling of the number assigned to a desired line for setting the selecting apparatus according to the called number, means controlled by the selecting apparatus for operating the sleeve connector to make a test connection to the set of line terminals bearing the called number, means normally controlled over such test

connection for operating said switching apparatus under the control of the selecting apparatus to complete a connection to the called line by way of the last-named set of line terminals subject to such line being idle and to the sleeve connector remaining operated, means effective along with the said operation of the sleeve connector for operating the translator to extend a connection to its set of terminals bearing the called number, means controlled over the reset conductors through the connected set of translator terminals when the number called is that of a shifted line for restoring said selecting apparatus and for resetting it in accordance with the number assigned to the set of line terminals to which the called line has been shifted, and means for restoring the sleeve connector and for reoperating it in accordance with the reset condition of the selecting apparatus while maintaining the translator operated, the said switch-operating means then becoming initially effective to operate the switching apparatus to complete a connection to the called line in its shifted location.

JOHN I. BELLAMY.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
Re. 22,820	Saunders	Dec. 17, 1946
1,505,171	Stearn	Aug. 19, 1924
1,601,052	Williams	Sept. 28, 1926
1,861,754	Powell	June 7, 1932
2,006,438	Carpenter	July 2, 1935
2,059,596	Meszar	Nov. 3, 1936
2,201,573	Carpenter et al.	May 31, 1940
2,279,822	Henry et al.	Apr. 14, 1942