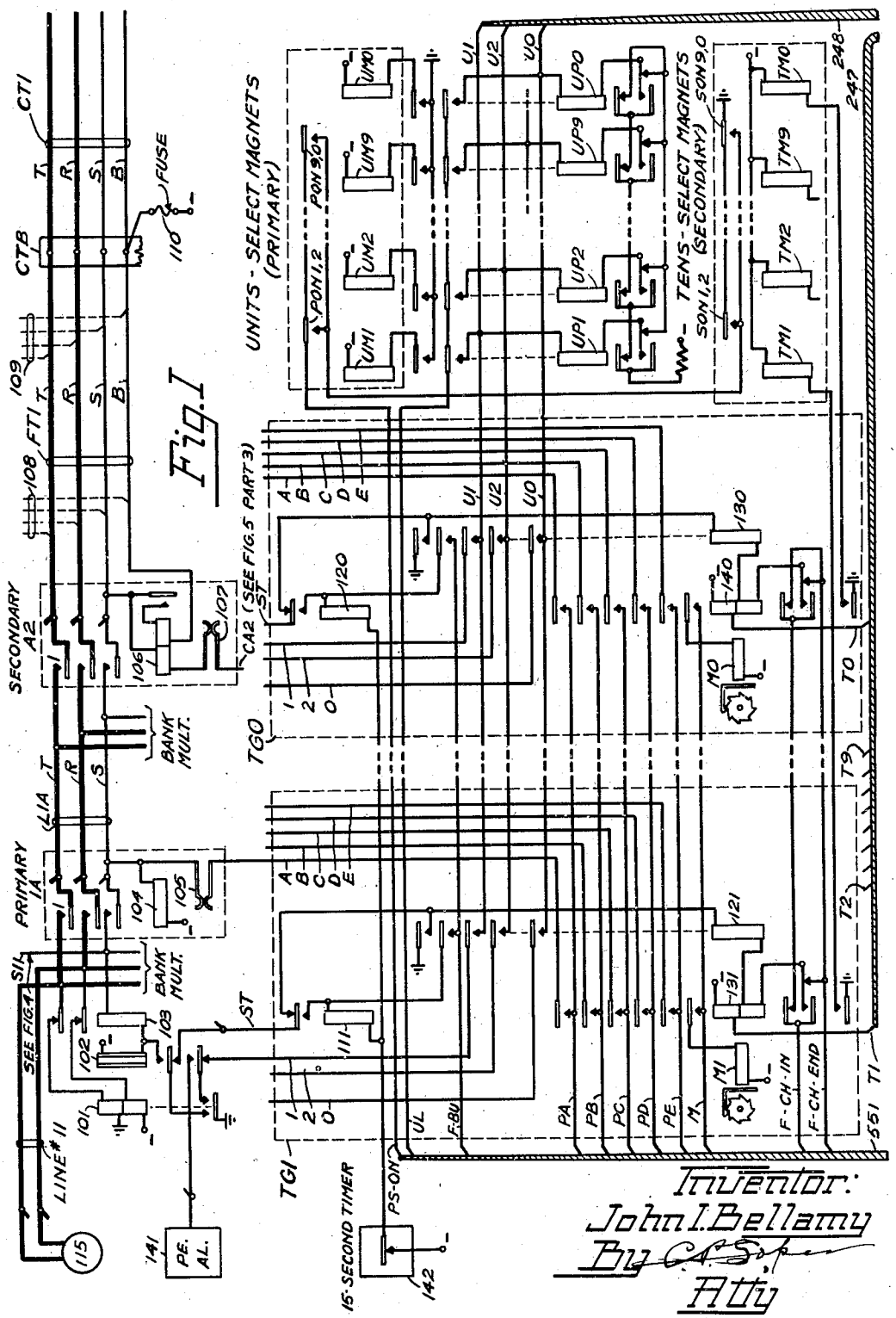
Oct. 18, 1949. J. I. BELLAMY 2,485,351

AUTOMATIC TELEPHONE SYSTEM

Filed Nov. 20, 1944 10 Sheets-Sheet 1



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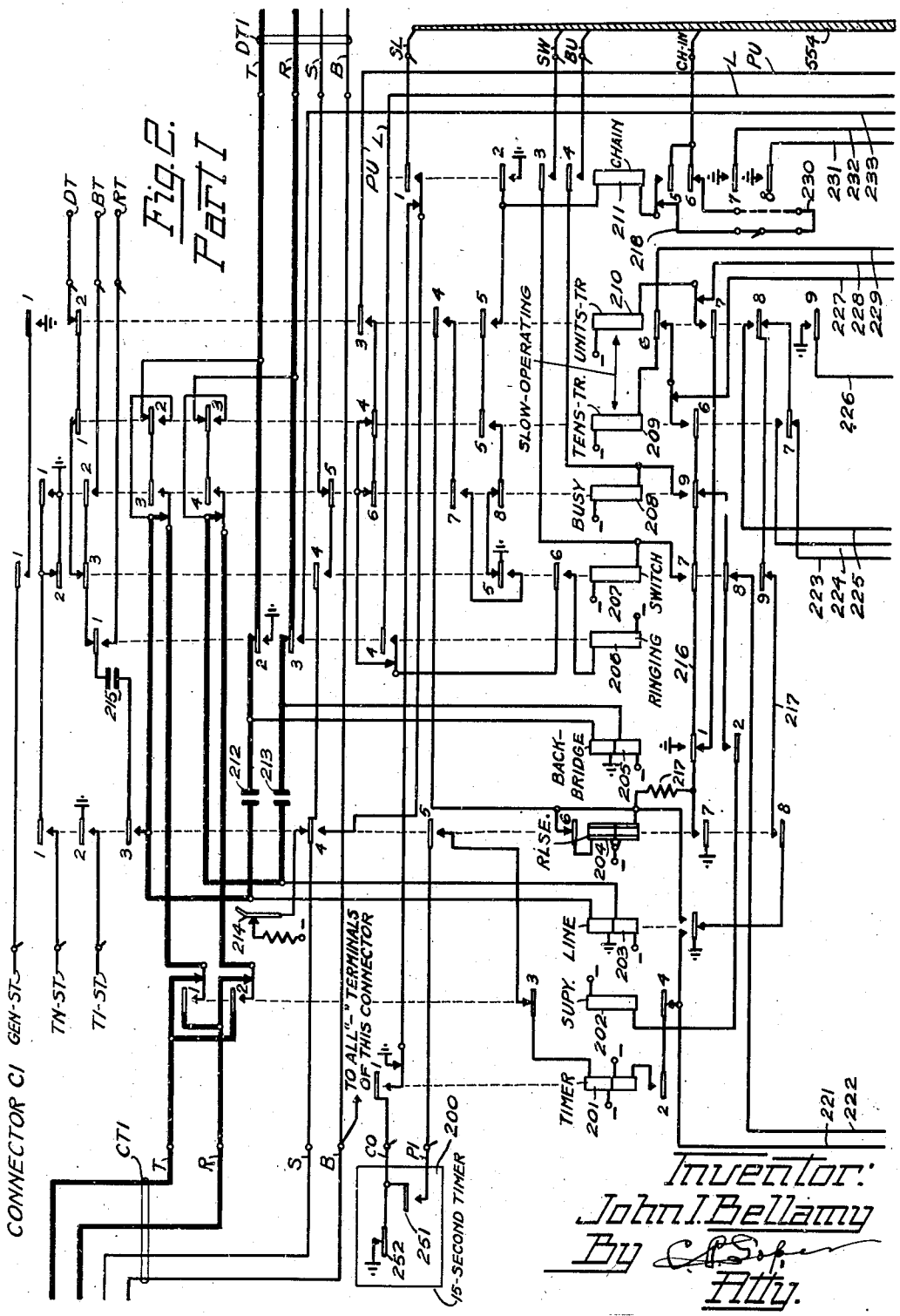
AUTOMATIC TELEPHONE SYSTEM

Filed Nov. 20, 1944 10 Sheets-Sheet 2



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AUTOMATIC TELEPHONE SYSTEM

Filed Nov. 20, 1944 10 Sheets-Sheet 3

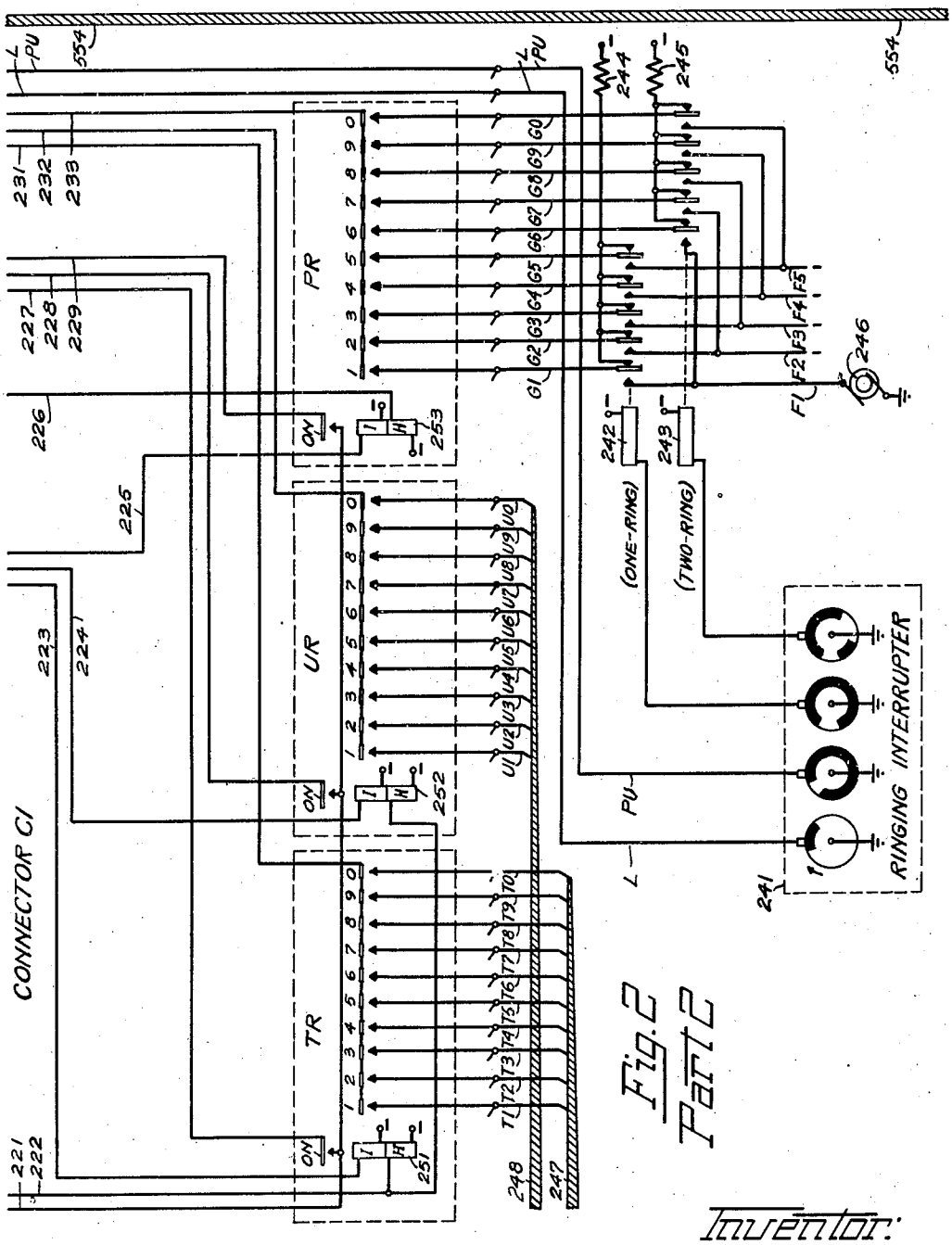

Fig. 2 Part 2

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AUTOMATIC TELEPHONE SYSTEM

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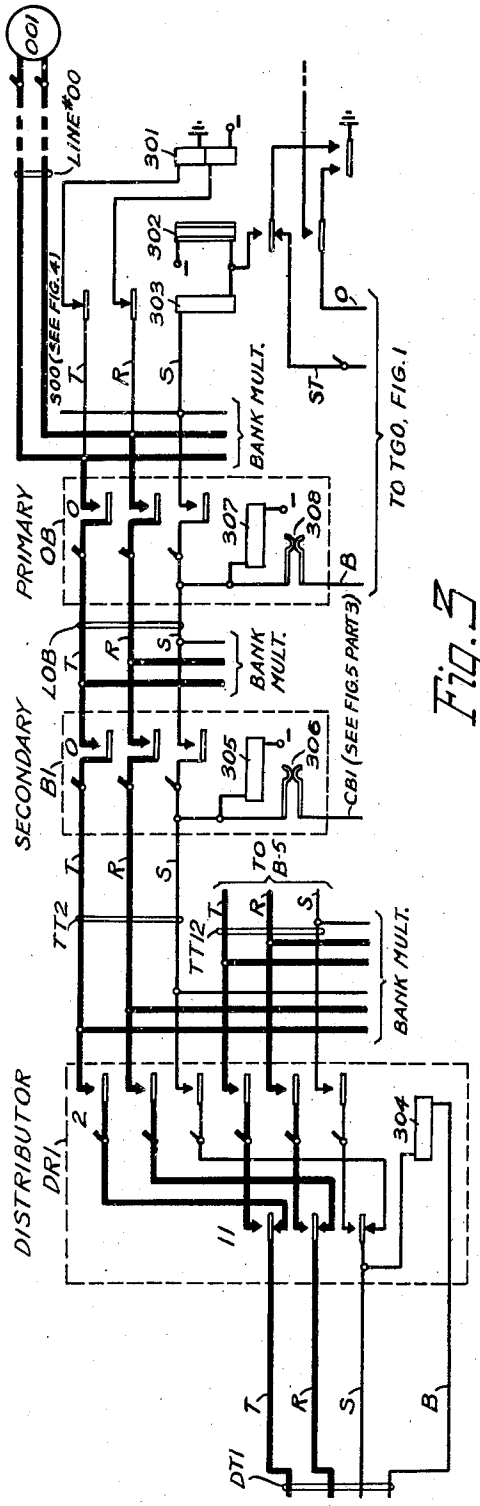

Fig. 3

Fig. 9

Fig. 1	Fig. 2 Part 1	Fig. 3
Fig. 4	Fig. 2 Part 2	
Fig. 5 Part 1	Fig. 5 Part 2	Fig. 5 Part 3

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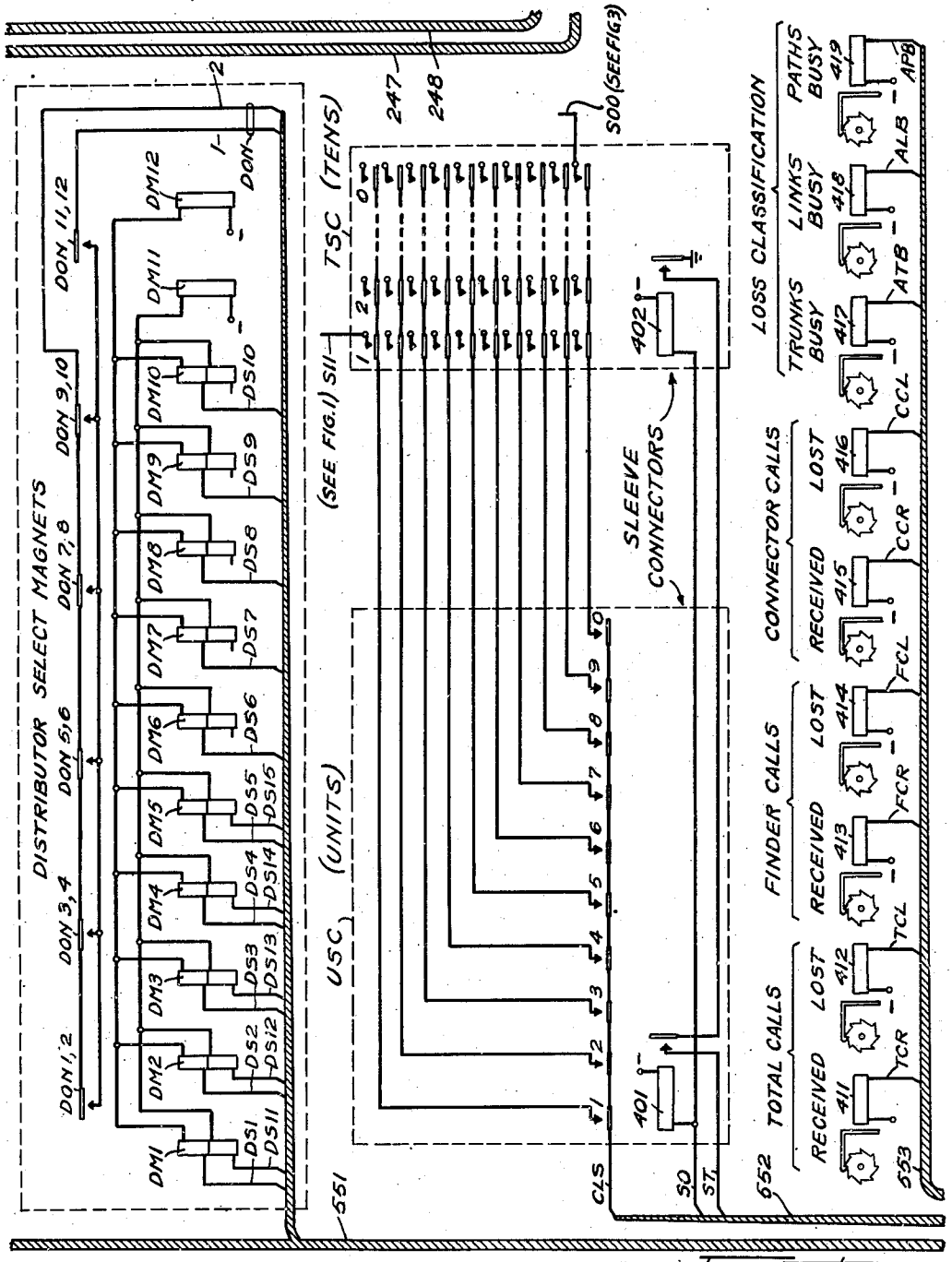

Fig. 4

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AUTOMATIC TELEPHONE SYSTEM

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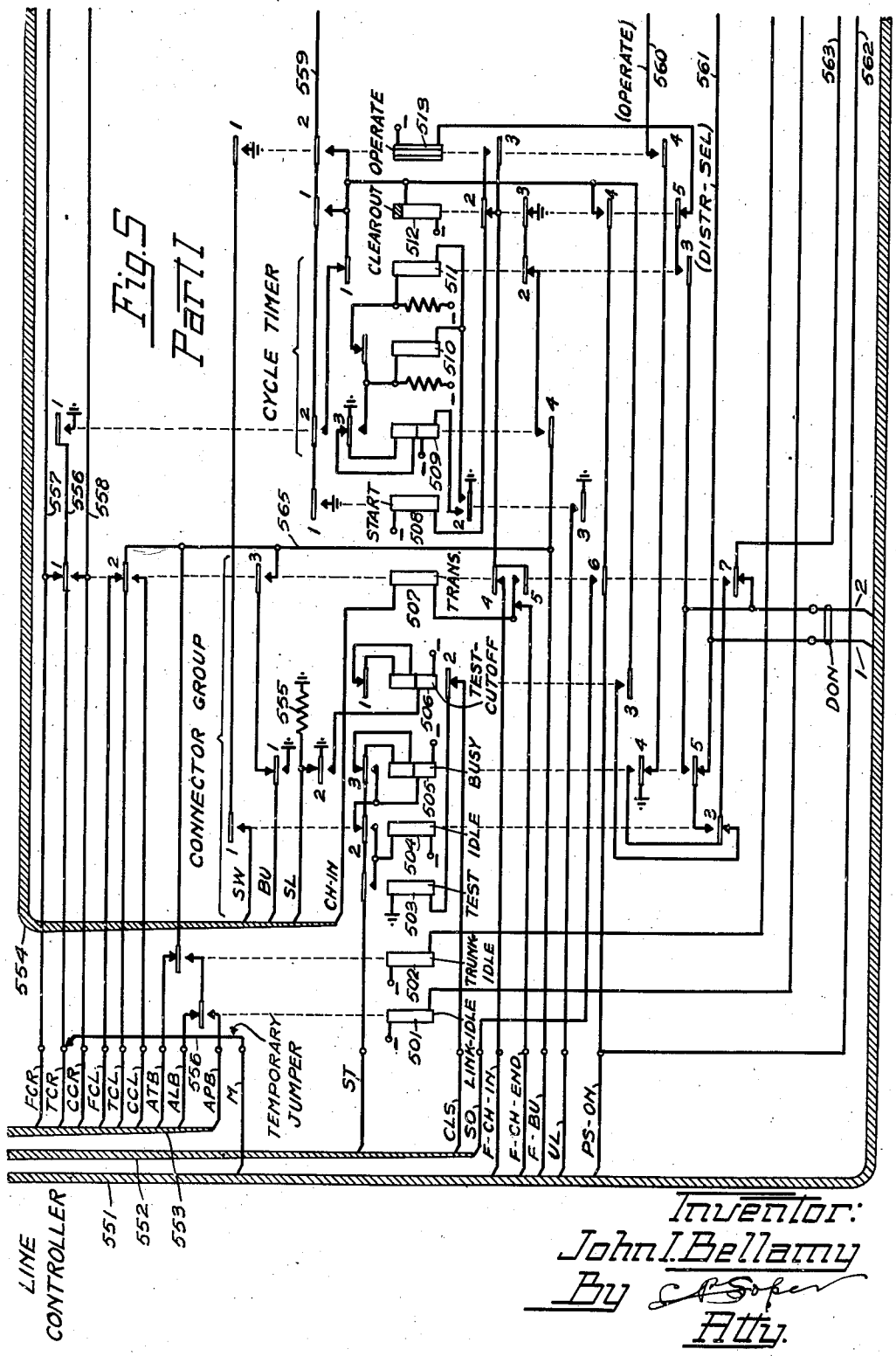

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AUTOMATIC TELEPHONE SYSTEM

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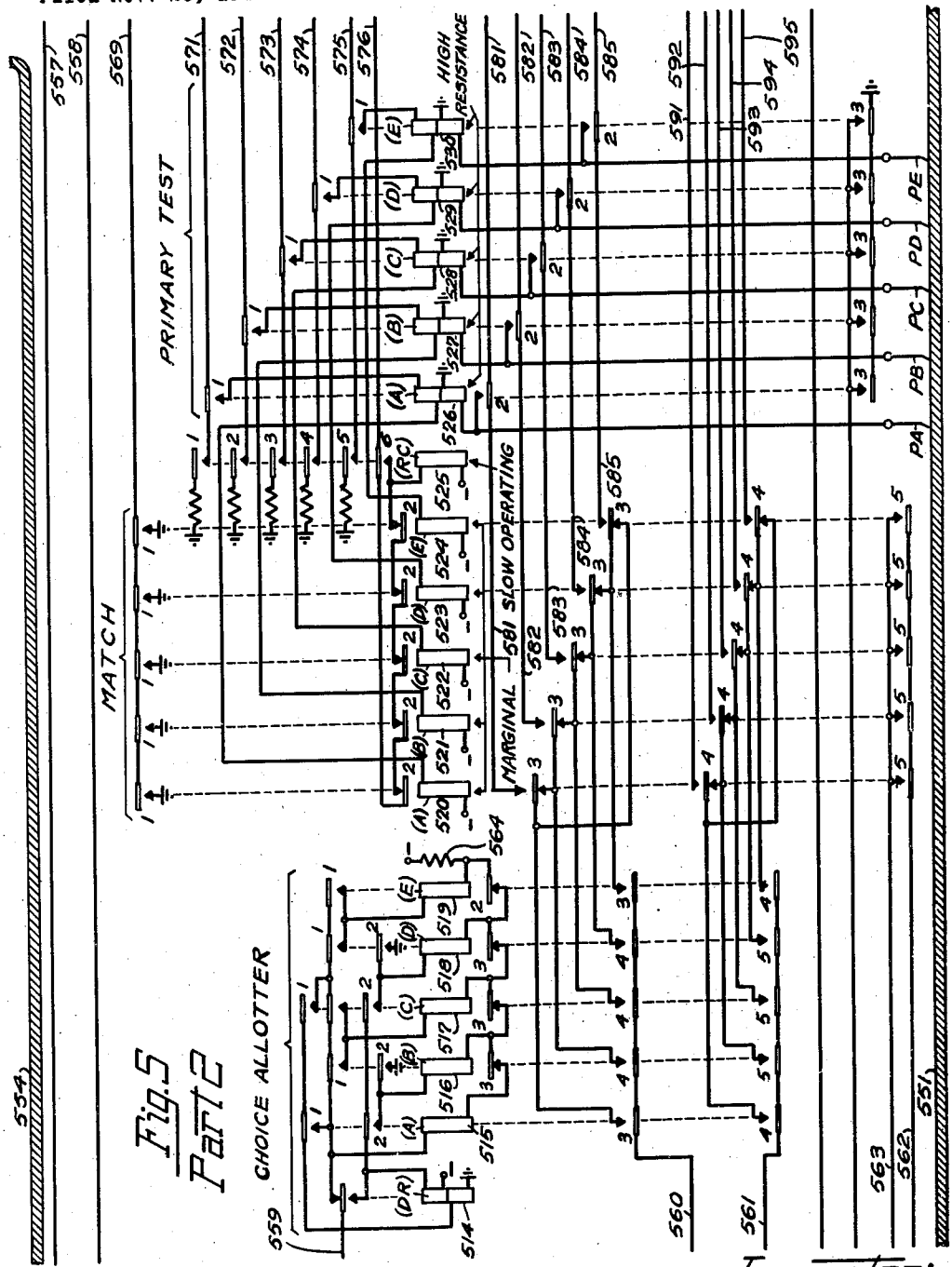

Fig. 5 Part 2

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AUTOMATIC TELEPHONE SYSTEM

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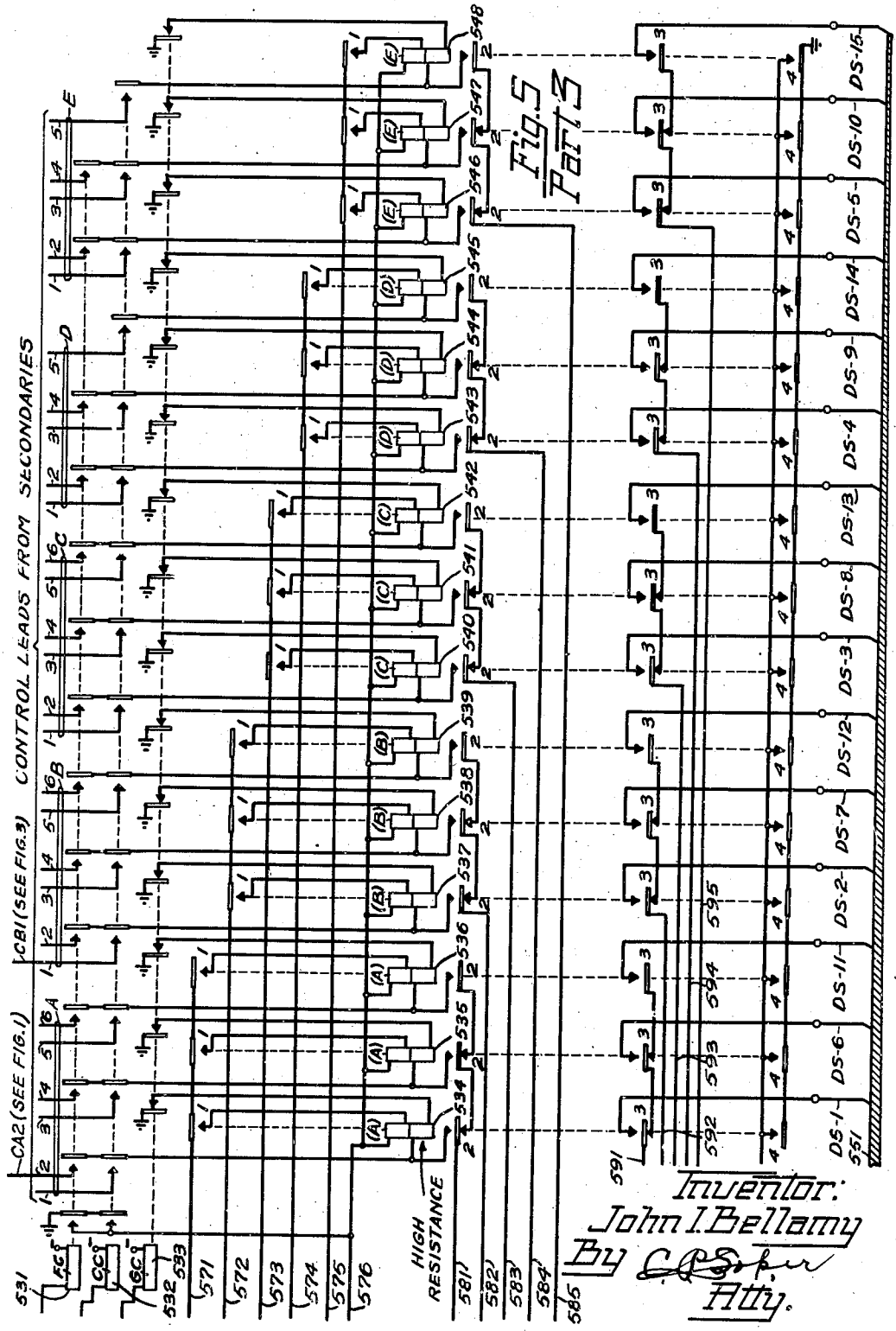

FIG. 5 Part 2

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AUTOMATIC TELEPHONE SYSTEM

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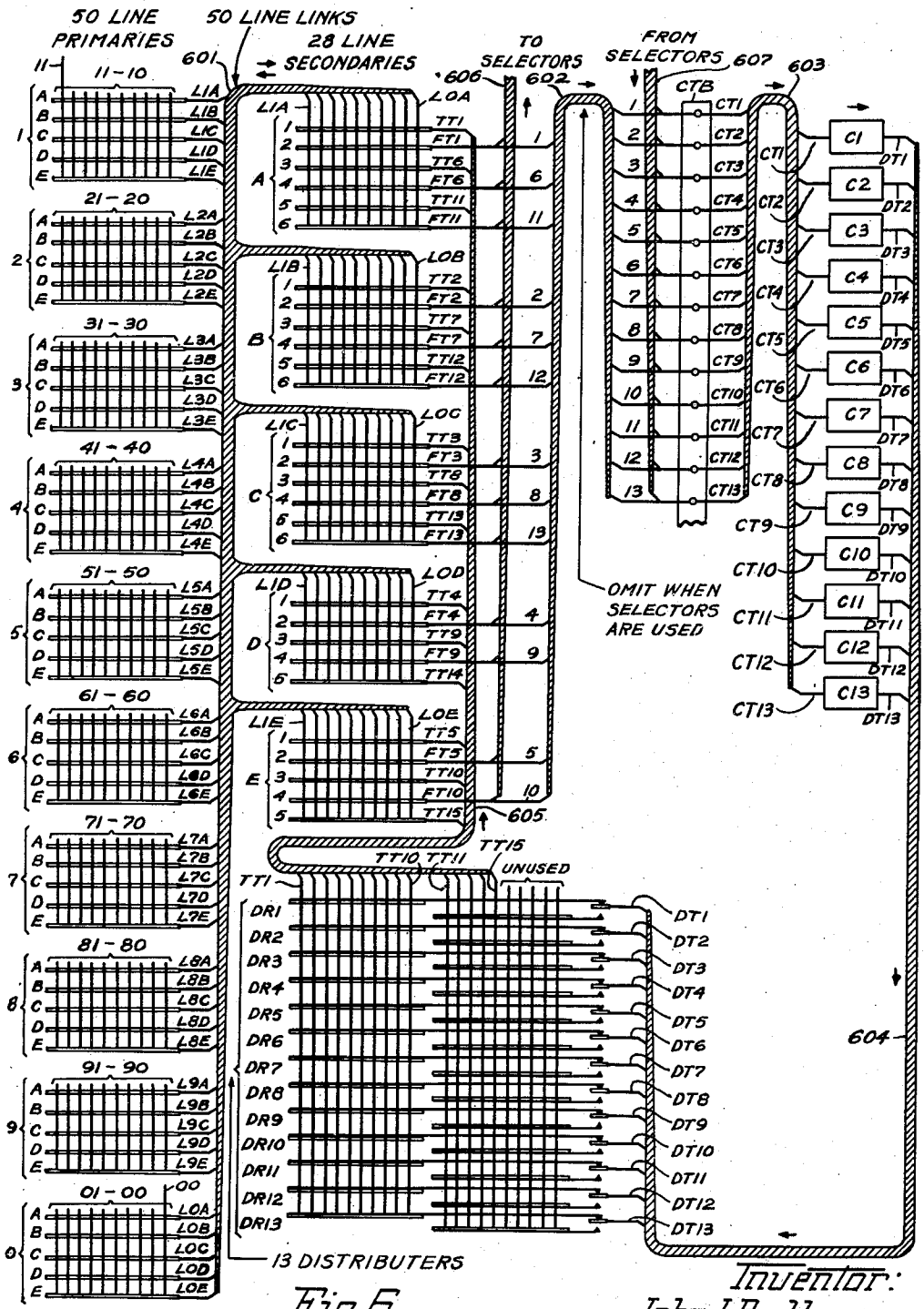

Fig. 6

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AUTOMATIC TELEPHONE SYSTEM

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Fig. 7 (Front)

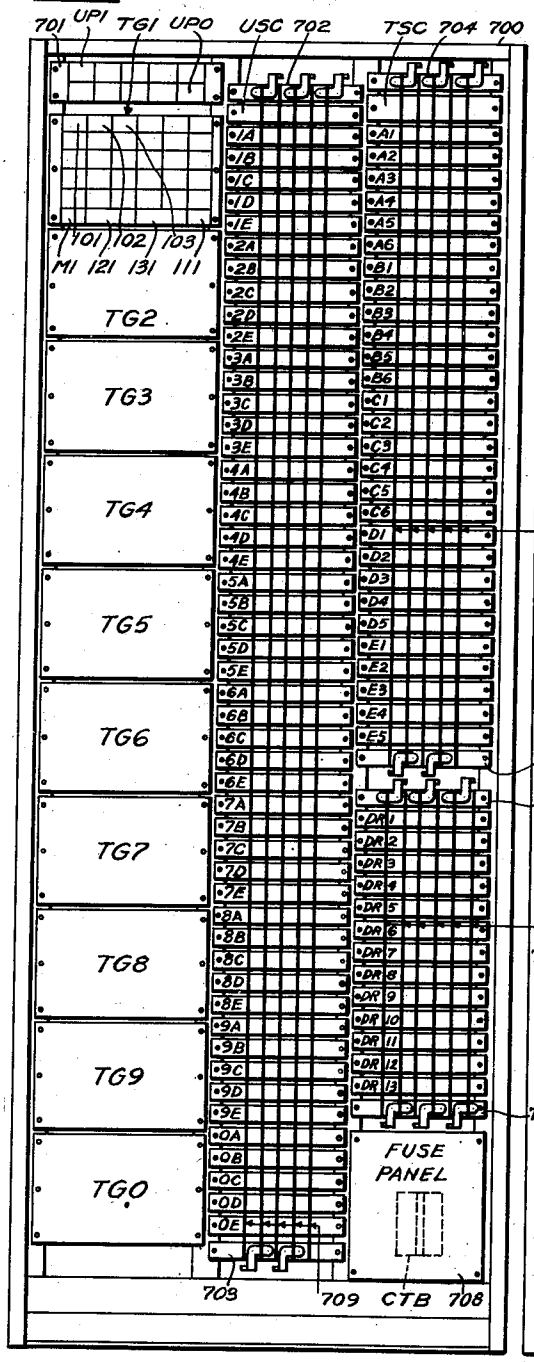
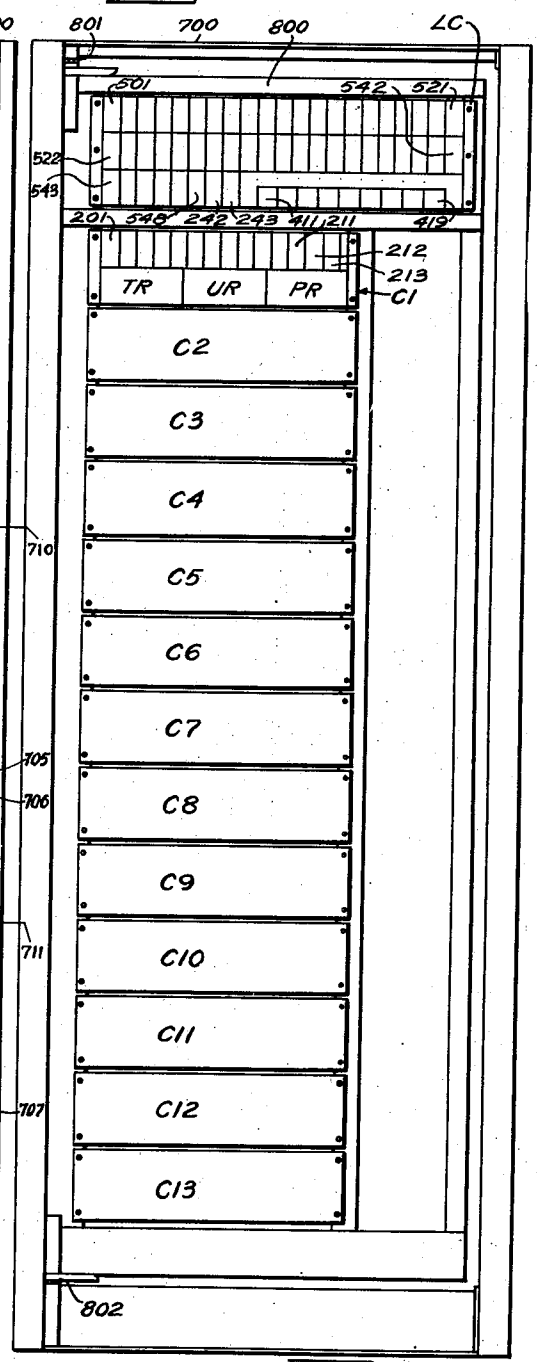


Fig. 8 (Rear)



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Patented Oct. 18, 1949

2,485,351

UNITED STATES PATENT OFFICE

2,485,351

AUTOMATIC TELEPHONE SYSTEM

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

Application November 20, 1944, Serial No. 564,293

30 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 line-finder and connector service for a group of lines, and serving either as a complete telephone exchange or as one line unit of a telephone exchange employing a desired number of such line units interconnected by one or more selector stages.

A specific object is to provide new and improved circuit and trunking arrangements enabling satisfactory service to be afforded by the line unit at a minimum cost in control and switching equipment.

Another specific object is to provide a new and improved mounting arrangement for the switching and control equipment of the line unit, enabling all such equipment to be completely preassembled and interconnected on a relatively compact frame which can be shipped and installed as a unit.

GENERAL DESCRIPTION

It has been chosen to illustrate the invention as applied to a unit serving one-hundred subscriber lines (including individual lines and ten-party lines) and employing switching equipment and control and trunking arrangements generally as disclosed in my prior Patent 2,354,660, issued August 1, 1944. The switches employed in the line unit disclosed in this application are assumed however to be of the improved construction disclosed in my co-pending application for Automatic telephone switches, Serial No. 524,816, filed March 1, 1944.

THE DRAWINGS

Of the accompanying drawings, Figs. 1 to 5 are circuit diagrams showing sufficient of the circuit arrangements of the improved 100-line unit to enable them to be understood;

Fig. 6 is a combined trunking and cabling diagram showing the interconnection of the separate classes of apparatus by cables carrying the trunks and links utilized in establishing the desired connections to and from the lines served by the unit;

Fig. 7 is a front view of the improved 100-line unit, showing the relative locations of the various pieces of apparatus mounted on the front face thereof;

Fig. 8 is a rear view of the unit showing the relative locations of the several pieces of apparatus mounted on the rear face thereof; and

Fig. 9 is a layout showing the way in which the sheets on which Figs. 1 to 5 are drawn should be assembled for a ready understanding thereof.

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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, over a certain one of several paths to a finder trunk (FT1). Such finder trunk extends directly to a connector trunk (CT1) when the unit disclosed serves as the complete exchange. When such unit serves as one unit of a larger exchange employing selectors, the direct connection between the finder trunk and the connector trunk is removed, and the finder trunk is extended by way of dotted conductors 108 to a selector, while the connector trunk is then reached by way of dotted conductors 109 incoming from the selectors.

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 1A to 0E shown in trunking diagram in Fig. 6, and shown locationally in Fig. 7. It is one of five switches, 1A to 1E, 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 being omitted for simplicity.

Primary switch 1A is accessible to line-secondary switch A2, and 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, each of which gives access to a line link extending to the corresponding one of the primary subgroups 2 to 0 of Fig. 6.

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 to connect the ten local units leads 1 to 0 of the first ten-line subgroup to the common units leads U1 to U0; connecting 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; and a meter M1 which is effective to record traffic data specific to the concerned ten-line subgroup.

At this point it may be noted that, for the convenience of manufacture and installation, as well as for the sake of compactness, the equipment illustrated in Fig. 1 as comprising tens subgroup TG1 is mounted on a plate shown in Fig. 7 arranged to be mounted opposite the five primary switches 1A to 1E which serve the associated ten-line subgroup, and on which plate are also mounted the three relays 101 to 103 comprising the line circuit of the illustrated line #11, as well as the nine remaining three-relay groups comprising the line circuits of the nine other lines of the associated ten-line subgroup. The arrangement of each of the remaining tens subgroups TG2 to TG0 is similar.

Fig. 1 also shows the units-select magnets, being the select magnets which control the five primary select shafts 709 (Fig. 7) serving the line primary group of switches. Only the first two and 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 five select shafts 710 (Fig. 7) 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. Among other things, this connector includes equipment for supplying transmitter current to the calling line, equipment for recording the tens, units, and party digits in the called number, and equipment for supplying ringing 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 includes the tens, units, and party registers TR, UR, and PR.

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 the control of ringing interrupter 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 the so-called chain relay, being included in the preference chain passing through the 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 PR (part 2 of Fig. 2) are controlled respectively over impulse conductors 223, 224, and 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 copending application for Electromagnetic counting devices, Serial No. 493,312, filed July 2, 1943, now Patent No. 2,441,001, dated May 4, 1948, reissued No. 23,089, March 15, 1949, 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.

Certain features residing in the connector C1 of Fig. 2 not brought out hereinbefore include the following:

(1) Release relay 204, which must be slow-acting to enable it to remain operated during successive restorations of line relay 203 pursuant to impulse transmission from the calling line, is rendered capable of remaining operated with a much heavier spring load than it could otherwise carry by virtue of a self-locking circuit therefor through resistor 217, having a resistance sufficiently low to carry substantial current during the time line relay 203 is restored, but insufficient to maintain the relay operated after its momentary slow holding action (residing principally in the diagrammatically illustrated conducting sleeve underlying its windings) has subsided. Additionally, in order to secure a powerful initial energization to give a fast operation, a second winding is provided on relay 204, which is disconnected by contacts 6 thereof to reduce the holding current for the purpose of economy in power consumption;

(2) As a matter of economy in the number of

relays used, tens-transfer relay **209** is reoperated as a party-transfer relay, pursuant to which it is restored by contacts **6** of units-transfer relay **210**;

(3) As a further matter of economy in the number of relays used, the units-transfer relay **210** is arranged to be restored by back-bridge relay **205** to act as a ring-cutoff relay, to prevent further operation of ringing relay **206** in the event that the called subscriber replaces his receiver ahead of the calling subscriber;

(4) Further relay economy is introduced by arranging that switching and busy relays **207** and **208**, which are normally operated in the alternative, are both operated to place the connector in reverting-call condition, when one subscriber on a party line calls another subscriber on the same line;

(5) Tens-transfer relay **209** has a third use. After operating, first as a tens-transfer relay, and second as a party-transfer relay, it is employed as a hang-up (or ring-start) relay during reverting calls, restoring upon the replacement of the receiver on the concerned line to initiate the ringing operation;

(6) A still further feature is that, when a reverting call is made, no forward connection is established from the connector to the called line, ringing current being transmitted back to the calling line (which is then also the called line) over the connection established initially therefrom to the connector. This is accomplished by the cooperation of busy relay **208** and the triple-duty tens-transfer relay **209**, as will be explained subsequently. This arrangement makes unnecessary the withdrawing of a further secondary switch such as B1 (Fig. 3) and a further primary switch such as **0B** from service during the concerned interval, as well as insuring that a reverting-call connection will not fail because of a temporary all-busy condition of the terminating trunks or line links between the connector and the called line.

The equipment shown in the lower part of Fig. 2, part 2, includes the common ringing interrupter **241**, which controls the associated common leads L and PU and controls the common one-ring and two-ring relays **242** and **243**. The particular system of party-line ringing illustrated in this application includes five common ringing leads F1 to F5 each of which is supplied with a separate frequency of ringing current, as by separate generator such as **246**.

On a ten-party line, the first five parties are signalled by a single, or one-ring, application of the respective frequencies F1 to F5, such application being made by the common one-ring relay **242** to the first five generator leads G1 to G5. Signalling of the last five parties on a 10-party line is accomplished by a two-ring application, by relay **243**, of the respective frequencies F1 to F5 to the last five generator leads G6 to G0. A feature of the ringing-interrupter arrangement is that resistors **244** and **245**, to which the ringing leads G1 to G0 are connected except during actual application of ringing current, serve to drain the condensers on the called line to prevent a disagreeable discharge of such condensers into the calling line upon the subsequent restoration of ringing relay **206**, as will be described more in detail hereinafter. This common arrangement avoids the necessity of provisions individual respectively to the several connectors, often used to accomplish the same result.

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 (#**00**), as a called line.

The distributor DR1 of Fig. 3 is one of the thirteen distributors DR1 to DR13 of Figs. 6 and 7. Each of these distributors is a three-wire, twenty-point switch of the type disclosed in my previously noted application, Serial No. 524,816, having a circuit arrangement as shown in Fig. 17 of such application. 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 the distributor DR1 is to be selected, one or another of the stackups **1** to **10** is actuated, along with stackup **11**. For selection of the stackup, or stackups, to be operated in one of the switches of the distributor group, the six selecting shafts **711** of Fig. 7 are provided. They correspond respectively to the shafts shown in Fig. 1 of the above-noted application (Serial No. 524,816) at S1—2, S3—4, S5—6, S7—8, S9—10, and S11.

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 **0B** by way of the associated line-link L0B; and through its illustrated stackup **0**, primary switch **0B** 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 relay **101** to **103** (Fig. 1).

Figure 4

Fig. 4 shows the twelve distributor select magnets DM1 to DM12 which control the select shafts **711** (Fig. 7). Magnets DM1 to DM10 correspond respectively to the stackups **1** to **10** of any of the thirteen distributors DR1 to DR13 (Figs. 3, 6, and 7); 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 prior application Serial No. 524,816. It may be located immediately to the right of magnet M11 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, DON11, 12, associated with the sixth shaft of the mechanism. Off-normal contacts DON1, 2; DON3, 4; DON5, 6; DON7, 8; and DON9, 10 are associated respectively with the first five selecting shafts of the distributor group. The off-normal contacts of Fig. 4 are interwired with each other and 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 also shows the circuit arrangement of

the units-sleeve connector USC and the tens-sleeve connector TSC. 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 for example as conductor S11, the sleeve conductor of line #11 (Fig. 1) and conductor S00, the sleeve conductor of line #00 (Fig. 3). 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 as shown in Fig. 7, and sleeve connector TSC is an additional switch in the line-secondary group. USC is controlled by select shafts 709 of the primary group along with primary switches 1A to 0E, while TSC is controlled by shafts 710 of the secondary group along with secondary switches A1 to E5.

By providing a direct and immediate test path from the line controller of Fig. 5 to the called line, the sleeve connectors make possible a more orderly and efficient handling of connector calls, rendering it unnecessary to extend a connection through a distributor, and matched secondary and primary switches, to a called busy line; they enable reverting calls to be handled even though all forward paths be busy between the connector and the called line; and they enable the secondary and distributor switches to be reduced from four-wire switches to three-wire switches.

Fig. 4 also shows traffic meters 411 to 419, which are controlled from the line controller of Fig. 5 to record the disposition of each call received by the line controller, according to whether the line controller is called in for finder action or is called in for connector action, and according to whether the received call is disposed of normally or is lost because there is no available path for its completion. Of these meters, 411 and 412 record the total calls; 413 and 414 record the finder calls; and 415 and 416 record the connector calls. The first meter in each pair records the calls received in the concerned category, while the second meter of the pair records the number of such received calls as are lost.

Meters 417 to 419 are assigned to recording of lost calls, whether finder calls or connector calls, according to the existing traffic condition resulting in the loss, as will be later described.

Figure 5

Fig. 5, consisting of parts 1, 2, and 3, shows the line controller previously referred to. This 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. The line controller of Fig. 5 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.

The line controller is connected by conductors in cable 551 with the equipment in Fig. 1 and with the distributor-select magnets of Fig. 4; it is connected through the conductors in cable 552 with the sleeve connectors USC and TSC of Fig. 4; it is connected through conductors in cable 553 with the traffic meters 411 to 419 of Fig. 4; it is connected through conductors in cable 554 with each connector, such as C1 of Fig. 2; and it is connected, through conductors shown at the top of part 3 of Fig. 5, to each of the twenty-eight line secondary switches shown in Figs. 6 and 7, including secondary A2 of Fig. 1 and secondary B1 of Fig. 3.

The line controller of Fig. 5 consists principally of forty-eight relays, 501 to 548. Of these relays, 501 and 502 are employed only for traffic-meter control, relay 501 operating on each call when there is an idle line link in the concerned ten-line subgroup, and relay 502 operating each time there is an idle trunk of the concerned category (finder trunk or terminating trunk).

Relays 503 to 507 comprise the connector group, being rendered operative during each connector call, but remaining unaffected during finder calls. Of these relays, relay 503 tests the busy or idle condition of the called line, over the sleeve conductor thereof to which relay 503 is connected by sleeve connectors USC and TSC (Fig. 4); relay 504 is the so-called idle relay, operated by relay 503 when the called line is found idle; relay 505 is the so-called busy relay, being operated through back contacts of idle relay 504 each time the called line is found busy; relay 506 is the test-cutoff relay, operated each time relay 505 operates; and relay 507 is the transfer relay, which operates in the connector chain to transfer the circuit arrangements of the line controller from finder-action condition to connector-action condition.

Relay 508 is the start relay. It operates each time the line controller is called in, whether for finder action or for connector action.

Relays 509 to 511 comprise a cycle timer, which is operated each time start relay 508 operates. It passes through a timed cycle of operations, which serves to clear out the line controller upon its completion, provided the line controller has not previously cleared out in normal manner.

Relays 512 and 513 are the clearout and operate relays. Relay 513 normally operates to "switch" the call through. Relay 512 normally operates under the control of operate relay 513 to clear out the line controller upon the restoration of the latter relay, but operates alternatively from the associated cycle timer or from the connector group of relays under certain conditions.

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. Relay 514 is a so-called driver relay, while relays 515 to 519 are arranged to operate successively in a counting operation as will be subsequently described.

Relays 520 to 525 comprise the matching group. Of these relays, 520 to 524 control the matching in secondary subgroups A to E respectively, subject in each case to there being an idle secondary switch in such subgroup of the concerned category (finder action or connector action), and subject further to there being an idle primary switch in the concerned primary subgroup accessible from such secondary subgroup. Relay 525 is a so-called reserve-control relay, which operates in a manner to be subsequently explained to permit the use of the last idle secondary switch in a

subgroup, of the category with which the current call is concerned.

Relays 526 to 530 are primary test relays, being controlled over leads PA to PE in cable 551, which leads are connected by apparatus as disclosed in Fig. 1 to the respective primary switches A to E in the primary subgroup concerned in any call, finder action or connector action.

Relays 531 to 533 are test-control relays. Relay 531 is operated on each finder call to connect the control leads of the even-numbered secondary switches (assigned to finder action) in each secondary subgroup to respective ones of the secondary test relays; relay 532 operates on each connector call to connect the control leads from the odd-numbered secondary switches (assigned to connector action) respectively to the secondary test relays; and relay 533 operates on each call to disconnect test ground from the secondary test relays when matching has been effected.

Relays 534 to 548 are the secondary test relays, connections to which are controlled by relays 531 to 533. Three secondary test relays suffice for each secondary subgroup, inasmuch as only three switches of a secondary subgroup are involved in any one call, finder action or connector action as the case may be. This arrangement effects a considerable saving in secondary test relays, as will be appreciated.

Figure 6

In the combined trunking and cabling diagram shown in Fig. 6, it wil be observed that the fifty line-primary switches are divided into ten subgroups of five switches each, subgroups 1 to 0 respectively. Each subgroup of primary switches 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, the conductor pair representing any line may be attached to the appropriate terminal contacts of the first primary switch in a subgroup, being connected through the vertically extending, bare-wire bank multiple to the corresponding contacts 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 to L0E, extending to the "E" switches in the ten primary subgroups, which are reached from the switches comprising secondary subgroup E.

As noted, each of the primary switches, together with its associated line link, is employed both for finder action and for connector action. On the other hand, each of the secondary switches 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.

When the unit disclosed is the complete exchange, selector cables 606 and 607 are omitted, and local cable 602 is employed to extend finder trunks FT1 to FT13 respectively to connector trunks CT1 to CT13 by way of terminals of connector trunk block CTB. But, when 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. In this event, local cable 602 is omitted, and selector cables 606 and 607 are installed. When used, cable 606 carries the thirteen finder trunks FT1 to FT13 to a corresponding number of selectors, while cable 607, when used, carries thirteen connector trunks, incoming from the selectors to the connectors by way of connector trunk block CTB.

Instead of a selector switching stage as disclosed in my previously noted Patent 2,354,660, the unit herein disclosed is particularly adapted to cooperate with an installation employing one or more selector switching stages of the improved type disclosed in my co-pending application for Selector switching systems, Serial No. 531,949, filed April 20, 1944, now Patent No. 2,400,530, dated May 21, 1946.

From the connector trunk block CTB, thirteen connector trunks CT1 to CT13 extend by way of cable 603 to connectors C1 to C13, respectively, of which connector C1 is shown in detail in Fig. 2. 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, 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 subgroups A to E. The assignment of the terminating trunks is such that the first five 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.

It is to be noted that fifteen terminating trunks TT1 to TT15 are employed to handle the traffic passing through the thirteen connectors C1 to C13, and the thirteen distributors DR1 to DR13. Consequently, except when one or more distributor trunks may be temporarily withdrawn from

service, as when the secondary switch to which a terminating trunk extends is being repaired, at least two terminating trunks remain idle at a time when the maximum number (13) of connections are established through the connectors C1 to C13. By this arrangement, the likelihood of being able to find an idle path to the called line through one or another of the secondary subgroups and the corresponding primary switch of the called subgroup is greatly increased with a minimum increase in equipment. The only increase in cost represented by an increase in terminating trunks is the cost of the added connector-action secondary switches, switches 5 in subgroups A and E in the illustrated arrangement. It is also clear that the five unused outlets (16 to 20) of the distributor group can be extended to five additional connector-action secondary switches if desired (one in each secondary subgroup) at a very small cost in equipment, if experience indicates that this is desirable. In this event, the five added connector-action secondary switches would be reached from the distributor group by way of terminating trunks TT16 to TT20 (not shown).

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

Figures 7 and 8

As previously noted, Fig. 7 shows a front view, and Fig. 8 shows a rear view, of an upright frame 700 on which the equipment and wiring comprising the disclosed 100-line unit are supported. Frame 700 is not shown in complete detail as its specific construction forms no part of this invention. It may be noted that in one physical embodiment of the unit, the frame 700 is of rectangular plan view having overall dimensions: 33 inches in width, 20 inches in depth, and 6 feet, 8¼ inches in height. Such a frame is conveniently constructed of angle iron sections welded together, with upright members as shown in Fig. 7 providing three columnar spaces for the mounting of face equipment thereon.

The face equipment mounted in the left-hand column of Fig. 7 includes mounting plate 701, on which the ten units-preference relays UP1 to UP0 (Fig. 1) are mounted, and ten similar tens-group mounting plates TG1 to TG0, each of which mounts the line-circuit relays and common equipment specific to a subgroup of ten lines.

The layout of the equipment on the first mounting plate TG1 is shown in detail in Fig. 7. Six line-circuit relays are mounted in each of the five rows provided in plate TG1. The first three spaces in the uppermost row are occupied by line-circuit relays 101 to 103 of Fig. 1, associated with line #1 of the first ten-line subgroup. The three line-circuit relays for the second line of the subgroup may be mounted in the three remaining spaces in the first row of plate TG1. The second, third, fourth, and fifth horizontal rows on plate TG1 may carry the line-circuit relays for the remaining eight lines of the ten-line subgroup. The lowermost row of equipment on plate TG1 comprises meter M1 and relays 121, 131, and 111 of Fig. 1.

The equipment mounted in the second columnar space in Fig. 7 comprises the primary group of switches, controlled by select shafts 709. These shafts are supported between upper and lower brackets 702 and 703, which carry the select magnets and off-normal contacts as disclosed in the previously noted application, Serial No. 524,816. The units sleeve connector USC of Fig. 4 is mounted as the first switch in the group immediately below upper shaft bracket 702, and is followed by the fifty line-primary switches 1A to 0E.

It will be noted that the ten plates TG1 to TG0 are each mounted substantially opposite the five primary switches which serve the associated ten-line subgroup, permitting short direct connections from the bank multiples to the respective line circuits, through uniform pre-formed cables.

The equipment mounted in the third column in Fig. 7 includes the secondary group of switches, controlled by the five select shafts 710, which extend between upper and lower shaft brackets 704 and 705. Tens sleeve connector TSC of Fig. 4 is mounted as the first switch in the secondary group, immediately below upper shaft bracket 704, and is followed by the twenty-eight secondary switches A1 to E5.

Immediately below the group of secondary switches, lies the distributor group, controlled by the six selecting shafts 711, extending between upper and lower shaft brackets 706 and 707. The thirteen distributor switches DR1 to DR13 are mounted between these shaft brackets.

The remaining portion of the space in the third face-equipment column of Fig. 7 is occupied by fuse panel 708, which carries the required fuses, such as 110 (Fig. 1), through which current is supplied from the ungrounded pole of the exchange battery to the various consuming circuits of the unit.

Connector-trunk block CTB of Fig. 1 is mounted behind the fuse panel 708, as is shown in dotted outline in Fig. 7. This block serves as a fixed terminal point for such conductors as extend from outside the unit to equipment mounted on gate 800.

The equipment mounted at the rear of the frame 700 is shown in Fig. 8. In order to give ready access to the wiring lying between the equipment mounted on the front of the frame (Fig. 7) and the equipment mounted on the rear (Fig. 8), the equipment at the rear of the frame is mounted on the abovenoted gate 800, hinged at 801 and 802 to enable it to be swung out of the way when desired. Connections to the equipment mounted on the swinging gate 800 include the trunk conductors in cables 603 and 604 of Fig. 6, together with miscellaneous connections such as battery, ground, generator leads, and the like. All such connections are by way of flexible cable conductors.

The uppermost space on gate 800 is occupied by the illustrated mounting plate LC extending entirely across the open space provided by the gate, and carrying principally relays 501 to 548 of the line controller shown in Fig. 5. Of these relays, 501 to 521 are mounted in a row along the top of plate LC; relays 522 to 542 are mounted in a row along the middle of plate LC; and relays 543 to 548 are mounted in the first six spaces along the bottom row on the plate. Immediately following relay 548, ringing interrupter relays 242 and 243 of Fig. 2 are mounted, and these relays are followed in turn by the nine traffic meters 411 to 419 of Fig. 4.

The remaining equipment carried on gate 800 comprises the thirteen connectors C1 to C13, of

which C1 is shown in Fig. 2. Each connector is mounted on a separate plate, as shown.

The relative locations of the relays, talking condensers, and registers of connector C1 are shown. Relays 201 to 211 of Fig. 2 are mounted in the first eleven spaces along the top of the plate, followed by talking condensers 212 and 213. Registers TR, UR, and PR of Fig. 2, part 2, are mounted in a row below devices 201 to 213. The arrangement for each of the remaining connectors C2 to C13 is similar.

The frame 700 as illustrated in Figs. 7 and 8 extends sufficiently to the front and to the rear to include within its confines all equipment mounted thereon. Such a frame may be fully enclosed by top and side covers, and by front and rear doors, attached directly thereto.

It will be observed that the plates on which the equipment comprising connectors C1 to C13 are mounted fall short of taking up the entire width of gate 800. Where connectors are employed requiring additional equipment, such as a greater number of control relays, the length of the connector mounting plates may be increased as desired, up to the full width of the gate.

It will be noted that the unit as disclosed in Figs. 7 and 8 makes no provision for the mounting of common equipment such as timers 142 and 200, ringing interrupter 241, generators such as 246, the current-supply battery, and its charging equipment. It will be understood, of course, that such equipment is ordinarily provided at a separate location, as on a so-called power board. Where the exchange installation employs a number of units such as the one disclosed, and one or more groups of selectors, the power-board equipment is more or less common to all of the units and to the selectors, for which reason it would be an unnecessary duplication to provide space on a line unit for such equipment.

DETAILED DESCRIPTION

A detailed description of the disclosure will now be given in conjunction with a description of the operation of the apparatus thereof in establishing and clearing out connections. For this purpose, it will be assumed that the disclosed unit comprises the entire exchange, in which case selectors are not used, and the trunks are connected directly with the connector trunks, through a local cable such as 602 (Fig. 6), and as shown at trunk FT1 (Fig. 1).

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 number, such as number 001.

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 1 individual to the calling line.

A2. *Tens selection*

Assuming that the line controller of Fig. 5 is currently 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 4 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 inner 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 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, as will be described hereinafter. Additionally, relay 131 connects the common meter conductor M to the meter M1 pursuant to recordation of the disposition of the initiated finder call.

Finally, at its lower contacts, 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 selections are locked in, independent of the continued energization of

line relay 101, partly as an aid to the further operations, and partly to prevent false or partially completed finder actions from resulting from momentary bridging or grounding of a line.

The tens selection is locked in at the upper contacts of relay 121, which ground the associated start conductor ST independent of line relay 101. The units selection is locked in at the inner upper contacts of units-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 conductor PS—ON in cable 551 (through off-normal contacts SON1, 2 and PON1, 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 magnet 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 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 on 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 (grounded by the line controller as will be subsequently explained), through make-busy contacts 107, left-hand winding of hold magnet 106, sleeve conductor S of finder trunk FT1 and connector trunk CT1, back contact 4 of release relay 204, make-busy contacts 214, and thence to battery through the associated resistor. 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 and connector trunk CT1.

A moment later, holding ground is placed on the sleeve conductor of the established connection, by the connector C1 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 the 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 ground on the sleeve conductor of the established connection, through the locking contacts of hold magnet 106 (the so-called off-normal stackup of the switch), the right-hand winding of magnet 106, to battery on lead B of the finder trunk FT1, supplied through fuse 110.

A6. *Preparing connector C1 for operation*

The connection has been extended as described, through primary switch 1A and secondary switch A2, to connector C1 (Fig. 2). In the 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 calling line and closes a circuit for both windings of release relay 204 in parallel. Current flow through these two windings provides a powerful initial energization of the release relay, resulting in fast operation thereof.

Upon operating, relay 204 disconnects its upper winding at contact 6 to reduce the holding current. At its contacts 7, relay 204 applies ground potential to local conductor 216, thereby preparing locking circuits for relays 207 to 210, closing a holding circuit for registers TR and UR, and establishing an auxiliary circuit for its own lower winding, by way of resistor 217. At armature 4, relay 204, disconnects the associated idle-indicating battery-supply resistor and applies the above-noted 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.

At its contacts 8, release relay 204 prepares the impulse circuit for the digit registers, while at its contacts 3, it applies dial tone to the tip talking conductor from the common dial-tone lead DT, by way of contacts of relays 210, 209, 207, and 206, and condenser 215. The dial-tone signal, thus applied to the calling line, informs the calling subscriber that he may now dial the digits of the desired number.

A7. *Setting tens register TR*

When the calling subscriber operates the dial of his calling device (not shown) in accordance with the first digit of the desired number, line relay 203 is restored momentarily a number of times corresponding to the value of the digit. Release relay 204, being slow-restoring, remains operated during dialing. The previously noted auxiliary holding circuit, through resistor 217, is effective to assist the normal holding provisions of relay 204 in maintaining operated the comparatively heavy contact load.

Each time it restores incidental to the dialing of a digit, line relay 203 applies ground potential, through contacts 8 of release relay 204, to impulse conductor 217. During the dialing of the first digit, conductor 217 extends through contacts 9 of relay 207, contacts 8 and 7 of relays 210 and 209, to branch conductor 223, extending to the impulse winding I of magnet 251 of the tens register TR. Tens register TR accordingly receives from one to ten impulses, depending upon the value of the first digit.

In the assumed example, the first digit is "0," wherefore it is represented by ten impulses. Recording contacts 1 to 0 of register TR close successively as the impulses arrive, each preceding contact pair opening on the receipt of the next

succeeding impulse. Accordingly, contacts 0 of register TR are closed at the end of the first 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 first digit, a circuit is momentarily closed as follows for tens-transfer relay 209: from ground through the 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 series of impulses, for line relay 203 remains operated only momentarily between impulses.

When line relay 203 comes to rest in an operated condition at the conclusion of the dialing of the initial digit (0, in the assumed example), tens-transfer relay 209 operates over the 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 to free conductor 221 for further similar control. At its contacts 1, relay 209 disconnects dial-tone lead DT so as to terminate the application of the dial-tone signal at the termination of the dialing of the first digit, in accordance with usual practice. 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 the register UR.

A8. *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 209) operates over the following circuit: from ground on conductor 221, off-normal contacts ON of units register 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 branch 225, extending to party register PR. At its contacts 9, relay 210 applies ground potential to holding conductor 226 local to party register PR, 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.

A9. *Setting the party register PR*

When the party digit (1) is dialed, the single impulse thereof is delivered over branch conductor 225 to the party register PR whereat contacts ON and 1 close.

At the termination of the dialing 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 register PR, 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 its armature 6 and associated contacts has been interrupted at contacts 6 of relay 210.

A10. *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 C1 to C13), 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 the line controller, normally closed contacts controlled by armature 5 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, chain contacts 4 of transfer relay 507, contacts 2 of clearout 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 5 and associated contacts, relay 507 locks itself to the origin point of the chain (through contacts 2 of relay 512 and the winding of relay 508) independent of conductors F—CH—END and F—CH—IN in cable 551, while at its contacts 4, it disconnects conductor F—CH—IN to preclude the operation of any of the finder control relays such as 131 and 121 (Fig. 1) for the time being.

Relay 507 adapts the line controller for connector action as will be subsequently described, 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 at armature 5 and its front contact, at the same time isolating its winding and chain-in conductor CH—IN from the 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, chain relay 211 locks ground on its upper winding terminal independent of contacts of relays 207 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 the reverting-call busy test; at its contacts 3 and 4, it connects switching and busy relays 207 and 208 respectively to the switching and busy leads SW and BU in cable 554; and at contacts 7 and 8, it grounds 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.

A11. *Tens and units selection*

In the assumed example, the ground potential applied to conductors **231** and **232** is extended through the closed contacts **0** of tens and units registers TR and UR to tens conductor T**0** in cable **247**, and to units conductor U**0** in cable **248**. Units-preference relay UP**0** operates over conductor U**0** to cause the tenth units-select magnet UM**0** to operate. The upper winding of tens-preference relay **140** is energized over tens conductor T**0**, wherefore relay **140** is operated without the accompanying operation of relay **130**. Relay **140** connects the associated common meter conductor M to the tens group meter M**0**; it connects common primary control conductors PA to PE to control conductors A to E of the tenth primary subgroup TG**0**; and at its lower contacts, it closes an operating circuit for the tenth tens-select magnet TM**0**.

A12. *The called line is busy*

If 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 its contacts **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 the clearing out, chain relay **211** is open-circuited and restored. With contacts **8** 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 DT**1**, wherefore there has been no forward extension of the connection from the connector C**1** toward the called line.

At its contacts **2**, busy relay **208** connects the common busy-tone lead BT through back contacts **1** 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. Such clearing out is accomplished in a manner similar to that to be hereinafter described.

A13. *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 one of the fifteen terminating trunks such as TT**2** and TT**12** 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 TT**2** and line link L**0**B, the distributor selection is such as to cause the illustrated stackup **2** of DR**1** (Fig. 3) to be selected.

A14. *Connector switch operation*

When the necessary selections have been effected by the line controller, control conductors CB**1** and B of the switches B**1** and **0**B (Fig. 3) are grounded along with switching conductor SW in cable **554**.

The grounding of conductor B associated with primary switch **0**B 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 UM**0** (Fig. 1).

Responsive to the placing of ground potential on control conductor CB**1**, a circuit is closed, through contacts **306**, for the hold magnet **305**, whereby the illustrated stackup **0** of switch B**1** is closed, having been selected by magnet UM**0** (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 DT**1**, thereby closing a circuit for hold magnet **304**, which includes conductor B (supplied with battery through fuse **110**). Hold magnet **304** now closes the selected stackup **2** of the distributor DR**1**, thereby extending conductors T, R, and S of trunk DT**1**, through the back contacts of stackup **11** and through the three upper pairs of stackup **2** of the distributor, to the selected terminating trunk TT**2**, whence the connection extends as illustrated to the called line. The ground potential on sleeve conductor S of distributor trunk DT**1** 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 test conductor S**00** 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 is subsequently reclosed.

A15. *Ringing the called substation*

Following the described operation of switching relay **207**, as soon as the common pick-up lead PU is next grounded momentarily, by ringing interrupter **241** at the beginning of the next 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 locking conductor L in substitution for pick-up lead PU, remaining locked over conductor L throughout 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 a further result of its operation, ringing relay **206** disconnects conductors T and R in distributor trunk DT**1** from talking condensers **212** and **213**, and from the windings of back-bridge relay **205**, and connects them to the ringing circuit. In this circuit, the tip conductor T is

connected directly to ground, while the ring conductor R is connected, over conductor 233 and through party register PR, to the selected one of the ten generator leads G1 to G0. In the assumed example, the first generator lead G1 has been selected. This lead, along with leads G2 to G5, is provided with one application of ringing current during the ringing cycle, by one-ring relay 242. Accordingly, one application of ringing current is made during each ringing cycle to the called line from frequency lead F1, supplied by generator 246. This application of ringing current is made comparatively early in the ringing cycle, following which relay 242 restores. Upon so doing, it reconnects each of the generator leads G1 to G5 to battery through the associated resistor 244, whereby battery potential is impressed on lead G1, and consequently on ringing lead 233, and thence to the ring conductor R of distributor trunk DT1 and the corresponding conductor of the called line. Any different potential tended to be maintained thereon by the usual condenser in the ringing circuit (not shown) at the substations on the called line is thereby dissipated.

When ringing relay 206 is restored at the end of each ringing cycle, it transfers the tip and ring conductors of the called line from the ringing circuit back to talking condensers 212 and 213, and to the windings of back-bridge relay 205. No disturbance is thereby created on the calling line, for tip conductor T is maintained at ground potential during the ringing cycle, which is the same potential normally maintained on condenser 212 by the upper winding of relay 205, and the ring lead of the called line is brought to battery potential as above described during the final portion of each ringing cycle, which is the potential normally maintained on condenser 213 by the lower winding of back-bridge relay 205.

A16. *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 210 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 register PR to clear out. The opening of off-normal contacts ON of the party register 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 the current flow over the talking leads 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.

During conversation, which may now ensue, the relays of connector C1 in energized condition are 202 to 205 and 207.

A17. *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 resistor 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 deenergizing the cutoff relays (103 and 303) and the 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 restored release relay 204, which idle-indicating potential manifests itself, through the left-hand winding of magnet 106, on control conductor CA2.

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; dials the directory number (110) 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 to the connector C1 (Fig. 2), in which connector, relays 203 and 204 operate as previously described.

When the called number (110) is dialed, tens, units, and party registers TR, UR, and PR respond as previously described. Contacts 1 are closed in registers TR and UR and contacts 0 are closed in register PR. 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 PR 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, and responds by grounding busy lead BU in cable 554, followed by the grounding of switching lead SW in such cable. As a result, busy and switching relays 208 and 207 are operated successively. It

should also be noted, that the line controller fails to bring about the operation of a secondary and primary switch to forward a call to the called line, such line having been recognized as also the calling line. Each of the relays **208** and **207**, on operating, locks itself to the grounded local conductor **216**. With busy relay **208** operated, its contacts **5** 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 invention 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 PR and the left-hand front contact of line relay **203**. Upon restoring, relay **209** (with busy relay **208** in operated condition), 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 digit 0 has been dialed in the assumed example, contacts **0** of the register PR are closed, and ringing current is transmitted to the line from frequency source F5 through front contacts of two-ring relay **243**, generator lead G0, contacts **0** of register PR, conductor **233**, front contact **3** of ringing relay **206**, back contact **3** of relay **209**, and front contact **4** of busy relay **208**. The return path to ground for such ringing current (bridged ringing being assumed) 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 (when locking lead L is temporarily ungrounded at interrupter **241**), it will be evident that the removal of the receiver at either of the concerned stations 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**, 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 2A releasing. Responsive to this operation, back-bridge relay **205** restores, removing ground potential from holding conductor **216** at its contacts **1**, whereupon connector C1 clears out completely and immediately. That is, relays **207** and **209** restore and register UR clears out.

B3. *Reverting-call lockout*

Upon the described removal of ground potential from the sleeve conductor of the connection established from line #11 to connector C1, cut-off relay **103**, in the line circuit of the calling line, restores immediately, but slow-restoring lockout relay **102** remains operated temporarily. With a direct-current bridge now across the conductors of line #11, line relay **101** immediately reoperates, through contacts of the restored cut-off 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 is called in. The calling and called subscribers may now con-

verse 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, bringing the line circuit into normal condition.

C. *Subgroup line-finder lockout*

In Fig. 1, arrangements similar to those disclosed in my prior Patent 2,354,660 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 interval thereof, while cutoff lead CO 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 CO 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 (assuming line 11, Fig. 1, to be the calling line) causes the associated line circuit to assume lockout condition, as described hereinbefore 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 and the calling subscriber does not replace his receiver, the timing arrangement again becomes effective responsive to the restoration of supervisory relay 202. Then, if the calling subscriber does not 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 leads DT and 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 interrupter 241 and generator such as 246 into operation. When units-transfer relay 210 is restored as described by back-bridge relay 205, lead GEN—ST is ungrounded at contacts 1 of relay 210.

E2. *Tone leads*

As previously noted, dial tone from the common dial-tone lead DT is applied to the calling line through contacts 3 of release relay 204 when the connector C1 is seized, which application continues until tens-transfer relay 209 opens its upper contacts 1 at the end of the dialing of the tens digit. Relay 209 is subsequently restored at the end of the dialing of the units digit, but the dial-tone signal is prevented from reappearing at that time by contacts 2 of units-transfer relay 210. During conversation, relays 209 and 210 are both restored as previously described, at which time dial tone is prevented from reappearing by contacts 3 of switching relay 207.

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 inasmuch as no one is listening on the line at that time.

At is 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 is preferably from one of the ringing generators such as 246. It may be obtained through a suitable step-down transformer, if desired.

F. *Line controller—Finder calls*

The operation of the line controller shown in 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 operate 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 from around its upper winding at back contact 3, to render the relay fast-releasing. At the front contact of said armature 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 relay to restore as a slow-acting relay. The restoration of relay 511 completes the timing cycle and operates 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 that it does not normally occur, being preceded by the completion of the regular operation of the line controller as will be described.

F2. *Setting the secondary test relays*

At its contacts 1, relay 509 of the cycle timer applies ground potential to conductor 556. With transfer relay 507 in restored condition (during a finder call), the grounding of conductor 556 grounds conductor 557, through back contact 1 of 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 leads above mentioned is the control lead 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 A2. Each connected one of the secondary test relays now operates, subject to the concerned secondary switch and associated finder trunk being idle. 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, the high-resistance lower winding of relay 534, contacts of relay 531, secondary control lead CA2, make-busy contacts 107, left-hand winding of hold relay 106 of secondary A2, sleeve conductor S in trunks FT1 and CT1, back contact 4 of release relay 204 of the connector C1, make-busy contacts 214, and through the associated resistor to battery, such battery connection being over the associated lead B and through fuse 110. It will be observed that is fuse 110 is blown, if relay 204 is operated, if make-busy contacts 214 are open, or if make-busy contacts 107 are open, the above-traced circuit is open and relay 533 fails to operate, treating the secondary A2 and associated trunk as busy. Obviously, the same result obtains if there is ground potential on the sleeve lead of the finder trunk FT1, from whatever source, in which event any battery potential reaching such sleeve lead is shunted away from the winding of relay 533.

Since relay 534 has a high-resistance lower winding (true for each of the relays 534 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 the secondary switch, subject to the matching operation to be described.

F3. *Setting the primary test relays*

As previously described, the energization of any one of the ten relays 131 to 140 (Fig. 1), incidental either to a finder call or to a connector call, connects the five primary control leads PA to PE respectively to the local primary control leads A to E of the concerned one of the tens subgroups TG1 to TG0. Leads PA to PE are connected respectively to 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 energizes 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 through the winding of hold magnet 104 to battery. While test relay 526 energizes over this circuit, hold magnet 104 is not effectively energized, because of the high resistance of the lower winding of relay 526. It is to be observed that, if the fuse (not shown) supplying battery potential to switch 104 is open, or make-busy contacts 105 are open, or if ground potential is

maintained on sleeve conductor S of line link LIA from any source, relay 526 fails to operate.

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

F4. *The matching operation*

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

The operation of any matching relay 520 to 524 is subject to ground potential being applied to the concerned one of the conductors 571 to 575 through the upper winding of two secondary test relays. Considering secondary subgroup A, for example, if all three secondary test relays 534 to 536 associated with such subgroup are operated, indicating that all three finder-action switches (numbers 2, 4 and 6 in secondary subgroup A, Fig. 6) 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 subgroup is idle, relay 520 operates through contacts 1 of primary test relay 526, in series with the upper winding thereof. Relay 520 also operates if only two of the three relays 534 to 536 are operated, provided relay 526 is operated. On the other hand, if only one of the relays 534 to 536 is operated, ground potential is applied to conductor 571 through only one upper winding of a secondary test relay, wherefore the marginally adjusted matching relay 520 is unable to operate even though relay 526 be operated. Relay 520 is likewise unable to operate, if none of the relays 534 to 536 operates, or if primary test relay 526 does 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 the grounded conductor 576, wherefore relay 525 is prevented from operating. At its armature 3, each of the 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 conductor 562 with conductor 563, as an indication that the matching operation 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 (ground) potential from the lower winding of each secondary test relay 534 to 548. This operation is performed on each matching operation, regardless of how many (one to four) 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 current through the locking upper winding of such relay, and 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 and secondary test relays 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 primary test relay 526 is effective to hold such relay operated independent of further current flow through the lower winding thereof.

F5. *Choice allotter*

Assuming the choice allotter, comprising relays 514 to 519, to be in the illustrated condition, with all relays restored, as it normally is on only one call 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, but such winding does not energize immediately, being short-circuited by the 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 its armature 3 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.

At this time, the subsequent operation of the choice allotter is described. When the call (termed the first call) being currently handled is disposed of, the consequent restoration of start relay 508 ungrounds conductor 559, removing the short-circuit from around the lower winding of relay 514, whereupon such driver relay energizes in series with relay 515 and the upper contacts thereof. Upon so doing, it transfers conductor 559 from the odd-operate conductor to the even-operate conductor, over which relays 516 and 518 are controlled.

On the second call, the grounding of conductor 559 results in the closure of a circuit through contacts of the operated relays 514 and 515 for relay 516. Counting relay 516 thereupon operates, and locks itself directly to ground at its inner upper contacts. At its upper contacts, relay 516 prepares a circuit for the next succeeding relay 517, while at its inner lower contacts, it open-

circuits the preceding relay 515. Relay 515 thereupon restores, leaving relay 516 locked operated.

Upon the opening of the circuit of the relay 515, the operating circuit (through the lower winding) of driver relay 514 is opened, but relay 514 remains operated through its upper winding so long as conductor 559 remains grounded. When conductor 559 is next ungrounded, relay 514 restores and again transfers conductor 559 to the odd-operating conductor.

On the third call, the grounding of conductor 559 operates the next succeeding counting relay 517, through contacts of the restored relay 514, and through the upper contacts of the preceding operated relay 516. Upon operating, relay 517 locks itself to the operating conductor, at its middle upper contacts, and further locks itself at its upper contacts, to ground, through the lower winding of relay 514, open-circuiting and restoring relay 516 at its lower contacts. When ground is next removed from conductor 559, relay 514 is reenergized by its lower winding, in series with the operated relay 517, to prepare for the operation of relay 518.

On the fourth call, the grounding of conductor 559, operates relay 518 through contacts of the operated relays 514 and 517, locking itself directly to ground at its inner upper contacts, and open-circuiting and restoring relay 517 at its lower contacts. The subsequent ungrounding of conductor 559 again restores relay 514 by deenergiizng its upper winding.

On the fifth call, the grounding of conductor 559, operates the final counting relay 519, through contacts of the restored relay 514 and contacts of the operated preceding counting relay 518. At its upper contacts, relay 519 locks itself to conductor 559, while at its lower contacts, it open-circuits and restores the preceding counting relay 518.

It will be noted that the final relay 519 does not lock itself independent of control conductor 559, as does each of the preceding counting relays 515 to 518. Accordingly, when conductor 559 is next ungrounded, relay 519 restores, bringing the choice allotter back into its illustrated condition.

From the foregoing description, it will be seen that each grounding of conductor 559, incidental to a finder call or a connector call, causes the next successive one of the relays 515 to 519 (operating in an 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 primary and secondary selection is effected by circuit arrangements as shown in Fig. 1, ground potential is extended through one or another of the five secondary off-normal contact pairs, 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, and as soon thereafter as the described matching operation has occurred, if it has not already done so, operate relay 513 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 7 of transfer relay 507, contacts 3 of operated cycle timer 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 5, applies ground potential to operate conductor 560, through back contact 4 of busy relay 505.

In the assumed example, the choice allotter is 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 concerned with finder action is operated. Accordingly, the grounding of operate conductor 560 operates the "A" switch in the calling primary subgroup, and the first finder-action switch (A2) in secondary subgroup A. The operating circuit of switch A2 is as follows: from ground on operate conductor 560, inner lower contacts 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 contact, contacts of the operated finder-call relay 531, secondary control 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 subgroup, 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*

In addition to closing operate circuits as previously described, operate relay 513 initiates the clearing-out operation by closing a circuit, at its contacts 2, for clearout relay 512, from the grounded conductor 559. Upon operating, clearout relay 512 locks itself to conductor 559 at its contacts 1; opens its contacts 2, without immediate effect because contacts 3 of 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 531; and, at its contacts 5, it open-circuits operate relay 513. Operate 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, amply long to permit the normal 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 the start relay 508 (clearout relay 512 being in operated condition), causing the operated tens subgroup relays such as 131 and 121 (Fig. 1) to restore for the lack of a current supply.

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 an 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 also somewhat slow in releasing. The slow-releasing characteristic keeps relay 512 operated long enough to insure that the concerned tens subgroup relays of Fig. 1 are 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 conductor PS—ON in cable 551.

The restoration of the operated tens subgroup relay such as 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 locking 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.

The line controller is now entirely cleared out, and its start chain is reclosed at contacts 2 of clearout relay 512, to permit another call (either a finder call or a connector call) 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 subgroup is busy, secondary test relay 534 remains in restored condition. Then, the described placing of an operating ground potential on conductor 581 extends ground potential through 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 is then 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 not to operate when current is supplied thereto through the upper winding of a single secondary test relay. 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 operates after a moment, responsive to the grounding of conductor 576. At its contacts 6, reserve-control relay 525 locks itself directly to conductor 576, and, at its armatures 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 resistance 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 a single one of the relays 534 to 536 is operated, ground potential is now supplied to conductor 571 through two resistance paths, permitting matching relay 520 to operate to render available the final, reserve secondary (in the concerned category, finder action or connector action) in the subgroup.

F10. *All-finders-busy operation*

In the preceding description, it was noted that the operation of operate 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 regular matching or as a 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 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. 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 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*

When the line controller is seized, or called in, for a connector call, the operation of a chain relay such as 211 is accompanied by the previously described operation of transfer and start relays 507 and 508 of the line controller. At its armatures 4 and 5 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 507 operated, the grounding of conductor 556 at contacts 1 of relay 509 results in the closure of a circuit, through 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, whereas only thirteen of them are employed for finder calls, as previously noted. 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 contacts of ground control relay 533, lower 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 the handling of finder calls.

G3. *Primary test*

As previously noted, the operation of a chain relay such as 211 of connector C1 is followed by the operation of one or another of the ten relays 131 to 140, dependent upon the value of the digit dialed. Such relay connects the common primary control leads 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 busy or idle 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 525, as described in connection with the 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 selections 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 another of the units magnets UM1 to UM0, a circuit is completed: from ground on conductor PS—ON in cable 551, through contacts 6 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 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 the ground-connected test relay 503 in the connector group of the line controller. With hold magnets 401 and 402 both in 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 the lower winding of busy relay 505 through back contact 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 interval following the operation of the sleeve connectors and preceding the operation of busy relay 505, while the second interval is the interval following the operation of busy relay 505 (if it occurs) and 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 contact 2, disconnects busy relay 505 before the latter relay has had time to operate. At its front contact 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 contact 3, prepares a circuit over distributor-select conductor 561 to operate the distributor select magnets of Fig. 4 in accordance with which terminating trunk must 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 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 slight interval. At the front contact of its armature 1, busy relay 505 grounds lead BU in cable 554, thereby immediately operating the busy relay of the calling connector, such as busy relay 208 of the connector C1.

G8. *Reverting-call test*

At its back contact 2, busy relay 505 removes the shunt from around sleeve resistor 555, and it closes a circuit for the operating winding of slow-operating test-cutoff relay 506, thereby initiating 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 the switches 1A and A2 (Fig. 1) to the connector C1 of 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 is 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 relays such as 102 and 103, or of hold magnets such as 104 and 106, but it 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 may proceed simultaneously with the described switch-testing and matching operations.

G9. *Distributor selection*

If the call being handled is not a reverting call; if idle relay 504 operates; and if an idle switching path can be matched from a terminating trunk to the called line, 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 4 of one or more of the matching relays 520 to 524, conductor 563, front contact 7 of transfer relay 507, front contact 3 of idle relay 504, back contact 5 of busy relay 505, distributor-select conductor 561, certain contact sets shown in parts 2 and 3 of Fig. 5, one or another of conductors 591 to 595, 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, ground on conductor 561 is further extended throughout contacts of relay 516, front contact 4 of matching relay 521, conductor 592, front contact 3 of relay 537, to distributor-select lead DS—2, closing a circuit for the upper winding of distributor-select magnet DM2 (Fig. 4) in series with distributor-select magnet DM12. Magnets DM2 to DM12 are thereby energized to perform their respective functions. It will be recalled that DM12 performs no selective function, but secures the closure of distributor-off-normal contacts DON11, 12. Magnet DM2 effects selection of the second stackup in the several distributors, also causing distributor-off-normal contacts DON1, 2 to close.

G10. *Closing the operating circuits*

During a connector call, the closure (over operate conductor 560) of the operating circuits is effected, if at all, only after the distributor-select magnets have been operated as described. When this operation has been accomplished ground potential on distributor-select lead 561 is extended over conductor 1 of pair DON in cable 551, and thence through distributor off-normal contacts DON 11, 12 (Fig. 4), one or another of the remaining pairs of off-normal contacts of the distributor, conductor 2 in pair DON, contacts 3 of relay 511, contacts 5 of relay 512, and thence to battery through the winding of operate relay 513. With busy relay 505 not operated, relay 513 applies ground potential at its contacts 4, 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 relay 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, operate relay 513 applies ground potential to conductor SW in cable 554, by way of contacts 1 of idle relay 504. If the calling connector is the connector C1, switching relay 207 now operates, and closes the previously described operating circuit for magnet 304 of the 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 6, transfer relay 507 removes ground from conductor S0 in cable 552, permitting sleeve connectors USC and TSC (Fig. 4) to clear out. Ground is thereby removed from conductor ST in cable 552, restoring idle relay 504.

G11*a*. *Regular-busy clear out*

As described, if the called line is regularly busy (not busy 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, 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 clear out, along with the other relays of the line controller.

G11*b*. *Reverting-call clear out*

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 the grounding of operate conductor 560 by operate relay 513, while the operation of armature 5 of busy relay 505 (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, since the operation of busy relay 505 is succeeded by the operation of idle relay 504: from ground, through front contacts 4 of relay 505, front contact 3 of relay 504, front contacts 5 of relay 505, and thence to relay 513 through contacts 3 and 5 of relays 511 and 512. Relay 513, besides initiating a clear-out operation as previously described, grounds conductor SW in cable 554 so as to bring about the operation of the switching relay such as 207 in the calling connector, the busy relay 208 in such connector having been previously operated by busy relay 505.

G11c. *Lost-connector-call clear out*

As previously noted, when the called line tests regularly idle (relay 504 operating and relay 505 remaining restored), the operating circuit for the operate 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 operation, 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 the 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 operation of clearout relay 512 by cycle-timer relay 511.

H. *Traffic-meter operation*

The operation of the traffic meters 411 to 419 by the line controller of Fig. 5 will now be described.

H1. *Recording total calls*

Each time the line controller of Fig. 5 receives a call, whether a finder call or a connector call, relay 509 of the cycle timer operates as previously described, thereby grounding conductor 556 at its contacts 1. A circuit is thereby completed over conductor TCR in cable 552 for meter 411. The total shown by meter 411 is accordingly the total of all calls received by the line controller.

From the previous description, it will be observed that whenever a finder call can be completed normally, clearout relay 512 is invariably operated prior to restoration of relay 511 of the cycle timer. In the case of connector calls, whether the called line tests idle or busy, clearout relay 512 is invariably operated prior to the restoration of relay 511, unless the called line tests idle and the matching operation cannot be completed within the allotted time. In this event, the call is recorded as a lost call, and conductor 565 is grounded as previously described. The grounding of conductor 565 closes a circuit over conductor TCL to operate meter 412, which meter records the total calls lost. It will be observed that calls not completed are not recorded as lost calls when the called line tests busy, for the term "lost call" as used herein refers to a call which would have been completed, except for the lack of sufficient trunk or link paths through the switching equipment.

H2. *Recording finder calls*

On the receipt of each finder call, transfer relay 507 not having been operated, the grounding of conductor 556 by relay 509 results in the closure of a circuit through back contact 1 of relay 507, and over conductor FCR for meter 413, which meter records the total number of finder calls received.

Each time conductor 565 becomes grounded because the call being handled is lost, if relay 507 is in restored condition, a circuit is thereby completed through back contact 2 of such relay, and over conductor FCL for meter 414. Such meter accordingly records all lost finder calls.

H3. *Recording connector calls*

With transfer relay 507 in operated condition, upon the receipt of each connector call, grounding of conductor 556 by relay 509 closes a circuit through front contact 1 of relay 507, and thence over conductor CCR for meter 415, which meter records the total number of connector calls received.

Each time a connector call is lost, the previously described consequent grounding of conductor 565 results in the closure of a circuit through front contact 2 of relay 507 and over conductor CCL for meter 416 which records the total connector calls lost.

H4. *Causal classification of lost calls*

The total calls lost are broken down, by meters 417 to 419, into three classifications according to the causes for the loss. The lost calls recorded collectively on these three meters are all lost calls, whether finder calls or connector calls.

H4a. *Recording trunks-busy lost calls*

Each time lost-call conductor 565 is grounded, if trunk-idle relay 502 is not in operated condition, the loss of such call is attributed to a busy condition of all trunks (finder trunks or terminating trunks) of the category with which the current lost call is concerned, thereby closing a circuit, through the back contact of the armature of relay 502, and over conductor ATB for trunks-busy meter 417. Meter 417 accordingly records all calls lost because all trunks over which such calls could have been completed are busy. The control circuit of trunk-idle relay 502 includes normally open contacts 4 of all secondary test relays 534 to 548. If no one of these relays can operate when the concerned one of the connecting relays 531 and 532 operates, then trunk-idle relay 502 fails to operate, and the closure of the above described circuit for meter 417 results when lost-call conductor 565 becomes grounded.

H4b. *Recording links-busy lost calls*

If lost-call conductor 565 becomes grounded at a time when trunk-idle relay 502 is in operated condition, the lost call is recorded on one or another of the meters 418 and 419. If there is no line link idle between the secondary group and the concerned primary subgroup of switches, none of the primary test relays 526 to 530 can operate, wherefore none of the contacts 5 of such relays are closed and link-idle relay 501 remains restored. Under this condition, the ground potential applied to conductor 565 passes through

front contacts of relay 502, and back contacts of relay 501, to conductor ALB, operating links-busy meter 418 to record the total number of calls lost because all links of the concerned primary subgroup are busy, with one or more trunks idle.

H4c. *Recording paths-busy lost calls*

If a call is lost at a time when there is at least one idle trunk over which it could be completed if such trunk can be reached, and at a time when there is at least one link idle between the concerned primary subgroup of switches and the secondary subgroup, trunk-idle relay 502 is operated through contacts 4 of one or more of the secondary test relays 534 to 548 and link-idle relay 501 is operated through contacts 5 of one or more of the primary test relays 526 to 530. Under this condition, the grounding of conductor 565 closes a circuit, through front contacts of relays 502 and 501, and thence over conductor APB to paths-busy meter 419, which meter totalizes the calls lost under such condition.

An instance of a paths-busy condition, when there is at least one idle link and at least one idle trunk, is when, for example, the line link extending from the "A" primary switch in the concerned primary subgroup is idle, but all secondary switches of the concerned category, such as finder action or connector action, are busy in the secondary subgroup A, such idle link cannot then be used. If that is the only idle link of the concerned primary subgroup, a trunk cannot be reached through another subgroup, even though idle. The occurrence of this condition is comparatively rare in practice.

H5. *Subgroup-meter operation*

As previously noted, on each call one or another of the tens-preference relays 131 to 140 (Fig. 1) operates to connect the concerned one of the meters M1 to M0 to the common meter conductor M in cable 551. The connected meter is accordingly operated, subject to receiving operating current over the said conductor M. In Fig. 5, part 1, conductor M is shown connected, through temporary jumper 550, to conductor TCR (being the total-calls-received conductor in cable 553). Accordingly, each meter M1 to M0 makes a record for the concerned ten-line subgroup corresponding to the record made by meter 411 for the entire group.

Instead of being connected to conductor TCR, temporary jumper 550 may be connected to any one of the conductors leading to meters 411 to 419, causing in each case a correspondingly different record to be made on the several meters M1 to M0 of Fig. 1.

I. *Varying traffic requirements*

Assuming that the calls received by the lines served by a unit equal the calls originated by the lines of the unit, both in number and in duration (not strictly true generally), generally accepted traffic data indicates that the provision of four line primary switches and four line links for each ten-line subgroup affords a traffic-handling capacity through the line primary switches and line links substantially equivalent to the traffic-handling capacity of ten finder trunks and ten connector trunks, on a lost-call basis such as the usual one in a hundred. From this, it follows that the fifth (E) switch can be omitted from each primary subgroup if traffic data indicates that ten finder trunks and ten connector trunks will amply serve the one hundred lines connected to the unit. In this event, the E subgroup of secondary switches may be omitted entirely, along with switches 5 and 6 in secondary subgroup C, together with the concerned ones of the connectors C1 to C13 and associated distributors.

It is preferable that the unit be installed with complete standardized cabling and wiring as disclosed, rendering it easy to add, and place in service, all or any part of the omitted equipment if its use is later indicated, as by the data recorded on the several traffic meters as hereinbefore described.

It will be understood also that any other curtailments of equipment may be employed to meet the needs of a group of one hundred lines not requiring the full traffic-handling facilities of the disclosed unit when completely equipped as desired. In this connection, it may be pointed out that the omission of a unit of equipment, such as a primary switch, a secondary switch, or a connector, does not require any compensating change to be made in the line controller of Fig. 5, for all testing operations performed thereby are for the presence of an idle-indicating battery potential on the concerned primary or secondary control conductor. When one of the above-noted devices is omitted, the resultant gap in the test circuit including such device thereby causes the line controller to by-pass such omitted device.

For the handling of calls to and from a 100-line group providing heavier traffic than can be satisfactorily handled by the quantities of equipment and corresponding paths afforded by the specific unit hereinbefore disclosed, a similar unit may be provided which is mounted on a similar frame except that it has greater height. Such a frame may provide for a total of sixty primary switches, six for each ten-line sub-group. In this event, the plates of equipment TG1 to TG0 of Fig. 7 are suitably spaced apart, so that each remains generally opposite the corresponding subgroup of primary switches.

The increased height of the mounting frame provides room for the required additional secondary switches (including a new subgroup F) along with additional connectors and additional corresponding distributors.

Obviously, by a similar increase in height, the unit can be arranged to provide for seven or more primary switches for each ten-line subgroup, together with space for the correspondingly increased number of secondary and distributor switches and connectors.

J. *Partially equipped units*

It often suffices to install the disclosed unit only partially equipped initially. It is customary to install standardized cabling and wiring for the full capacity of a partially equipped unit, greatly facilitating the later addition of equipment as it becomes required by future growth. If, for example, only fifty lines are needed at the outset, tens group plates TG1 to TG5 may be installed initially, along with the first twenty-five line primaries 1A to 5E, tens group plates TG6 to TG0 being omitted, as are line primaries 6A to 0E.

The smaller traffic offered by the initially operating fifty lines enables a smaller number of secondary and distributor switches and connectors to be used initially.

When more lines are to be served by the installed unit, the above-noted omitted equipment can be installed, either all at once, or from time to time, as required. For each additional ten lines to be served, it suffices to install an additional plate of equipment such as TG6, together

with the associated primary switches such as 6A to 6E. The omitted connectors may be installed as desired, along with a corresponding number of the omitted distributor and secondary switches.

With complete standardized cabling and wiring provided on the unit, when additional equipment is installed, such equipment may be made available for service with a minimum of labor. After the additional equipment has been fastened in place, the appropriate adjacent cable conductors are attached to the terminals thereof.

The five added primary switches comprising a subgroup may be provided with a factory-installed bank multiple. In the case of secondary and distributor switches, the existing bank multiple may be extended downwardly to the newly installed switches. This procedure is facilitated by the disclosed secondary arrangement wherein the switches of the two categories (finder action and connector action) are interspersed, as compared to prior arrangements wherein the first half of the switches in a secondary subgroup are for finder action, followed by the remaining switches assigned to connector action.

I claim:

1. 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, each group including 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 each common switch to complete a temporary connection serially through the common switch of the other group in accordance with such setting, means controlled over the temporary connection for operating a remaining switch in each of the two groups to complete a relatively permanent connection in accordance with the setting of the selecting apparatus, and means for restoring the common switches to sever the temporary connection while leaving the relatively permanent connection established.

2. In a switching system, two groups of selective switches serially related for the extension of connections, a 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 common selecting apparatus, one group including 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 said common switch to complete a temporary connection in accordance with such setting, means controlled over the temporary connection for operating a remaining switch in each of the two groups to complete a relatively permanent connection in accordance with the setting of the selecting apparatus, and means for restoring the common switch to sever the temporary connection while leaving the relatively permanent connection established.

3. In a switching system, two groups of selective switches serially related for the extension of connections to desired called lines, 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, each group including one switch common to the remaining switches thereof, means effective when a connection is to be completed to a desired called line for correspondingly setting the selecting apparatus of each group and for operating each common switch to complete a temporary test connection to the called line serially through the common switch of the other group in accordance with such setting, means controlled over the temporary test connection, and depending on the called line being idle, for operating a remaining switch in each of the two groups to complete a relatively permanent connection to the called line in accordance with the setting of the selecting apparatus.

4. In a switching unit serving a group of lines and employing a group of secondary switches and a group of primary switches serially related for extending connections to called lines; trunks incoming to the unit; terminating trunks, greater in number than the incoming trunks, extending from the incoming trunks to the secondary switches; line links, greater in number than the terminating trunks, extending from the secondary switches to the primary switches, the lines served extending from the primary switches; the lines, the primary switches, and the primary end of the line links, being divided into primary subgroups; the secondary end of the line links, the secondary switches, and the terminating trunks, being divided into secondary subgroups, line links at any secondary subgroup extending respectively to the primary subgroups; and distributor switches effective to interconnect any incoming trunk with any terminating trunks.

5. In a switching unit serving a group of lines and employing a group of secondary switches, and a group of primary switches serially related for extending connections to called lines, trunks incoming to the unit, terminating trunks, greater in number than the incoming trunks, extending from the incoming trunks to the secondary switches, line links, greater in number than the terminating trunks, extending from the secondary switches to the primary switches, the lines served extending from the primary switches; the lines, the primary switches, and the primary end of the line links, being divided into primary subgroups; the secondary end of the line links, the secondary switches, and the terminating trunks, being divided into secondary subgroups, line links at any secondary subgroup extending respectively to the primary subgroups; means for extending a connection from a calling line to any incoming trunk and for identifying any desired called line; means for operating a primary switch in the primary subgroup containing the called line, and for operating a secondary switch in any secondary subgroup, to connect any idle terminating trunk to the called line by way of an idle line link; and means for extending the connected incoming trunk to the last-named terminating trunk to thereby connect the calling line with the desired called line.

6. In a switching unit serving a group of lines divided into subgroups, corresponding subgroups of primary switches of a given capacity having access to the lines of the respective subgroups, secondary switches of the same capacity having access to the respective subgroups of primary switches, distributor switches of increased capac-

ity having access to the secondary switches, and trunks incoming to the distributor switches and having access to said lines therethrough by way of the secondary and primary switches in tandem.

7. In a switching unit serving a group of lines divided into subgroups, trunks, line relays individual respectively to said lines, switching means for extending any calling line to any idle one of said trunks, subgroup-marking and line-marking conductors for directing the operation of the switching means according to the respective identities of calling lines, each line relay being operable over its line, when calling, to place marking potential on the concerned subgroup-marking conductor and line-marking conductor, relay means controlled over the marked subgroup conductor for locking marking potential thereon independent of the operated line relay, and relay means controlled jointly over the marked subgroup and line conductors for locking marking potential on the marked line conductor independent of the operated line relay.

8. In a switching unit serving a group of lines divided into subgroups, trunks, line relays individual respectively to said lines, switching means for extending any calling line to any idle one of said trunks, subgroup-marking and line-marking conductors for directing the operation of the switching means according to the respective identities of calling lines, each line relay being operable over its line, when calling, to place marking potential on the concerned subgroup-marking conductor and line-marking conductor, and relay means controlled over said conductors respectively for locking marking potential thereon independent of the operated line relay.

9. In a switching system, a common current-supply conductor, a group of switching links, each link including talking conductors, a test conductor, and a branch current-supply conductor; automatic switches to which said links respectively connect at one end; control-relay groups through which said links respectively pass; each branch current-supply conductor, when connected to the common conductor, being effective to supply operating and holding current to the automatic switch and relay group of its link, and to normally apply an idle-indicating potential to the test conductor thereof; and protective circuit-opening devices interposed between the respective branch conductors and the common conductor, whereby the protective opening of the current supply leading to the relay group or switch of a link automatically withdraws such link from service by removing the idle-indicating potential from the test lead thereof.

10. In a switching system, a group of switching links, each link including a test conductor, a pair of individually interlinked automatic switches, and a connector interposed therebetween; a common current-supply conductor, branch current-supply conductors for the respective links, each branch conductor, when connected to the common conductor, being effective to supply operating and holding current to the two switchs and connector of its link, and to normally apply an idle-indicating potential to the test conductor thereof; and protective circuit-opening devices interposed between the respective branch conductors and the common conductor, whereby the protective opening of the current supply leading to the connector or to either switch of a link automatically withdraws such link from service by removing the idle-indicating potential from the test lead thereof.

11. In an automatic switching system wherein series of impulses representing respective digits in the number of a called line are transmitted successively from a calling line, a trunk circuit common to a group of lines and including means for receiving and recording successive digit series of impulses, means for seizing the trunk circuit for temporary use individually with any calling line of the group, a release timer and means for starting it into operation from a normal position responsive to such seizure, means responsive to the uninterrupted operation of the release timer for not less than a predetermined interval for terminating the seizure and returning the trunk circuit to common use, and means responsive to the receipt at the trunk circuit of any of the successive series of impulses for resetting the timer to its normal position to start a new timing interval.

12. In an automatic switching system wherein series of impulses representing respective digits in the number of a called line are transmitted successively from a calling line, a trunk circuit common to a group of lines and including means for receiving and recording successive digit series of impulses, means for seizing the trunk circuit for temporary use individually with any calling line of the group, a release timer and means for starting it into operation from a normal position responsive to such seizure, means responsive to the uninterrupted operation of the release timer for not less than a predetermined interval for terminating the seizure and returning the trunk circuit to common use, and means responsive to the receipt at the trunk circuit of any of the successive series of impulses for resetting the timer to its normal position to start a new timing interval, means including automatic switching apparatus responsive according to the recorded digit series for extending the calling line to the called line, and relay means in the trunk circuit controlled over the called line for disabling said release timer during conversation, said release timer restarting from normal position under control of said relay means at the end of conversion provided the seizure of the trunk circuit is not otherwise terminated.

13. In a trunk circuit for use in an automatic switching system, a line relay arranged to be operated over a calling line extended thereto and to be restored momentarily responsive to each of a series of open-circuit impulses received over the calling line, the line relay having a back contact and a pair of front contacts, a slow-restoring release relay having an operating circuit including one front contact of the line relay, a local impulse circuit including the back contact of the line relay and a front contact of the release relay in series, a release-timer relay having two windings, an operating circuit including the first winding of the release-timer relay in series with another front contact of the release relay, means for closing such operating circuit momentarily at predetermined intervals, and a self-locking circuit including the second winding of the release-timer relay in series with the other front contact of the line relay, whereby the release-timer relay may operate and lock following seizure of the trunk circuit, and is unlocked and restored, if operated, at the beginning of the transmission of a series of impulses.

14. In a trunk circuit for use in an automatic switching system, a line relay arranged to be operated over a calling line extended thereto and to be restored momentarily responsive to each of

a series of open-circuit impulses received over the calling line, a slow-restoring release relay having an operating circuit including a front contact of the line relay, a local impulse circuit including a back contact of the line relay and a front contact of the release relay in series, and a self-locking circuit for the release relay having a resistance sufficiently low that it substantially aids the relay in remaining operated while the line relay is responding to impulses, said resistance being sufficiently high that the release relay restores responsive to an opening of the operating circuit when the line relay remains restored longer than momentarily.

15. In a trunk circuit for use in an automatic switching system, a line relay arranged to be operated over a calling line extended thereto and to be restored momentarily responsive to each of a series of open-circuit impulses received over the calling line, a double-wound slow-restoring release relay having an operating circuit through a front contact of the line relay including both windings of the release relay in parallel, a local impulse circuit including the back contact of the line relay and a front contact of the release relay in series, one of said windings being in series with a back contact of the release relay whereby it is disconnected when the release relay operates.

16. In a trunk circuit for use in an automatic switching system; a line relay arranged to be operated over a calling line extended thereto and to be restored momentarily responsive to each of a series of open-circuit impulses received over the calling line; a double-wound slow-restoring release relay having an operating circuit, through a front contact of the line relay, including both windings of the release relay in parallel; a local impulse circuit including the back contact of the line relay and a front contact of the release relay in series; and means for disconnecting one winding of the release relay, following operation of the line relay, leaving the other winding connected as a holding winding.

17. In a trunk circuit for use in an automatic switching system; a line relay arranged to be operated over a calling line extended thereto, and be restored momentarily responsive to each of a series of open-circuit impulses received over the calling line; said line relay having a back contact and two front contacts; a slow-restoring release relay having an operating circuit including one front contact of the line relay; a local impulse circuit including a back contact of the line relay and a front contact of the release relay in series; an impulse-recording device controlled over said local conductor and having off-normal contacts; and a slow-operating transfer relay having a circuit including the other front contact of the line relay in series with said off-normal contacts.

18. In a trunk circuit for use in an automatic switching system; a line relay arranged to be operated over a calling line extended thereto, and be restored momentarily responsive to each of a series of open-circuit impulses received over the calling line, said line relay having a back contact and two front contacts; a slow-restoring release relay having an operating circuit including one front contact of the line relay; a register included in a local impulse circuit including a back contact of the line relay and a front contact of the release relay in series, said register having a pair of off-normal contacts closed responsive to the receipt of a local impulse; and a fast-restoring slow-operating transfer relay having a circuit including the other front contact of the line relay in series with said off-normal contacts.

19. In a connector for use in an automatic telephone system; register circuits for receiving impulse series corresponding to the tens and units digits respectively of called numbers; a local impulse conductor common to both circuits; tens and units transfer relays operable respectively at the termination of the series of impulses constituting the tens and units digits for associating said common conductor selectively with said circuits in timed relationship to the said series of impulses; means controlled over the register circuits for extending a connection to the called line and for applying ringing current thereto; and means controlled over the called line for restoring the units-transfer relay, as a ring-cut-off relay when the called subscriber answers.

20. In an automatic switching system, a group of lines, a group of line links, and a group of trunks; a group of selective primary switches for interconnecting the lines individually with the line links, and a group of selective secondary switches for interconnecting the line links individually with the trunks; means effective when any line is to be interconnected with any trunk for selecting the line and the trunk to be interconnected as well as the line link over which the connection is to extend; means for selecting the respective positions the concerned primary and secondary switches must assume to complete the interconnection; each primary and secondary switch having a normally open operate circuit which, when closed, causes it to assume its selected position; all said selections occurring contemporaneously, and means effective subject to all said selections having been effected for closing the operate circuits of the concerned primary and secondary switches to complete the interconnection.

21. In an automatic switching system, a group of lines, a group of line links, and a group of trunks; a group of selective primary switches for interconnecting the lines individually with the line links, and a group of selective secondary switches for interconnecting the line links individually with the trunks; means effective when any line is to be interconnected with any trunk for selecting the line and the trunk to be interconnected as well as the line link over which the connection is to extend; means common to the primary switches and means common to the secondary switches for selecting the respective positions the concerned primary and secondary switches must assume to complete the interconnection; each primary and secondary switch having a normally open operate circuit which, when closed, causes it to assume its selected position; and means effective subject to all said selections having been effected, and including primary and secondary off-normal contacts controlled by the common selecting means, for closing the operate circuits of the concerned primary and secondary switches to complete the interconnection.

22. In an automatic switching system, (*a*) a group of lines, a group of two-way line links, a first group of trunks including outgoing trunks and terminating trunks, and a second group of trunks comprising incoming trunks over which calls for said lines arrive; (*b*) a group of selective primary switches for interconnecting the lines individually with the line links, a group of selective secondary switches for interconnecting the line links individually with the trunks of the first group, and a group of selective distributor

switches for interconnecting the incoming trunks individually with the terminating trunks, each switch having a normally open operate circuit which, when closed, causes it to assume its selected position; (c) means effective when any line is to be interconnected with any trunk in the first group, either as a calling line or as a called line, for selecting the line and the trunk to be interconnected as well as the line link over which the connection is to extend, said means operating to select an outgoing trunk if the line is calling and to select a terminating trunk if the line is called; means for selecting the respective positions the concerned primary and secondary switches must assume to complete the interconnection between the line and the selected trunk of the first group, all said selections occurring contemporaneously; (d) means effective subject to all said selections having been effected for closing the operate circuits of the concerned primary and secondary switches to complete the interconnection; and (e) means effective when the concerned line is a called line for selecting the position the concerned distributor switch must assume to interconnect the incoming trunk over which the call arrived with the selected terminating trunk, the means for closing the operate circuits of the concerned primary and secondary switches being then further subject to the last-named selection having occurred and to the called line being idle, said closing means being then also effective to close the operate circuit of the concerned distributor switch.

23. In an automatic switching system, (a) a group of lines, a group of two-way line links, a first group of trunks including outgoing trunks and terminating trunks, and a second group of trunks comprising incoming trunks over which calls for said lines arrive; (b) a group of selective primary switches for interconnecting the lines individually with the line links, a group of selective secondary switches for interconnecting the line links individually with the trunks of the first group, and a group of selective distributor switches for interconnecting the incoming trunks individually with the terminating trunks, each switch having a normally open operate circuit which, when closed, causes it to assume its selected position; (c) means effective when any line is to be interconnected with any trunk in the first group, either as a calling line or as a called line, for selecting the line and the trunk to be interconnected as well as the line link over which the connection is to extend, said means operating to select an outgoing trunk if the line is calling and to select a terminating trunk if the line is called; means for selecting the respective positions the concerned primary and secondary switches must assume to complete the interconnection between the line and the selected trunk of the first group, all said selections occurring contemporaneously; (d) means effective subject to all said selections having been effected for closing the operate circuits of the concerned primary and secondary switches to complete the interconnection; and (e) means effective when the concerned line is a called line, and subject to its being idle, for selecting the position the concerned distributor switch must assume to interconnect the incoming trunk over which the call arrived with the selected terminating trunk, the means for closing the operate circuits of the concerned primary and secondary switches being then further subject to the last-named selection having occurred, said closing means being then also effective to close the operate circuit of the concerned distributor switch.

24. In an automatic switching system, a group of lines, a group of line links, and a group of trunks; a group of selective primary switches for interconnecting the lines individually with the line links, and a group of selective secondary switches for interconnecting the line links individually with the trunks; the trunks, the secondary switches, and the secondary end of the line links being divided into secondary subgroups; link-test relays corresponding respectively to the line links, and trunk-test relays corresponding respectively to said trunks, each test relay being operable to one position or another dependent upon whether the corresponding link or trunk is busy or idle; match relays corresponding respectively to the secondary subgroups; means controlled by the concerned link-test and trunk-test relays for operating any match relay subject to the corresponding secondary subgroup containing an idle line link and containing two or more idle trunks; and means controlled by any operated match relay for operating a primary switch and a secondary switch to interconnect a selected line with an idle trunk in the associated secondary subgroup by way of an idle line link.

25. In an automatic switching system, a group of lines, a group of line links, and a group of trunks; a group of selective primary switches for interconnecting the lines individually with the line links, and a group of selective secondary switches for interconnecting the line links individually with the trunks; the trunks, the secondary switches, and the secondary end of the line links being divided into secondary subgroups; link-test relays corresponding respectively to the line links, and trunk-test relays corresponding respectively to said trunks, each test relay being operable to one position or another dependent upon whether the corresponding link or trunk is busy or idle; match relays corresponding respectively to the secondary subgroups; means controlled by the concerned link-test and trunk-test relays for operating any match relay subject to the corresponding secondary subgroup containing an idle line link and containing two or more idle trunks; means controlled by any operated match relay for operating a primary switch and a secondary switch to interconnect a selected line with an idle trunk in the associated secondary subgroup by way of an idle line link; and means effective, subject to no secondary subgroup containing more than one idle trunk, to render any match relay operable under control of the corresponding test relays provided the corresponding subgroup contains an idle link and an idle trunk.

26. In a line controller for use in a switching system, trunk-test relays divided into subgroups, link-test relays corresponding respectively to said subgroups, match relays corresponding respectively to said subgroups, each match relay having an operating circuit closed by the operation of the corersponding link-test relay jointly with the operation of any trunk-test relay in the corresponding subgroup.

27. In a line controller for use in a switching system, trunk-test relays divided into subgroups, link-test relays corersponding respectively to said subgroups, each test relay having a local hold winding and having an operating winding in circuit with the test conductor of its associated link or trunk, match relays corresponding respectively to said subgroups, each match relay

having an operating circuit closed by the operation of the corresponding link-test relay jointly with the operation of any trunk-test relay in the corresponding subgroup, the operating circuit of each match relay including the holding winding of the corresponding link-test relay in series with the holding winding of any operated trunk test relay in the corresponding subgroup, and means responsive to the operation of any match relay for open-circuiting the operation windings of the trunk-test relays.

28. In a line controller for use in a switching system, trunk-test relays divided into subgroups, link-test relays corresponding respectively to said subgroups, match relays corresponding respectively to said subgroups, each match relay having an operating circuit closed by the operation of the corresponding link-test relay jointly with the operation of any trunk-test relay in the corresponding subgroup, each link-test relay controlling a separate parallel branch of said operating circuit, each such branch being of such resistance as to substantially limit the flow of current thereover, each match relay requiring for its operation the current flow over two or more such parallel branches, and a reserve-control relay and means for operating it to close a reserve parallel branch for each match relay subject to all match relays failing to operate otherwise.

29. In a switching system, switches having common access to a group of circuit paths arranged in subgroups, subgroup-selecting means operable to select one subgroup or another of the paths in all idle switches, path-selecting means operable to select one path or another within the selected subgroup in all idle switches, contact means actuated by the subgroup-selecting means incidental to its operation in selecting any subgroup, contact means actuated by the path-selecting means incidental to its operation in selecting any path in the selected subgroup, and means dependent on the actuation of both said contact means for operating an idle one of said switches to close the selected path.

30. In a trunk circuit for use in an automatic switching system, a line relay arranged to respond to each of a series of impulses received over a calling line, a slow-restoring release relay having an operating circuit controlled by the line relay, a local circuit controlled jointly by said relays, and a holding circuit for the release relay having a resistance sufficiently low that it substantially aids the release relay in remaining operated while the line relay is responding to impulses, said resistance being sufficiently high that the release relay cannot remain operated indefinitely over its said holding circuit.

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