June 3, 1947. N. H. SAUNDERS 2,421,717

AUTOMATIC TELEPHONE SYSTEM

Filed April 28, 1943 17 Sheets-Sheet 1

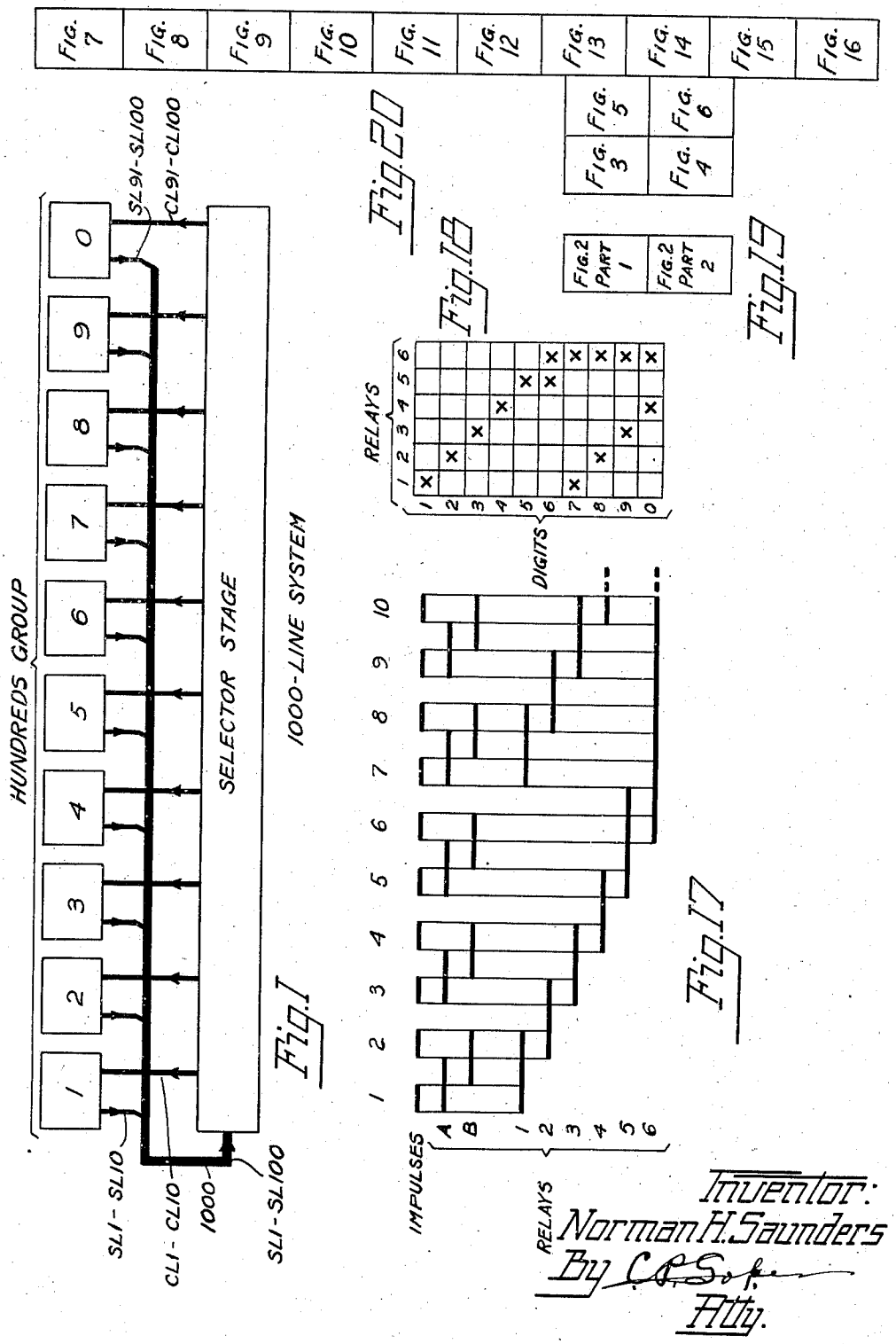


Fig. 1

Fig. 20

Fig. 18

Fig. 19

Fig. 17

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AUTOMATIC TELEPHONE SYSTEM

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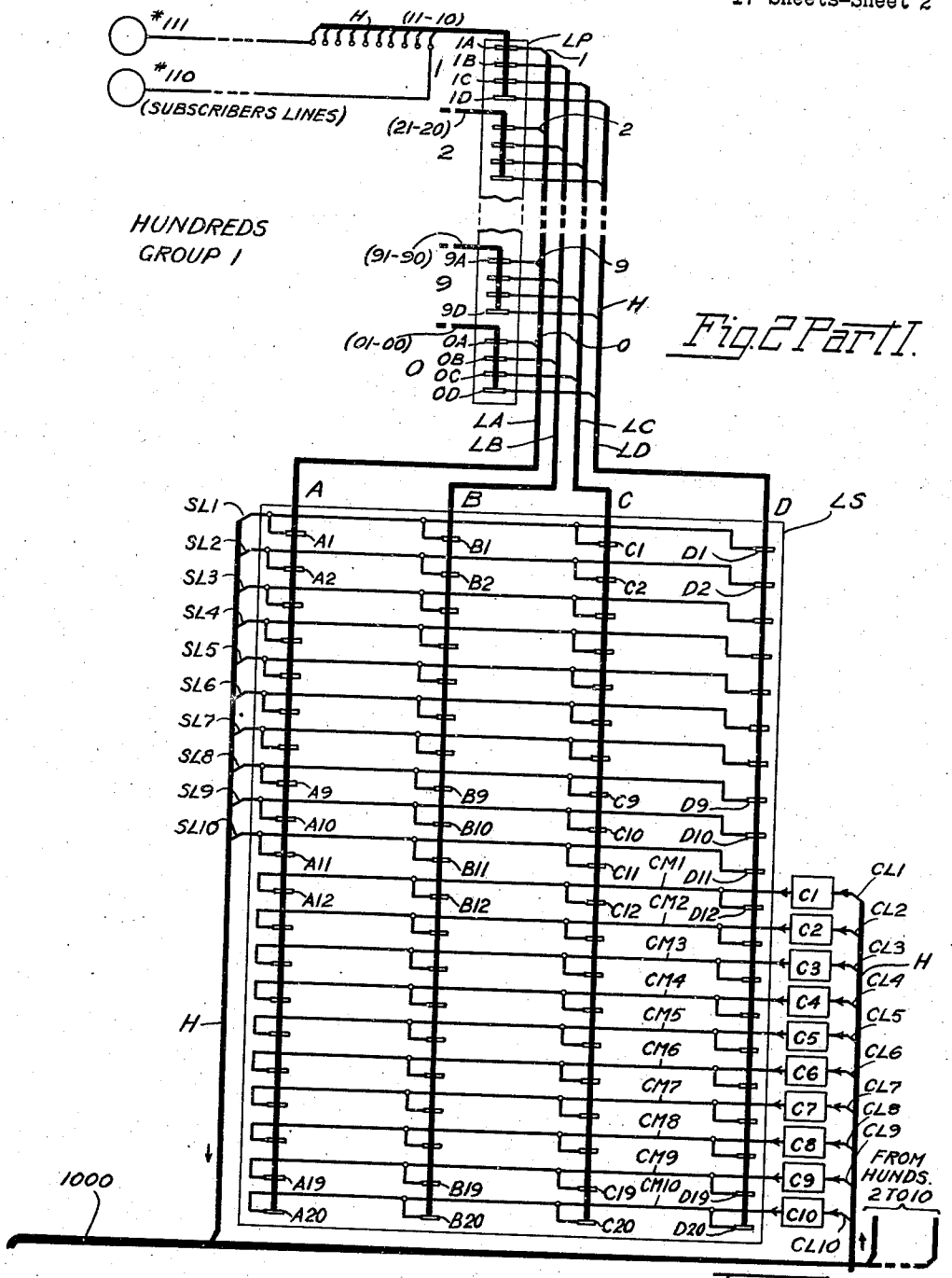


Fig. 2 Part I.

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AUTOMATIC TELEPHONE SYSTEM

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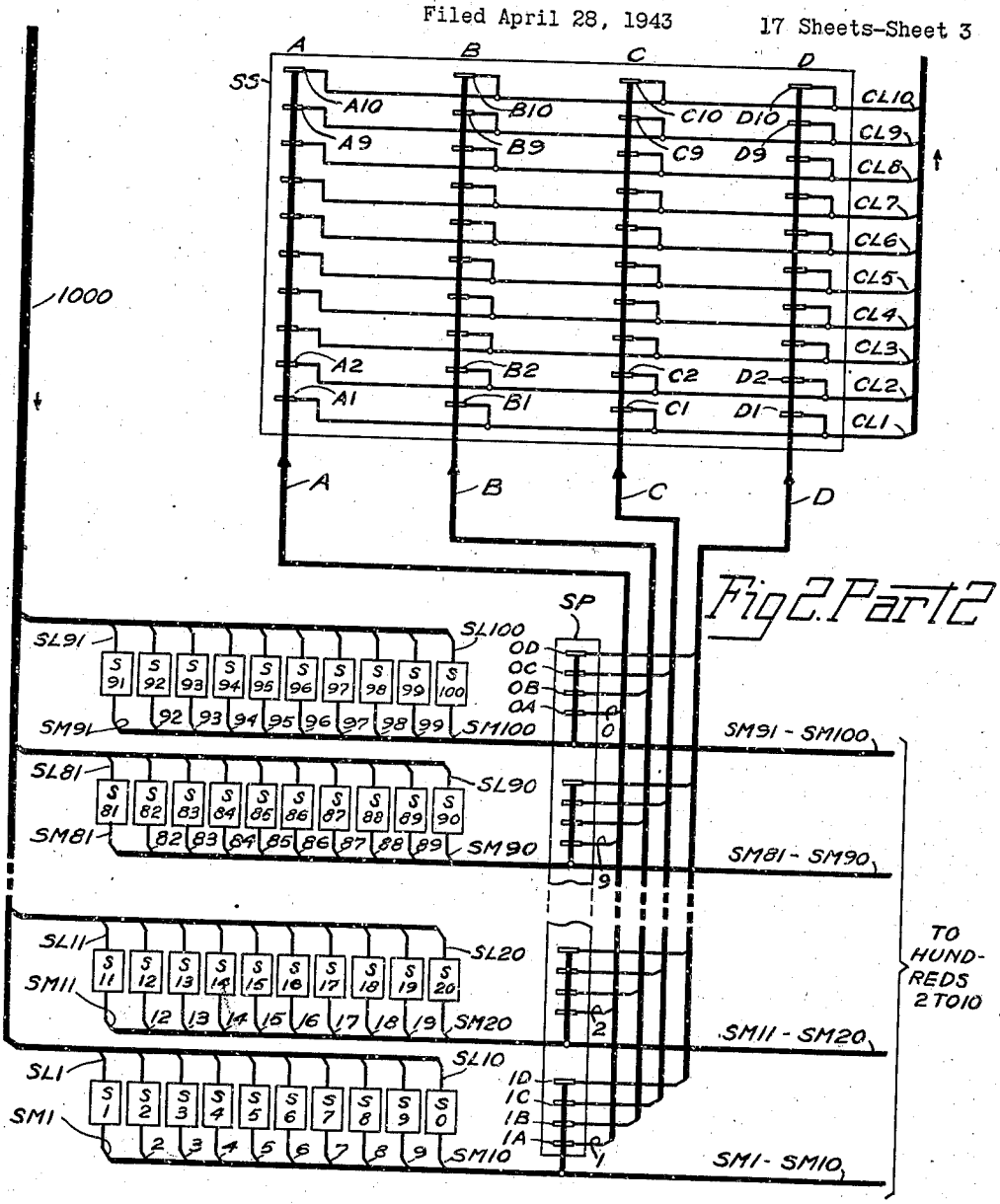


Fig 2. Part 2

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AUTOMATIC TELEPHONE SYSTEM

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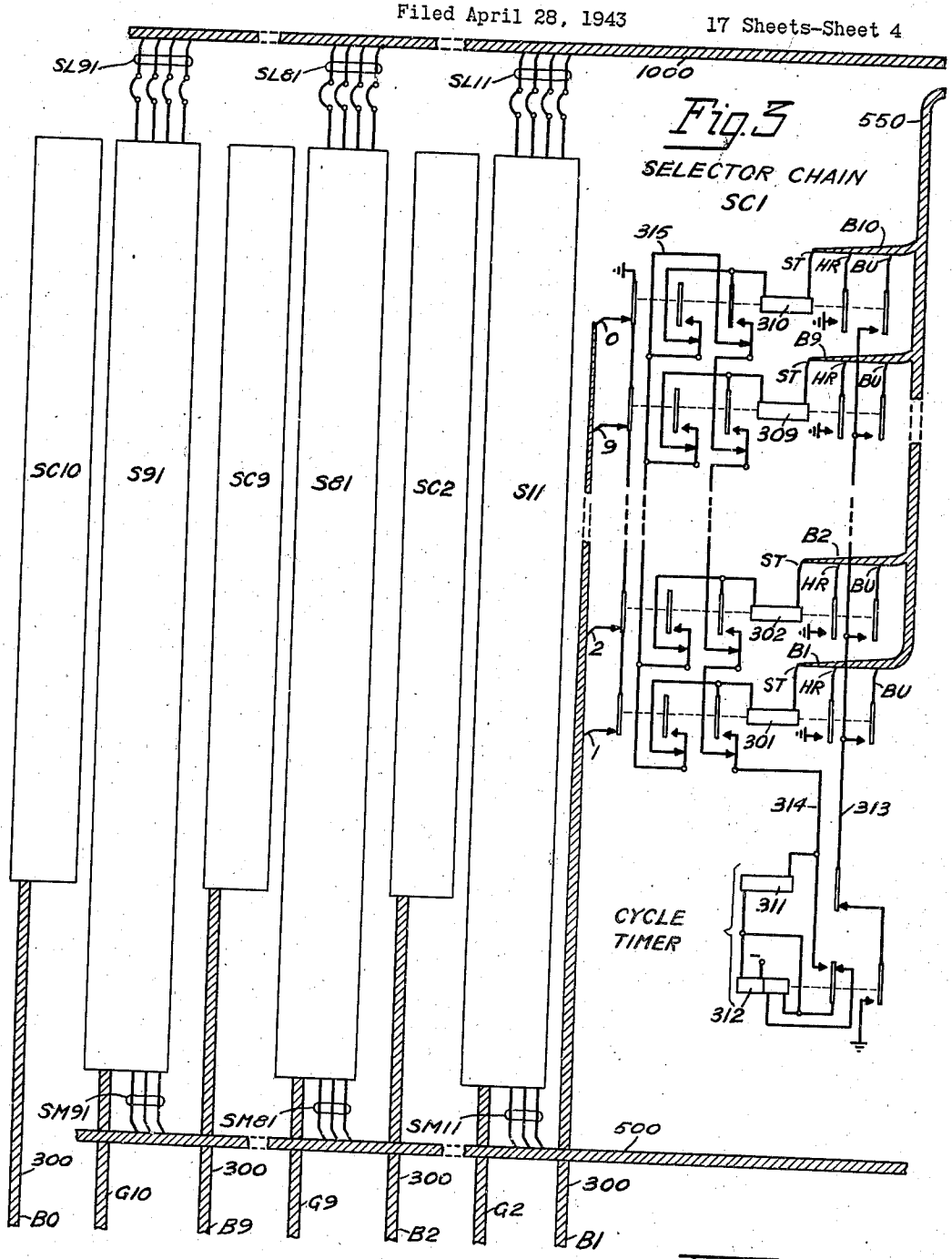


Fig. 3

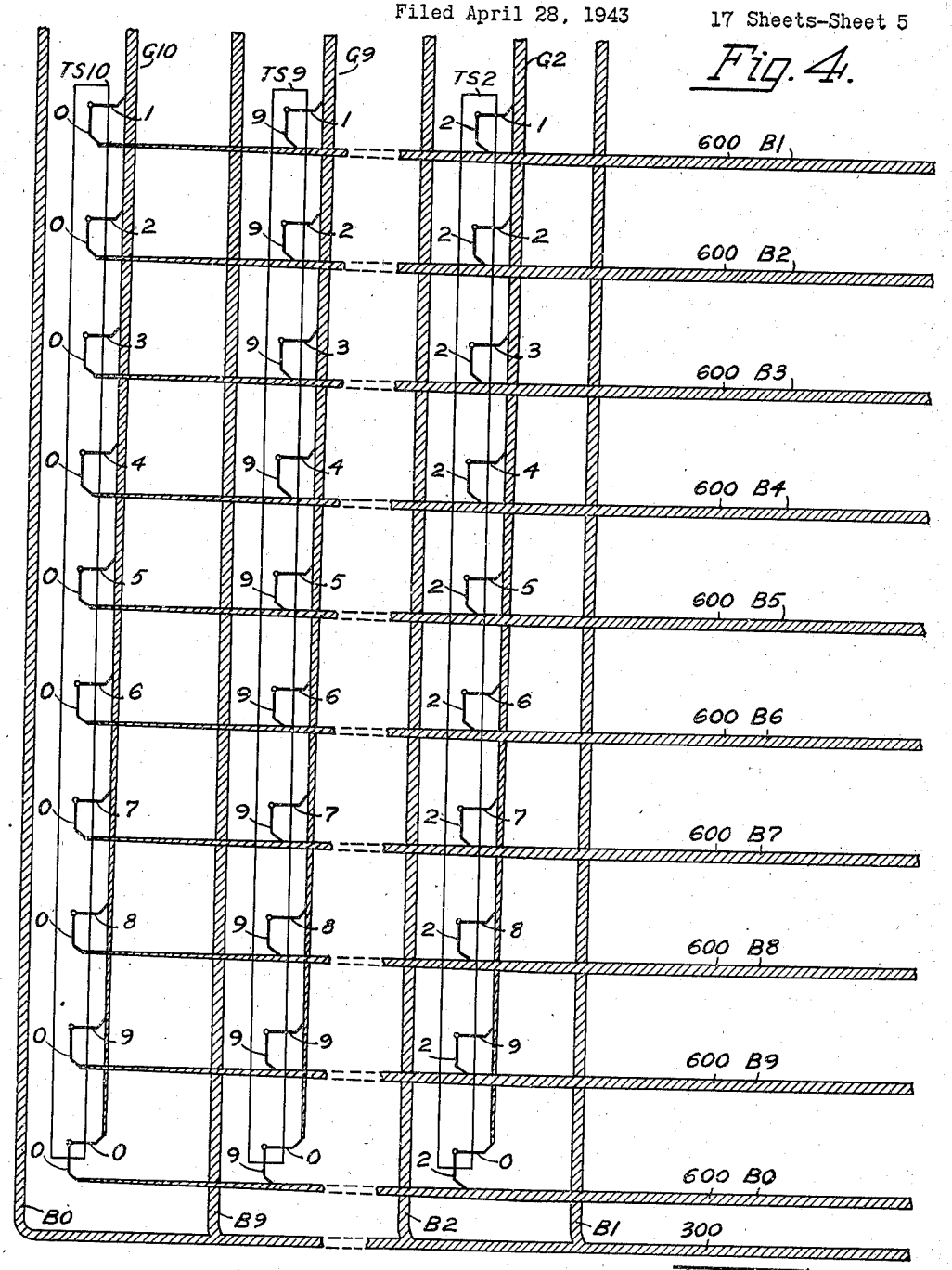
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June 3, 1947. N. H. SAUNDERS 2,421,717

AUTOMATIC TELEPHONE SYSTEM

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Fig. 4.

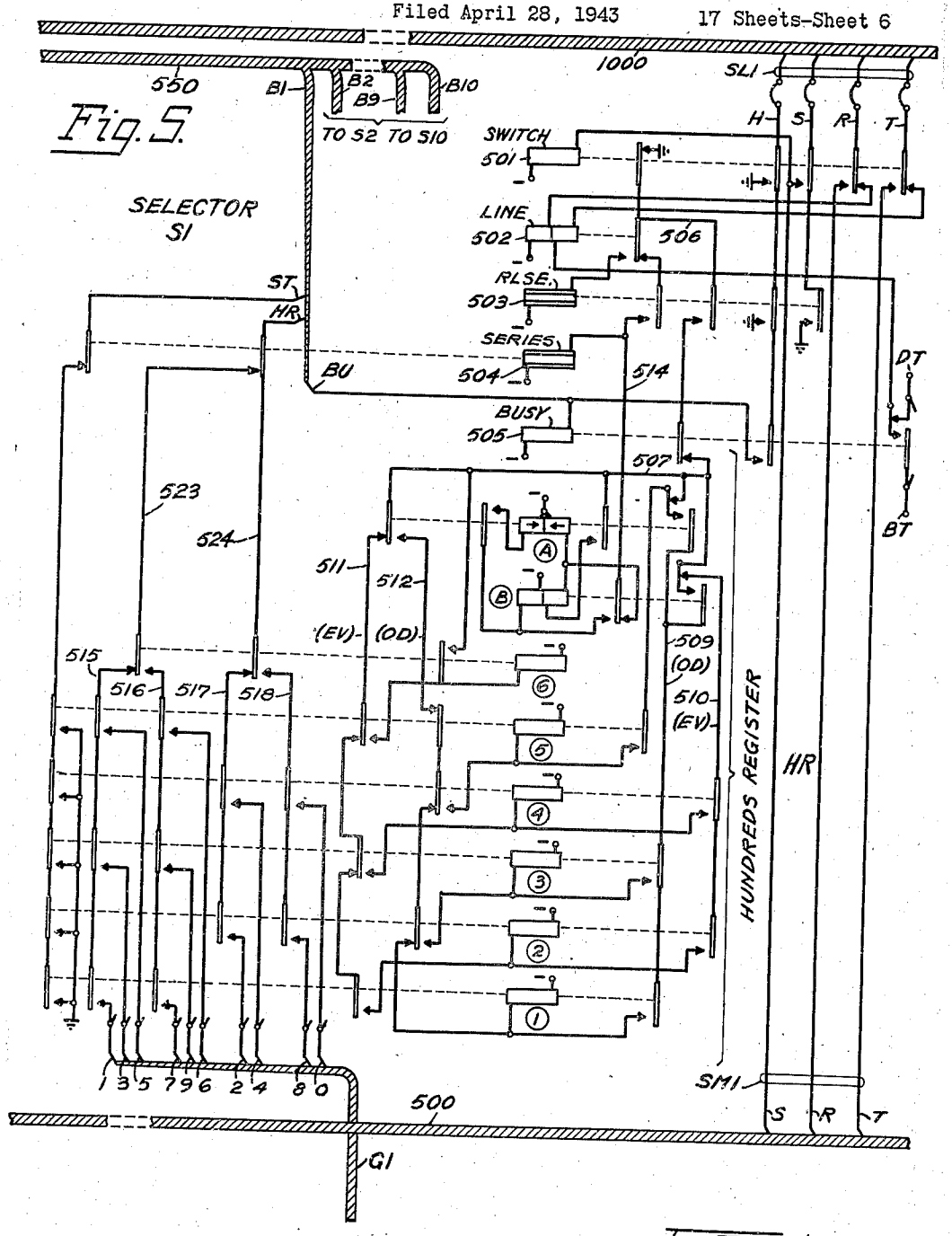


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AUTOMATIC TELEPHONE SYSTEM

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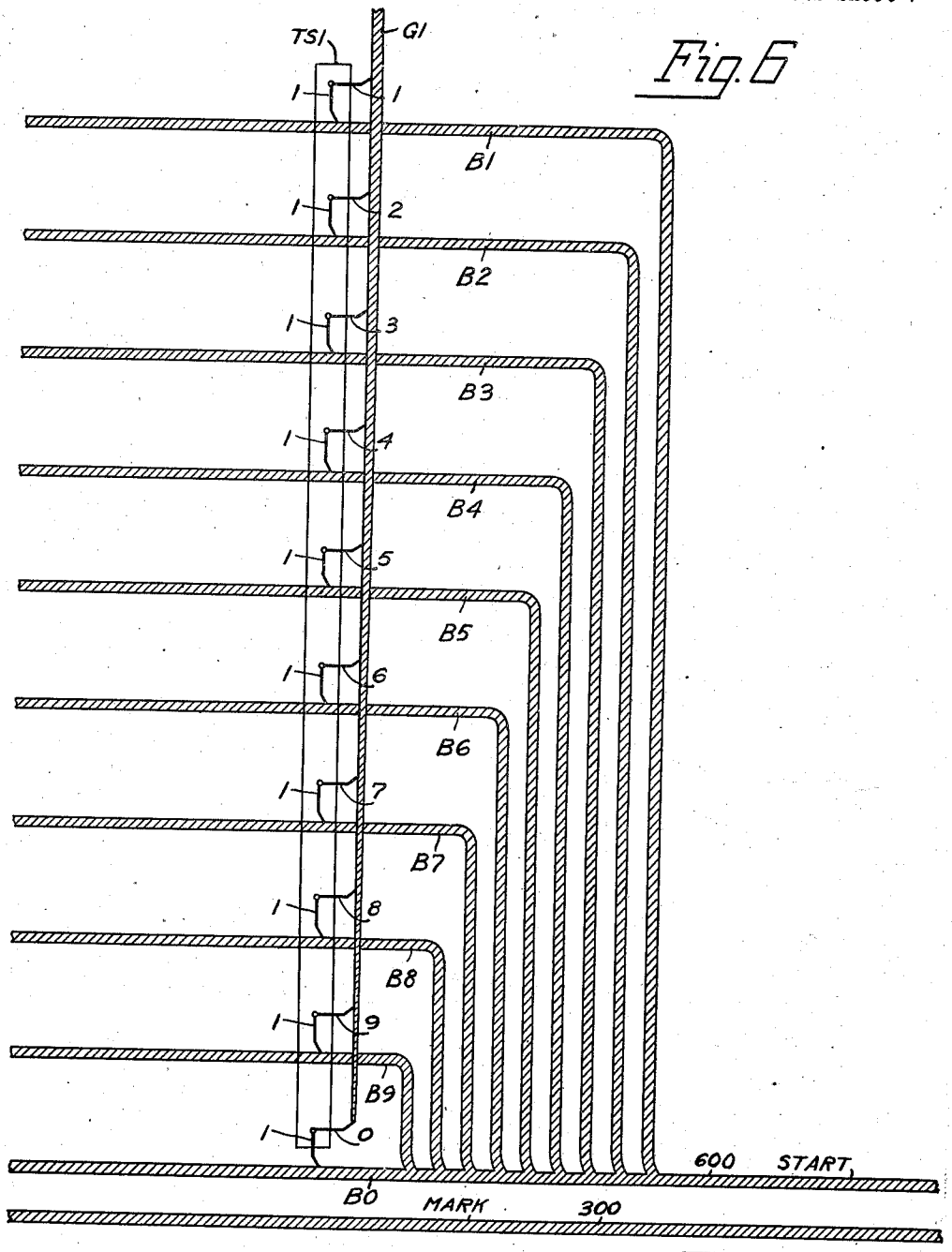
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AUTOMATIC TELEPHONE SYSTEM

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Fig. 6



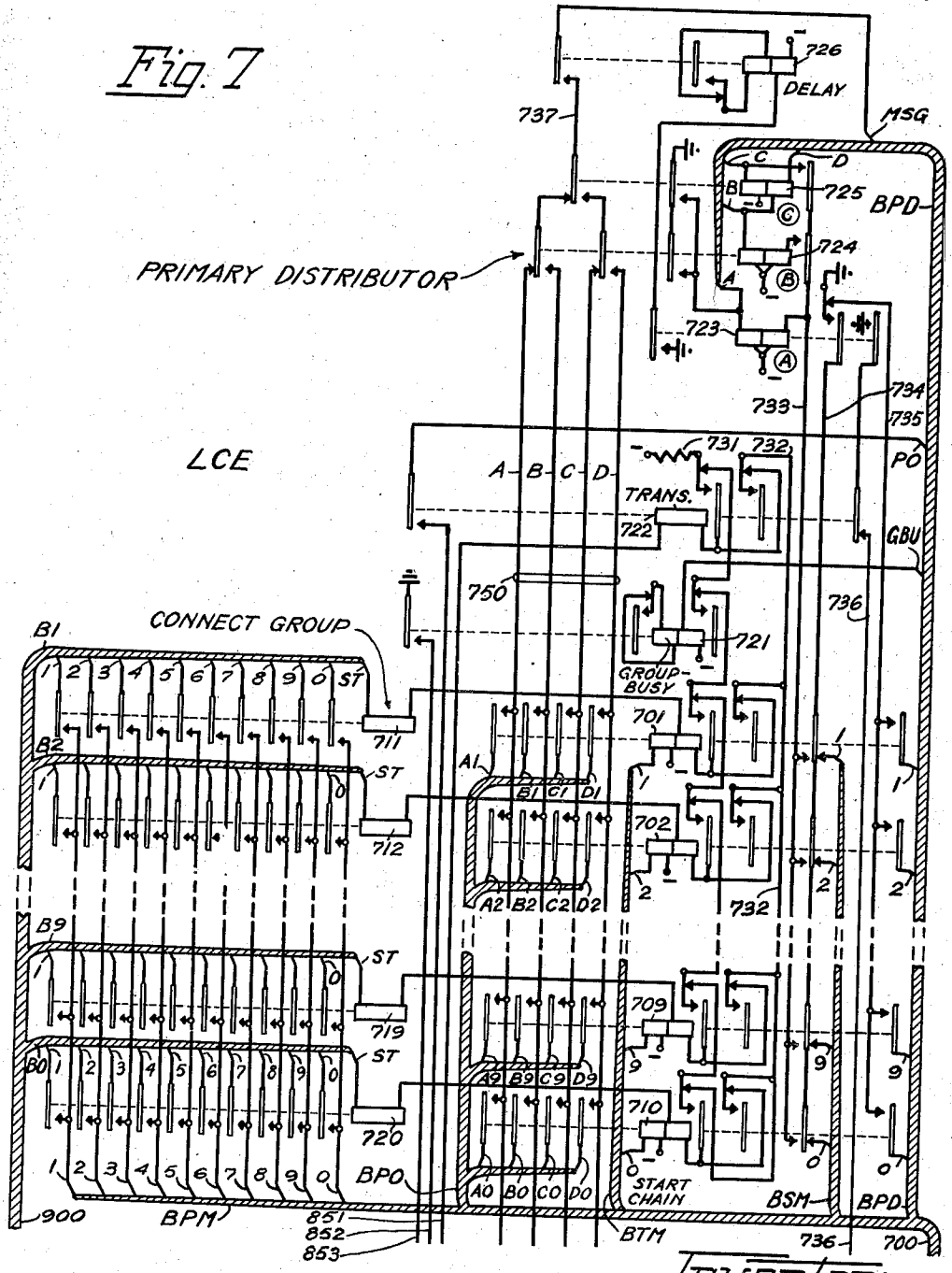
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Fig. 7



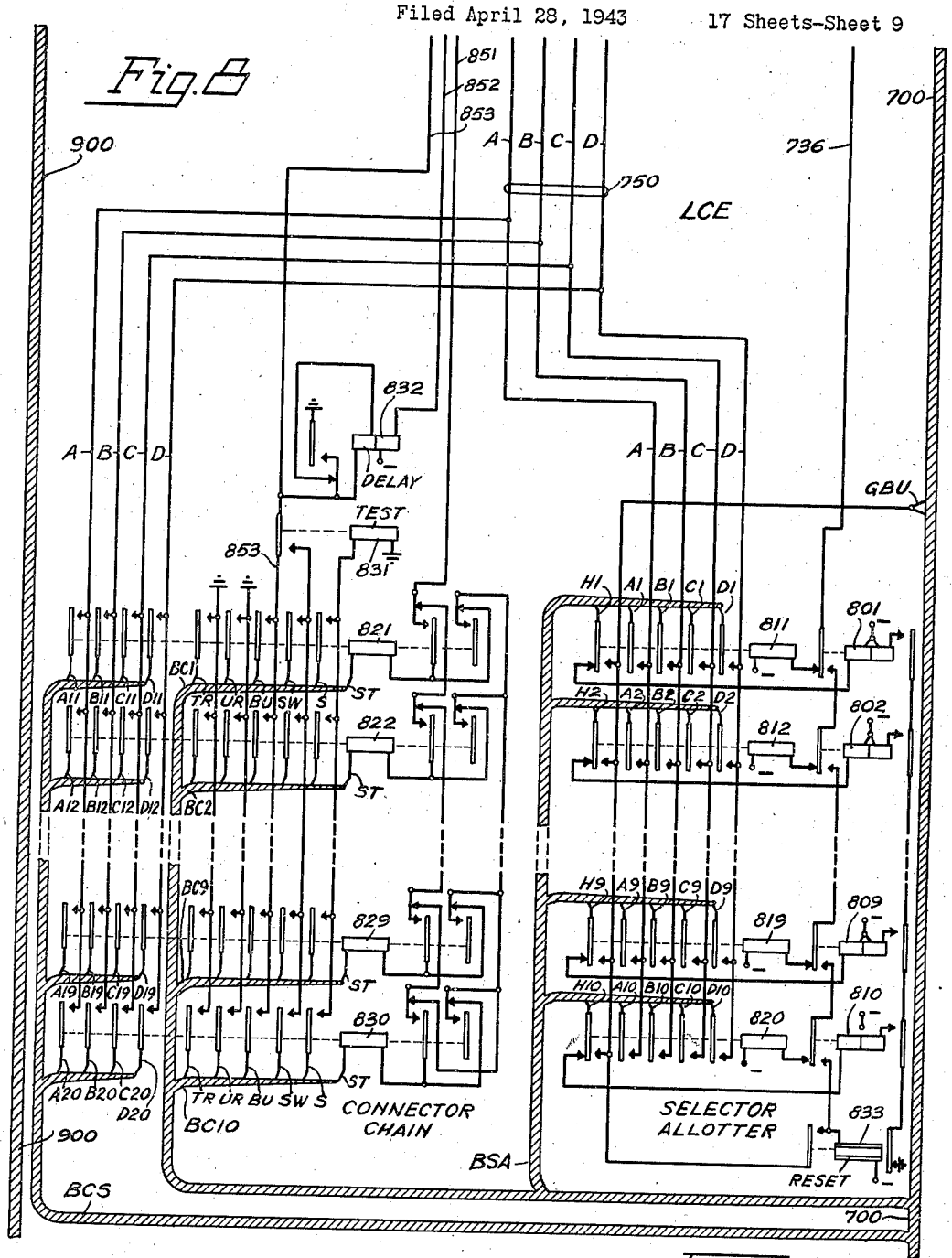
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Fig. 8



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AUTOMATIC TELEPHONE SYSTEM

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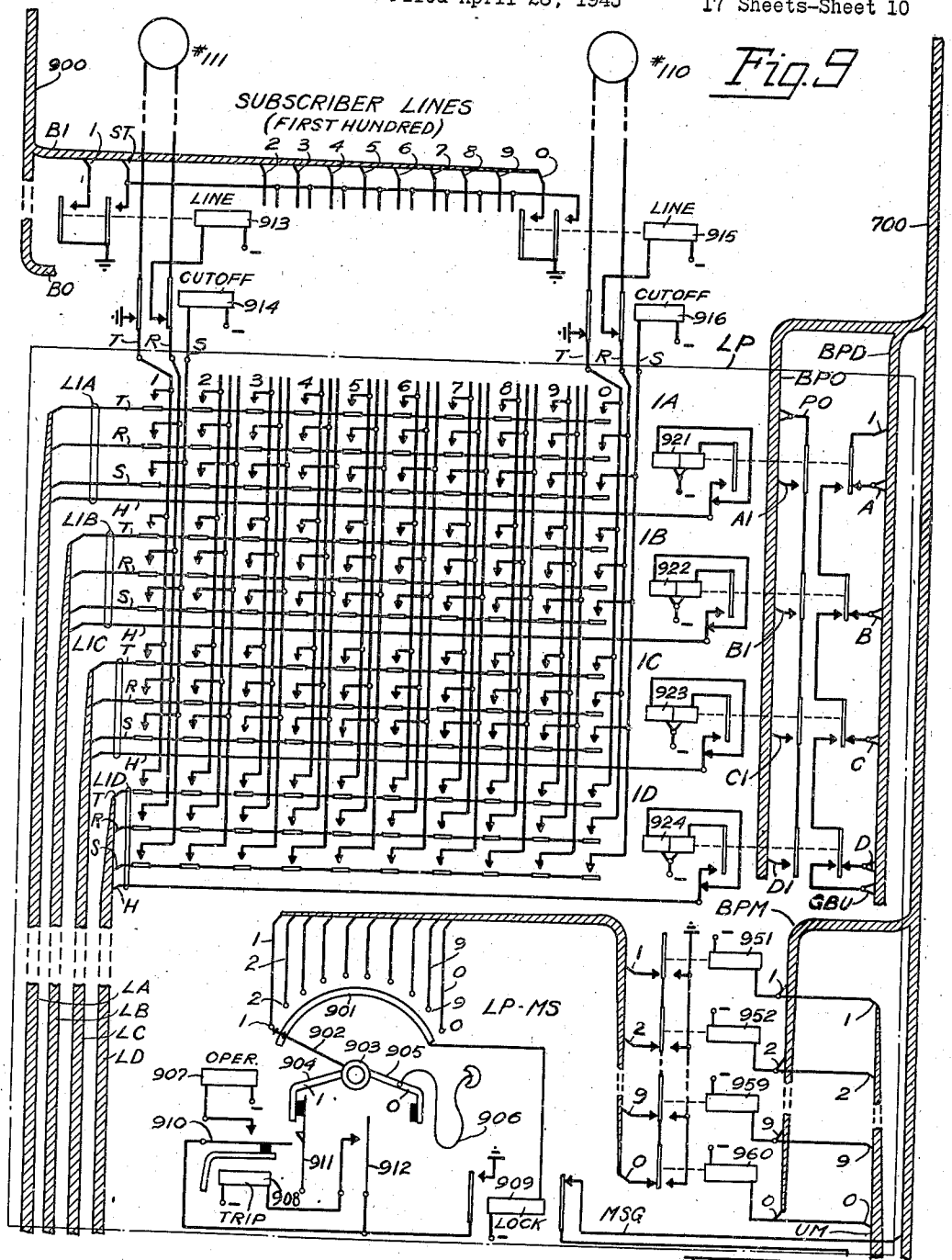


Fig. 9

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AUTOMATIC TELEPHONE SYSTEM

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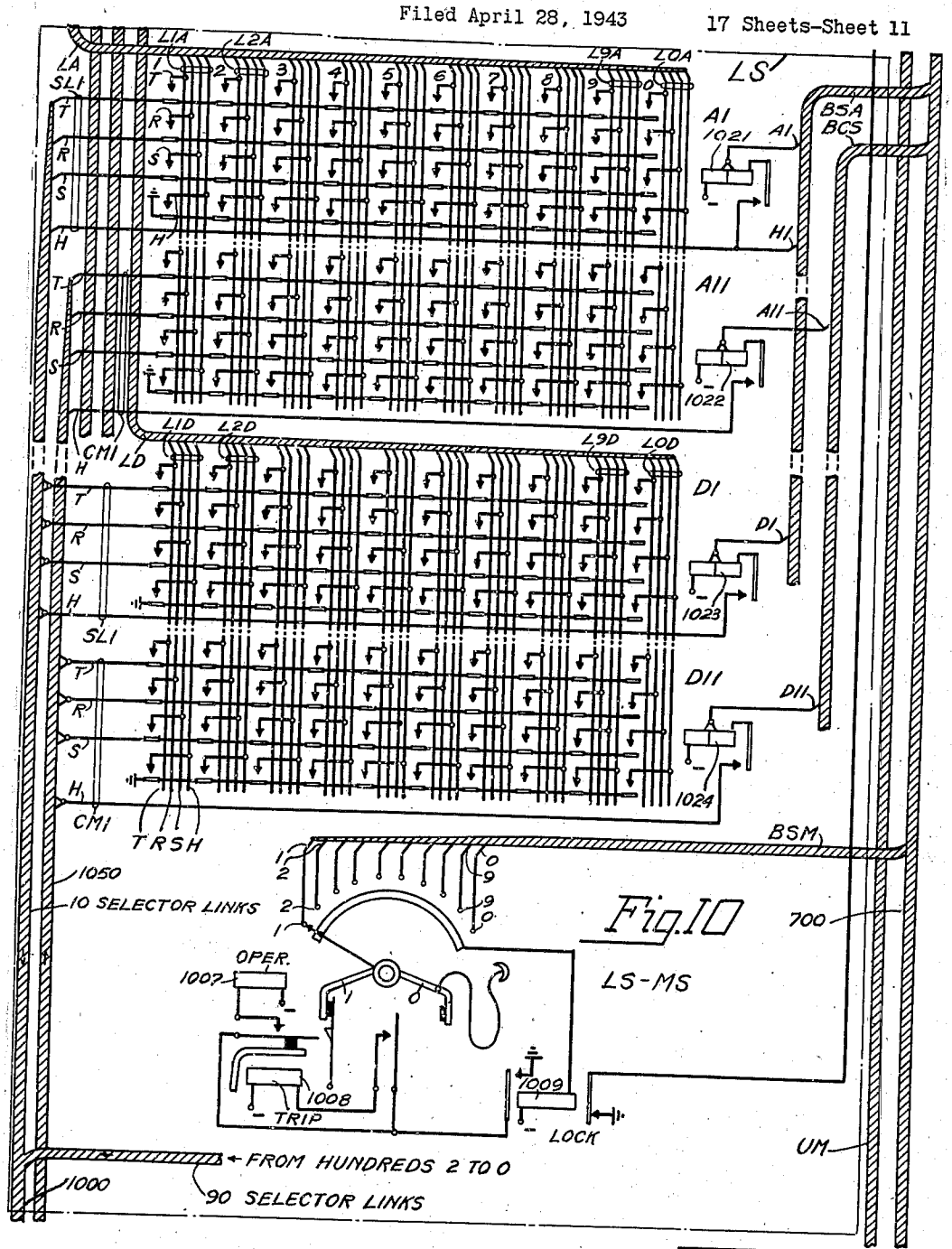


Fig. 10

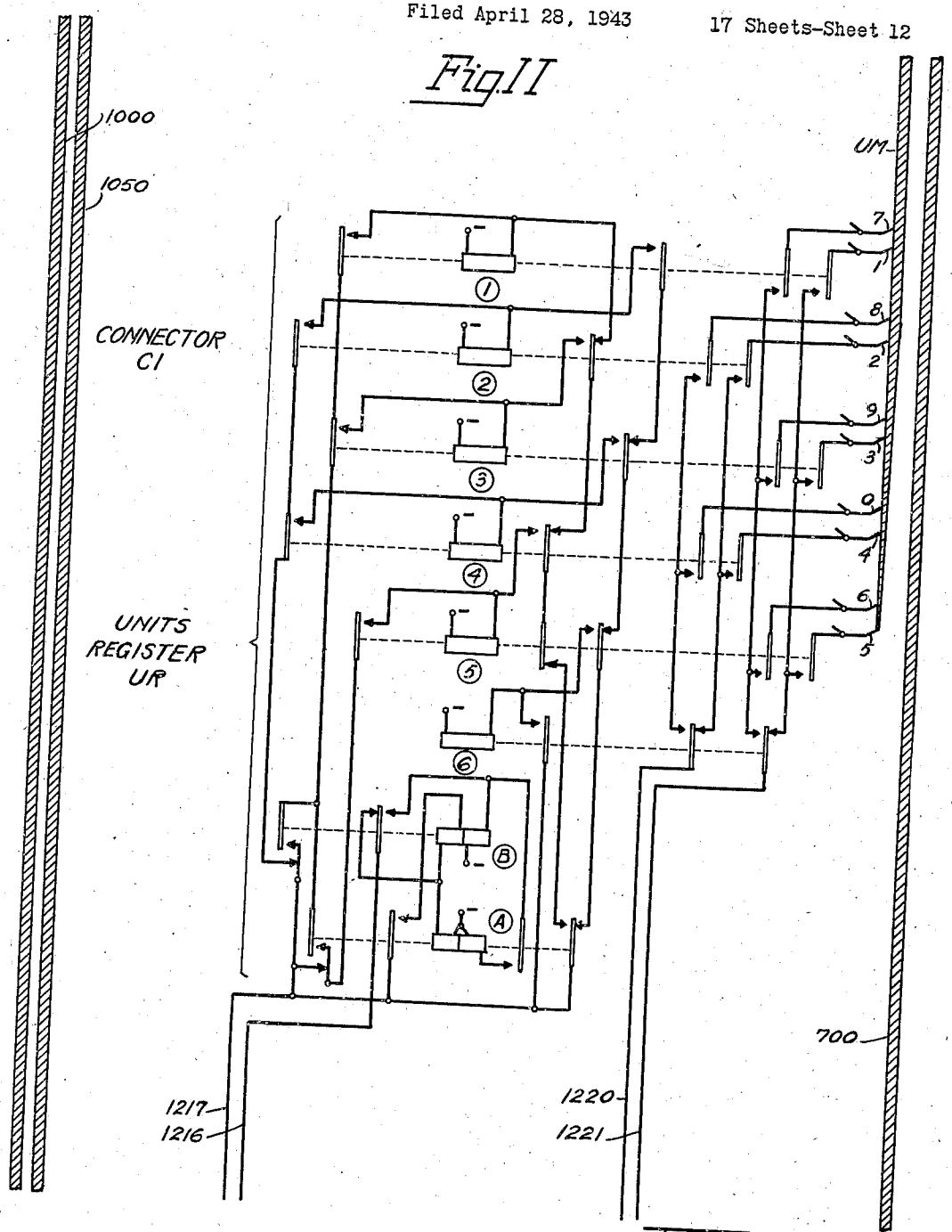
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AUTOMATIC TELEPHONE SYSTEM

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Fig. 11

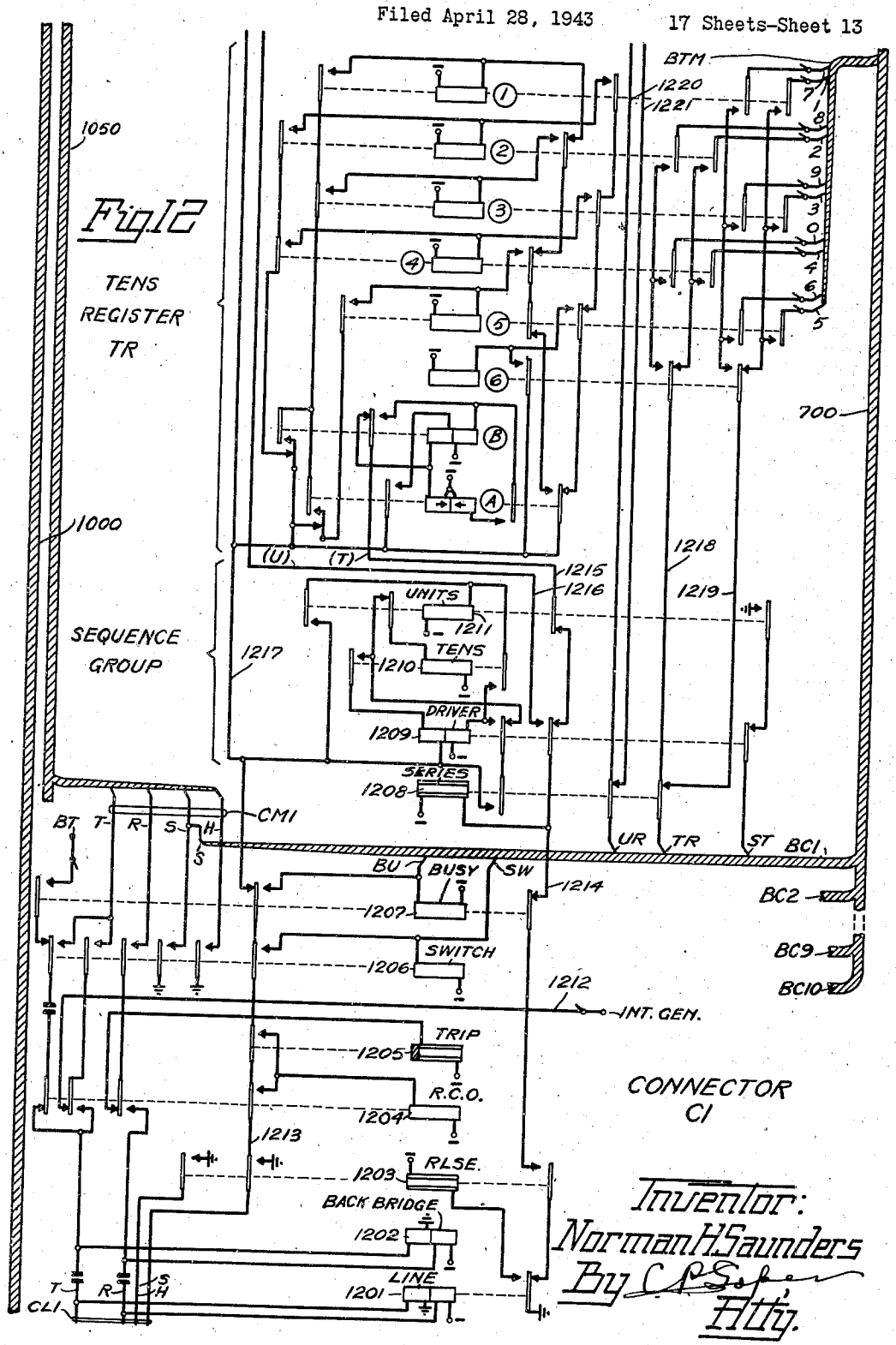


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AUTOMATIC TELEPHONE SYSTEM

Filed April 28, 1943 17 Sheets-Sheet 14

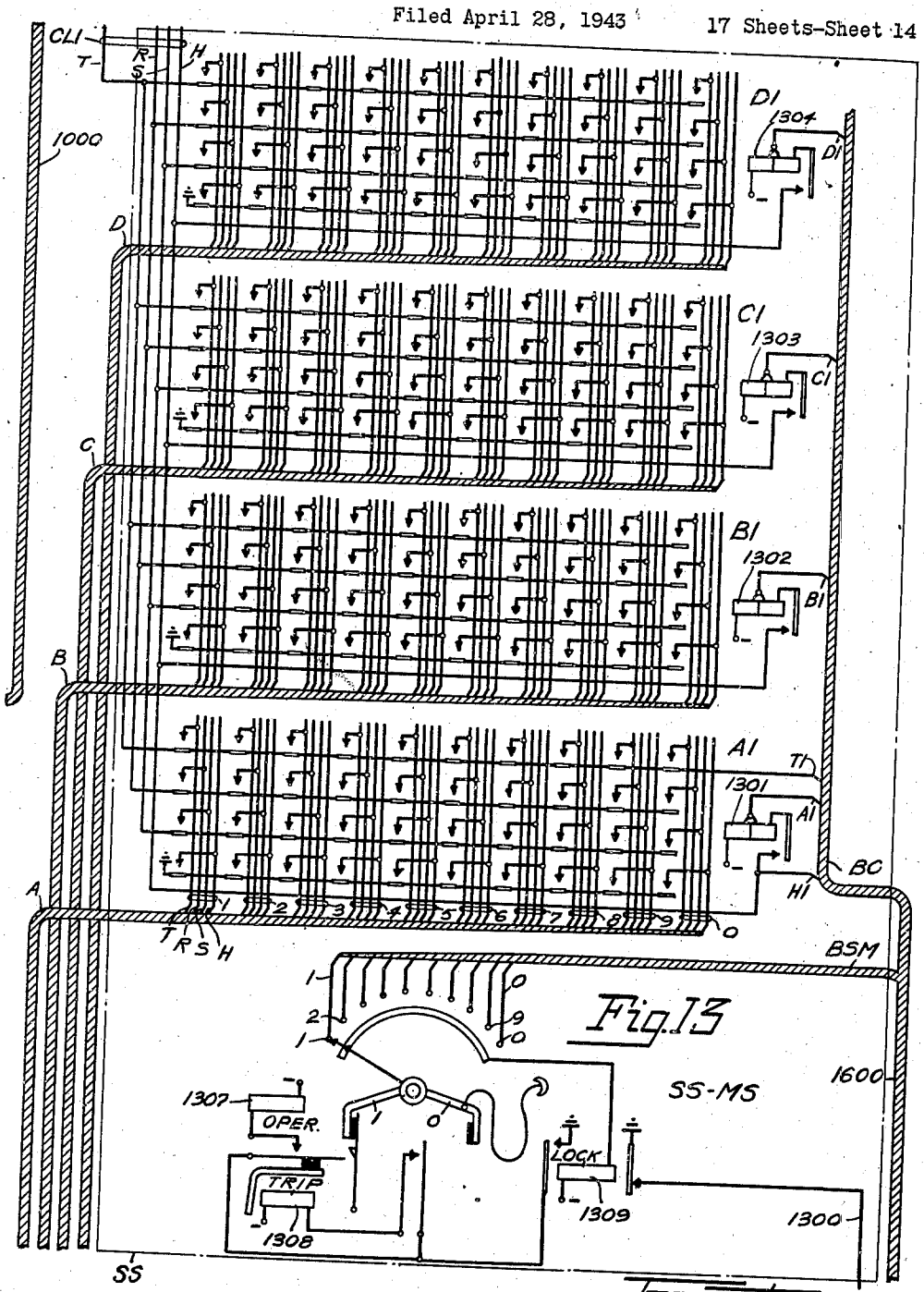


Fig. 13

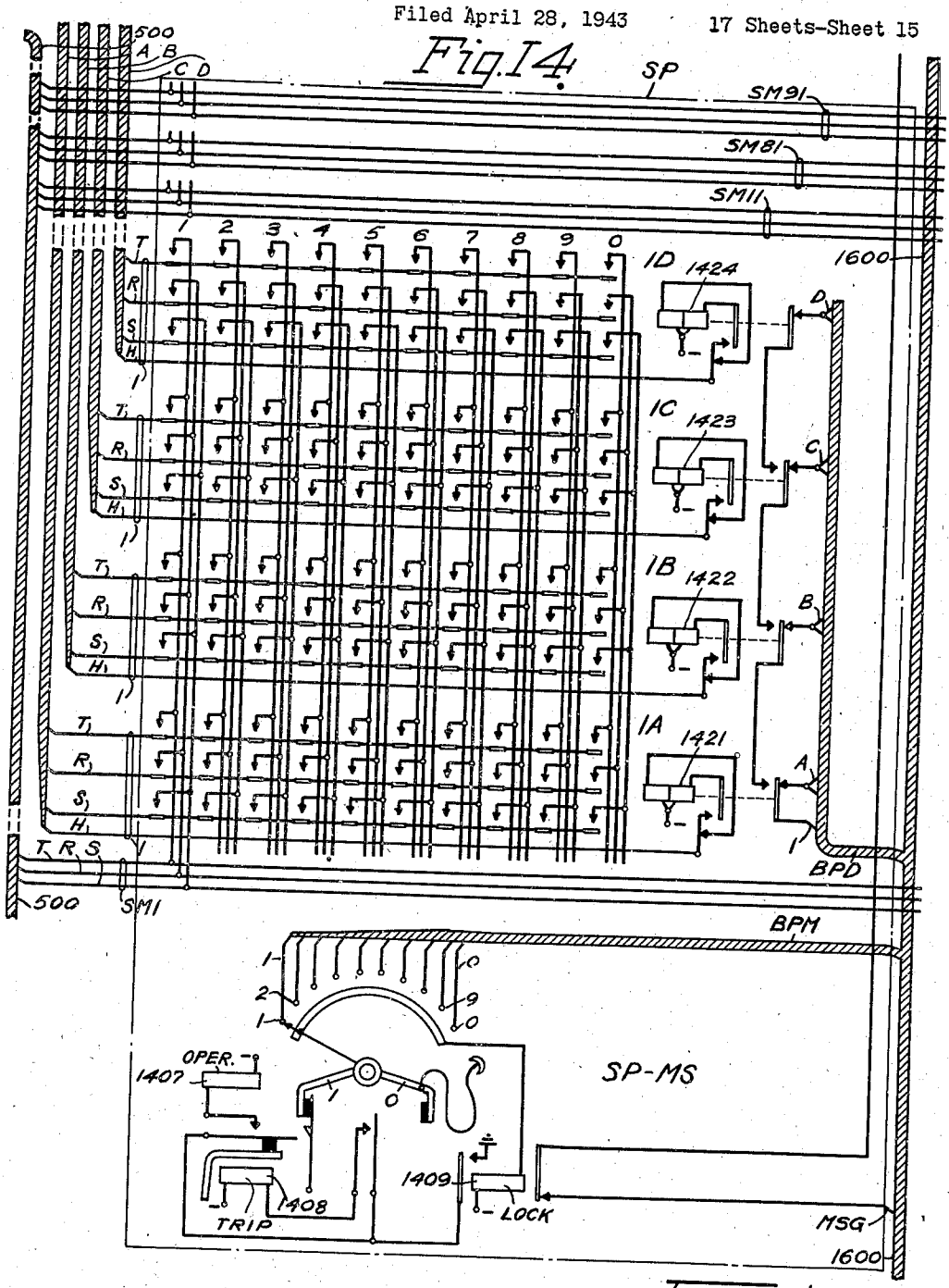
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Fig. 14.



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AUTOMATIC TELEPHONE SYSTEM

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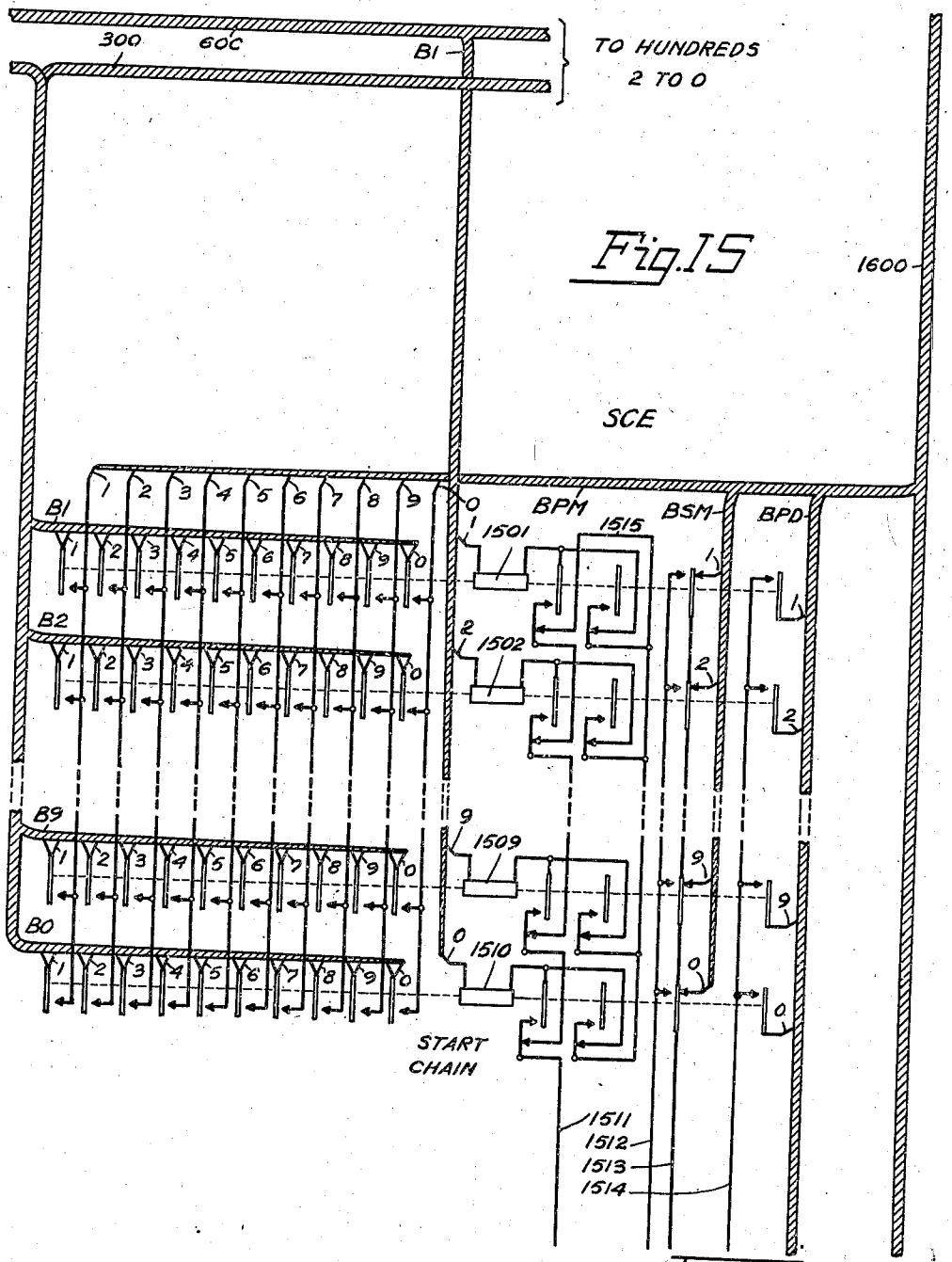


Fig. 15

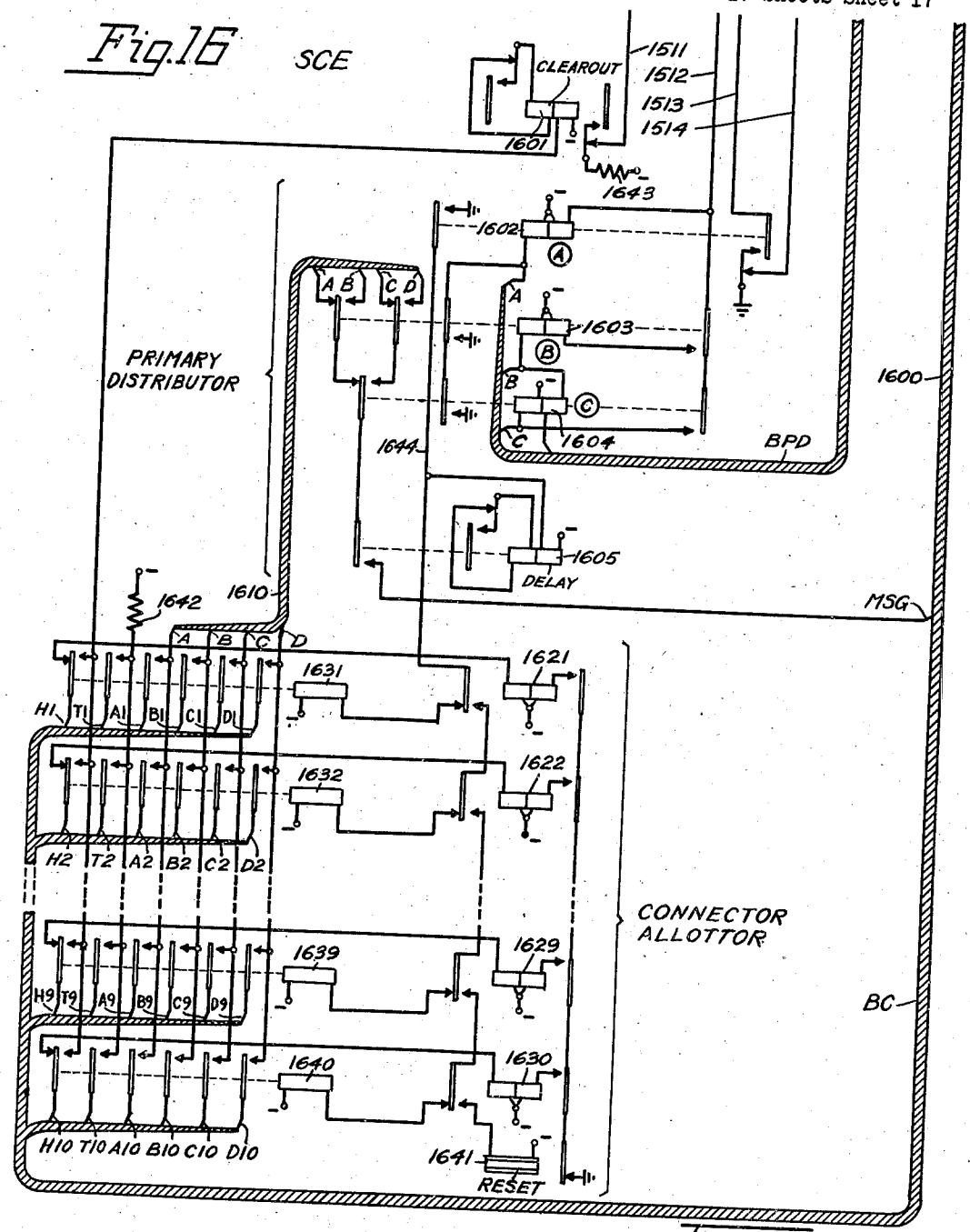
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AUTOMATIC TELEPHONE SYSTEM

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Fig. 16



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Patented June 3, 1947

2,421,717

UNITED STATES PATENT OFFICE

2,421,717

AUTOMATIC TELEPHONE SYSTEM

Norman H. Saunders, Chicago, Ill., assignor to Kellogg Switchboard and Supply Company, Chicago, Ill., a corporation of Illinois

Application April 28, 1943, Serial No. 484,886

22 Claims. (Cl. 179—18)

1

This invention relates to automatic telephone systems, being concerned more particularly with automatic telephone systems wherein a switching stage comprises serially related primary and secondary switches and in which the same primary switches are used to extend calling lines and to complete connections to called lines.

The principal object of the invention is to provide a new and improved trunking arrangement for systems of the foregoing character wherein the groups of links extending between switching stages are rendered more efficient in the extension of connections therethrough.

A further object is the provision of simple and efficient circuit arrangements for controlling the setting up and clearing out of connections by the use of a minimum of reliable relay equipment.

General Description

It has been chosen to illustrate the invention as applied to an isolated 1000-line telephone system comprising ten separate hundreds groups interconnected through a selector stage, each hundreds group containing its own line-finder and connector switching stages.

In the illustrated system, the lines in each hundreds group are divided into ten subgroups of ten lines each, and a separate subgroup of primary links is provided for each subgroup of lines. The primary links are two-way links, in that each may be used to extend connections both from and to the associated lines.

Calculations show that, for the substantial equivalent of the usual ten percent trunking arrangement, four two-way primary links in each subgroup are sufficient. Since there are ten primary subgroups of links, there are a total of forty two-way primary links serving a hundred-line group.

To complete the line-finder switching stage in a hundreds group, a number of ten-point secondary line-finder switches are employed. They are termed finder-action secondary switches; they have access to the primary links; and they are interconnected with selector links, extending from the line-finder switching stage to the selector switching stage.

It is a feature of the invention that each selector link is provided with a sufficient number (four) of the ten-point switching devices that it can be thereby interconnected with any one of the primary links serving the hundred-line group, whereby the call-handling efficiency of the selector links is increased.

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To complete the connector switching stage at any hundreds group, further ten-point secondary switches are provided for interconnecting the connector links (incoming from the selector stage to the hundreds group) with the above-mentioned forty primary links. These further switches are termed connector-action secondary switches. In keeping with the last-named feature of the invention, four of these connector-action secondary switches are provided for each connector link, whereby any connector link can be interconnected with any primary link, thereby increasing the call-handling efficiency of the connector links.

The selector stage in the present disclosure comprises a separate group of primary and secondary switching devices for each of the hundreds groups of lines, each such group of primary and secondary switching devices being arranged to interconnect any idle connector link of the associated hundreds group of lines with any selector link over which a call is received for such hundreds group.

In the usual ten-percent trunking arrangement herein disclosed, there are ten selector links for each hundreds group of lines, making a total of one hundred selector links for the complete 1000-line system. Each selector link extends to a separate selector and is represented by an extension of that link, termed a selector multiple, extending through the selector into association with the primary switches of the selector switching stage.

The one hundred selectors and selector links are conveniently divided into ten subgroups, each subgroup comprising ten selectors and ten selector multiples.

Within the portion of the selector switching stage allotted to any called hundreds group of lines, a separate subgroup of primary links (four in number) is provided for each of the ten subgroups of selector multiples. These selector primary links are one-way links, being used only to extend connections from the associated selector multiples. The portion of the selector switching stage assigned to a given hundreds group thus compares directly with the line-finder switching stage within a hundreds group.

To complete the portion of the selector switching stage assigned to a hundreds group, a number of ten-point secondary selector-finder switches are employed. They have access to the associated selector primary links, and they are interconnected with the connector links extending

to the connector switching stage of the associated hundreds group.

In keeping with the previously noted feature of the invention, four of these secondary selector-finder switches are provided for each connector link whereby any connector link can be interconnected with any associated primary link in the selector switching stage, thereby increasing the call-receiving efficiency of the connector links.

In the line-finder and connector switching stage, and in the selector switching stage, the disclosed arrangement is that each primary link is provided with a separate primary finder switch. Each such primary finder switch is a ten-point switch, having access to the ten lines or selector multiples in the associated subgroup. This arrangement is preferred over an arrangement wherein the primary switches are individual to the lines or selector multiples. The preferred arrangement results, in the illustrated system, in the reduction of the number of primary switches in the ratio of ten to four; that is, four primary switches suffice for ten lines.

Other objects and features of the invention will become more apparent as the description progresses.

The Drawings

Referring now to the accompanying drawings comprising Figs. 1 to 20, they show sufficient trunking diagrams and circuit diagrams of the apparatus involved in a system embodying the invention to enable the invention to be understood.

Fig. 1 is a general diagram of a 1000-line telephone system comprising ten hundreds groups of lines arranged according to the previous discussion;

Fig. 2 is a trunking diagram of the switching-stage portions local to hundreds group one of the 1000-line system;

Figs. 3 to 16 are circuit drawings of certain of the apparatus of Fig. 1;

Fig. 17 is a chart showing the sequence of relay operations in a register such as HR of Fig. 5;

Fig. 18 is a code table showing which of the counting relays of a register are operated for each of the several digit values;

Fig. 19 shows how the two parts of Fig. 2 are intended to be arranged; and

Fig. 20 shows the way the sheets on which Figs. 3 to 16 are drawn are intended to be arranged.

Figure 1

Referring now particularly to Fig. 1, ten hundreds groups are represented respectively by rectangles 1 to 0. Each such hundreds group includes its own primary and secondary equipment as previously discussed, comprising a line-finder switching stage for extending calling lines to selector links and comprising a connector switching stage for extending calls from connector links to called lines.

The selector switching stage is represented by a further rectangle. This switching stage comprises ten groups of primary and secondary selector finders, one for each hundreds group, and is arranged to interconnect any calling selector link with a connector link in the desired called hundreds group.

Cable 1000 carries the selector links from the hundreds groups to the selector stage. This cable has a branch incoming thereto from each hundreds group. Each such branch includes ten selector links. For example, the branch incoming from the first hundreds group includes selector links SL1 to SL10, while the branch associated with the tenth hundreds group includes selector links SL91 to SL100. Included within the selector stage are one hundred selectors which terminate the selector links SL1 to SL100, respectively.

Ten cables are shown outgoing from the selector stage to the hundreds groups respectively. Each such cable carries ten selector links, which extend respectively to connectors within the hundreds group. For example, the cable extending from the selector stage to the first hundreds group carries connector links CL1 to CL10, while cable extending from the selector stage to the tenth hundreds group carries connector links CL91 to CL100.

The above-noted trunking arrangement will be recognized as providing the usual ten-percent trunking for each of the hundreds of a 1000-line system.

Figure 2

Part 1 of Fig. 2 shows the primary and secondary switches comprising the line-finder and connector switching stages of one of the hundreds groups (group 1) of Fig. 1, together with connectors C1 to C10 in such hundreds group.

The switching equipment shown in part 1 of Fig. 2 comprises the line primary group LP and the line secondary group LS, while the switches shown in part 2 of Fig. 2 comprise the selector primary group SP and the selector secondary group SS.

Part 2 of Fig. 2 shows the first twenty (S1 to S20) and the last twenty (S81 to S100) of the selectors at the selector switching stage, together with the portion of the selector switching stage associated with hundreds group 1 of Fig. 1.

Referring particularly to part 1 of Fig. 2, the switches of the line primary group LP comprise forty ten-point primary line finders divided into ten subgroups of four switches each. Of these, subgroups 1 and 2 and subgroups 9 and 0 are shown, the intervening subgroups being omitted for the sake of compactness of the drawing. The switches in any primary subgroup are termed for convenience switches A, B, C, and D. For example, the switches in the first subgroup of the line primary group LP are indicated in the drawing as being switches 1A to 1D, while the switches in the tenth subgroup are indicated as being switches 0A to 0D.

All of the switches comprising group LP are similar, the circuits of switches 1A to 1D thereof being shown in detail in Fig. 9.

The one hundred subscriber lines served by the switches in the line primary group LP are divided into ten subgroups corresponding to the subgroups into which the primary switches are divided. The lines in the first subgroup (accessible to the switches 1A to 1D comprising the first subgroup of primary switches) are lines 11 to 10 within the hundreds group; the lines in the second subgroup are lines 21 to 20; the lines in the ninth subgroup are lines 91 to 90; and the lines in the tenth subgroup are lines 01 to 00.

Each hundreds group of lines is indexed by a separate hundreds digit. Thus, all of the lines in the first hundreds group have the common hundreds digit 1. Accordingly, the illustrated subscriber lines 11 and 10 in the first subgroup of hundreds group 1 have the indicated directory numbers 111 and 110, respectively.

Each of the forty primary switches in group LP terminates a primary link accessible to the

secondary switches in the line secondary group LS. These links are represented by the cables LA, LB, LC, and LD. Cable LA contains the ten links terminating in the ten "A" primary switches, cable LB contains the ten links terminating respectively in the ten "B" primary switches; and so forth, to cable LD, which contains the ten links terminating in the "D" primary switches.

The links in each of the cables LA to LD may be numbered from 1 to 0 in accordance with the respective numbers of the subgroups to which the links extend. For example, the cables in link LA are numbered 1 to 0, and they extend respectively to the primary switches 1A to 0A, each such primary switch being located in a separate ten-line subgroup.

The switches making up the line secondary group LS comprise a total of eighty ten-point secondary switches designated respectively A1 to A20, B1 to B20, and so forth, to D1 to D20. The "A" secondary switches have access in common to the ten primary links in cable LA; the "B" secondary switches have access in common to the primary links in cable LB; and so forth, to the "D" secondary switches which have access in common to the links in cable LD.

The first ten switches in each of the subgroups A to D in group LS are specific to the line-finder switching stage. They are connected by fours with the ten selector links SL1 to SL10 in the associated branch of cable 1000, over which connections are extended to the selector switching stage. For example, selector link SL1 is connected in common to the four switches A1 to D1; selector link SL2 is connected in common to the four links A2 to D2; and so forth, to the tenth selector link SL10, which is connected in common to the four switches A10 to D10. Accordingly, each selector link can be interconnected with any one of the forty primary links contained in cables LA to LD, representing respectively the forty primary switches in line primary group LP.

The links outgoing from the connectors C1 to C10 toward called lines are termed connector multiples to distinguish them from the connector links CL1 to CL10 incoming respectively to these connectors. These connector multiples are labeled CM1 to CM10.

The secondary switches 11 to 20 in each of the subgroups A to D of group LS are specific to the connector switching stage. They are connected by fours with the connector multiples CM1 to CM10. For example, connector multiple CM1, the outgoing path of the connector C1, is connected to each of the secondary switches A11 to D11; the connector multiple CM2 is connected to each of the secondary switches A12 to D12; and so forth, to the connnector multiple CM10, which is connected to each of the secondary switches A20 to D20 in group LS. Accordingly, the outgoing path of each of the connectors C1 to C10 can be connected through the connector stage secondary switches with any one of the primary links contained in cables LA to LD and extending respectively to the forty primary switches in group LP.

Referring now particularly to part 2 of Fig. 2, one hundred selectors (S1 to S100) are indicated, but selectors S21 to S80 are omitted for convenience. These one hundred selectors are divided into ten subgroups of ten selectors each. The incoming paths of the selectors S1 to S100 are the selector links SL1 to SL100 respectively, while their outgoing paths are the selector multiples SM1 to SM100 respectively.

Cables are shown extending to the right from the illustrated subgroups of selectors. There are ten such cables, each of which carries ten selector multiples. Selector multiples SM1 to SM10 are carried in the first of these cables; SM11 to SM20 are carried in the second; and so forth, to selector multiples SM91 to SM100, which are carried in the tenth of these cables.

The selector primary group SP contains forty ten-point primary switches divided into ten subgroups of four switches each, each subgroup having access in common to a separate subgroup of selector multiples.

Besides being multipled into the selector primary switches of group SP associated with the first hundreds group of lines, the cables carrying the ten subgroups of selector multiples extend to the right and make connection with the corresponding selector primary switches of hundreds groups 2 to 0, as indicated by the associated bracket and label.

Forty primary links, associated respectively with the primary switches in group SP, are contained in cables A to D extending to the selector secondary group SS, ten links in each cable. Cable A carries the primary links associated with the respective "A" switches in the primary subgroups; cable B carries the links associated with the "B" switches; and so forth, to cable D which carries the primary links associated with the "D" primary switches.

The selector secondary group SS contains forty ten-point selector secondary switches bearing designations from A1 to D10. The subgroups A to D of secondary switches have access to the links carried in cables A to D, respectively.

The secondary switches in group SS are connected by fours with the connector links CL1 to CL10, extending from group SS to the connectors C1 to C10 of Fig. 2, part 1. For example, switches A1 to D1 of group SS are multiply connected to connector link CL1; switches A2 to D2 are multiply connected with connector link CL2; and so forth, to the switches A10 to D10, which are multiply connected with connector link CL10. Accordingly, any connector link can be connected, through its associated secondary switches, with any one of the forty primary links contained in the cables A to D extending from group SP to group SS.

It is obvious that the switching operations to be performed incidental to the setting up of connections in a system such as hereinbefore discussed in connection with Figs. 1 and 2 can be performed by switching mechanisms of any one of a number of different constructions. It has been chosen to illustrate the invention as applied to a system employing throughout the ten-point switching mechanism commonly known as the plunger line switch. Such plunger line switches are well known. For example, they are described in the book entitled, Telephone Theory and Practice, Automatic Switching and Auxiliary Equipment, by Kempster B. Miller, first edition, published by McGraw Hill Book Company, Inc., 1933. These plunger line switches are associated together in practice in groups of any size up to one hundred, and a mechanism known as a master switch is provided to control the selecting operation of the associated group of plunger line switches.

In the above-noted book, a discussion of plunger line switches and of the controlling master switch may be found on pages 32 to 48, the discussion being accompanied by illustrative drawings, Fig-

ures 19 to 29. Further discussion of plunger line switches is found on pages 61 to 63 of the said book, accompanied by illustrative Figures 38 to 40.

As is discussed in the above-mentioned publication, a group of plunger line switches comprises individual ten-point switches arranged in vertical or horizontal alignment, each switch having its own plunger and plunger-actuating magnet. A plunger-control shaft extends along the row, and a master switch is provided for rotating such shaft to align the plungers of all idle ones of the line switches opposite one or another of their ten sets of contacts. It is preferred that the plunger line switches used herein be of the self-aligning type discussed in the matter beginning on page 43 of the above publication and illustrated in Figures 26 and 27 thereof, but the mechanism of the plunger line switches herein used may be simplified to the extent that each has only a plunger arm and a plunger-operating magnet, lacking the usual cutoff arm and line relay.

Figures 3 to 6

Referring now particularly to Figs. 3 to 6, they show the interrelation and arrangement of the selectors S1 to S100 of Fig. 2. As noted in connection with Figs. 1 and 2, cable 1000 carries one hundred selector links SL1 to SL100 to the selectors S1 to S100. The circuits of selector S1 are shown in full in Fig. 5, and selectors S11, S81, and S91 are indicated by separate rectangles in Fig. 3.

As shown in Fig. 5, the selector link SL1, incoming to selector S1, comprises four conductors labeled respectively T, R, S, and H (tip, ring, sleeve, and hold). Selector S1 includes switching relay 501, line relay 502, release relay 503, series relay 504, busy relay 505, and the relays (A, B, and 1 to 6) comprising the hundreds register HR.

The hundreds register HR of the selector S1 is employed to control the extension of start potential to the selected one of the conductors 1 to 0 in the associated cable G1 according to the value of the dialed hundreds digit. The conductors in the cable G1 are common to selectors S1 to S10, forming the first of the ten subgroups of selectors.

The selector chain SC1 (Fig. 3) is common to the first selector subgroup comprising selectors S1 to S10. This selector chain is interconnected with the associated selectors by cable 500. This cable comprises ten branches, B1 to B10, associated respectively with the ten selector chains SC1 to SC10.

Selector chain SC1 includes relays 301 to 310, associated respectively with selectors S1 to S10, and a pair of cycle-timer relays 311 and 312. This selector chain operates to render the selectors S1 to S10 effective only one at a time to control the setting up of connections, and controls the application of marking potential to mark conductors 1 to 0 in branch B1 of cable 300, to identify the calling selector.

Figs. 4 and 6 show the branched arrangements of the start and mark cables 600 and 300, in addition to showing the terminal strips TS1 to TS10. There are ten of these terminal strips, one for each subgroup of selectors. They terminate the cables such as G1, G2, G9, and G10.

Start cable 600 comprises ten branches B1 to B0. Each branch contains ten conductors. The conductors of the first branch are connected to the first terminals of the terminal strips TS1 to TS10, respectively. The conductors of the second branch are connected to the second terminals of the strips TS1 to TS10 respectively; and so forth, to the tenth branch B0, whose conductors are connected to the tenth terminals of the strips TS1 to TS10 respectively.

Mark cable 300 comprises ten branches B1 to B0. Each of these branches contains ten mark conductors. The branches extend respectively to the selector chains SC1 to SC10 of Fig. 3.

Figures 7 and 8

Figures 7 and 8 show the line-common equipment LCE of the first hundreds group. This common equipment is associated, through the conductors in cable 700, with the switching equipment comprising the line primary group LP of Fig. 9 and the line secondary group LS of Fig. 10, which groups constitute the line-finder and connector switching stages for the lines of the first hundreds group.

The line-common equipment LCE comprises groups of relays constituting the primary distributor, the start chain, and the connect group of Fig. 7, and the selector allotter and connector chain of Fig. 8.

The primary distributor (Fig. 7) comprises relays 723 to 726. It is used to select the first idle one of the primary switches A to D in the subgroup of group LP with which the currently handled call is concerned.

The start chain of Fig. 7 comprises relays 701 to 710 (the showing of relays 703 to 708 being omitted), associated respectively with the ten subgroups into which the switches in the line primary group LP of Figs. 2 and 9 are divided. This start chain also includes group-busy relay 721 and transfer relay 722, the latter relay being operable to change over the common equipment LCE from line-finder action to connector action.

The connect group of Fig. 7 comprises relays 711 to 720, associated respectively with relays 701 to 710, and operative to connect the individual mark conductors of the currently calling ten-line subgroup with the common mark conductors contained in branch BPM of cable 700.

The selector allotter of Fig. 8 comprises marking relays 801 to 810, associated respectively with the selectors S1 to S10 through conductors in branch BSA of cable 700. Reset relay 833 is associated with relays 801 to 810.

Allotter relays 811 to 820 are associated respectively with relays 801 to 810. During line-finder action, one or another of allotter relays 811 to 820 operates, under the control of marker relays 801 to 810, to allot for operation the first idle selector of the ten assigned to the hundreds group.

The connector chain of Fig. 8 comprises relays 821 to 830, associated respectively with the connectors C1 to C10 of Fig. 2, of which the connector C1 is shown in Figs. 11 and 12. These relays operate to render the line common equipment LCE temporarily individual to a connector in which the tens and units digits of the desired number have been stored, to enable such common equipment to control the setting up of the desired connection through the connector switching stage.

Figure 9

Fig. 9 shows certain of the switches comprising the line primary group LP, as well as subscriber lines #111 and #110 in the first ten-line subgroup.

Line and cutoff relays 913 and 914 are associated individually with line #111, and line and cutoff relays 915 and 916 are associated individ-

ually with line #110. The intervening lines (112 to 119) are similarly provided with individual line and cutoff relays. Each cutoff relay is controlled over the associated sleeve conductor S to disconnect the associated line relay during the time the line is in use as a calling line or as a called line. The line relays are employed to apply a starting potential to the associated start conductor, and to remove marking potential from the associated mark conductor.

The illustrated start conductor ST is common to the ten lines in the subgroup comprising lines #111 to #110, while the illustrated mark conductors 1 to 0 are individual respectively to these lines. These mark and start conductors form branch B1 of the cable 900. This cable has nine other similar branches, associated respectively with the second to tenth subgroups of lines in the hundreds group, of which the branch B0 is indicated.

The cable 900 extends to the connect group of relays of Fig. 7, in the line-common equipment LCE, whereat the ten branches B1 to B0 thereof are associated respectively with relays 711 to 720, forming the connect group hereinbefore referred to.

Of the forty primary switches in the previously discussed line primary group LP, only four are shown in Fig. 9. These are the primary switches 1A to 1D comprising the first primary subgroup in group LP and having access in common to subscriber lines #111 to #110. Each of the switches 1A to 1D is assumed to be a plunger line switch of the general type hereinbefore discussed.

The switch 1A, for example, has a bank of contacts comprising ten sets labeled 1, 2, and so forth, to 9, and 0, reading from left to right. Each of these contact sets includes three pairs of contacts. The three contact pairs of a set are adapted to close through the tip, ring, and sleeve conductors of the associated subscriber line to the corresponding conductors of the associated primary link L1A. These contacts are normally open and are closed only when impelled to do so under the action of the plunger, not shown.

Switch 1A has magnet 921, whose principal function is to actuate the usual plunger of the line switch to cause the contact set thereof corresponding to the position currently assumed by the associated master switch to close. In addition to actuating the plunger, magnet 921 is adapted to actuate the three sets of contacts shown to the right thereof in the manner of an ordinary relay operation. The contact springs to the right of magnet 921 are thus common springs which operate upon every operation of the switch independent of which of the ten selective sets of contacts are operated by the line switch plunger.

It will be observed that each of the illustrated switches 1B, 1C, and 1D is similar to the switch 1A, above discussed.

The circuit arrangement of the master switch associated with the primary switches in group LP is disclosed in Fig. 9. This master switch is labeled LP—MS, indicating that it is a line-primary master switch. The master switch circuit includes the usual master switch bank comprising ten individual contacts 1 to 0, and a common conducting segment 901. The master switch wiper 902 is affixed to the master switch shaft 903, and bridges between the common segment 901 and the individual contact corresponding to the current setting of the master switch. This master switch is provided with the usual locking segment, not shown, which has a separate notch for each of the ten positions of the master switch, and a lock arm controlled by lock magnet 909 for locking the master switch in position at all times when the start magnet is not energized.

Movement of the master switch from its illustrated position 1 across the other positions to position 0 is controlled by the usual U spring 906.

The master switch LP—MS has a pair of spring-actuating fingers 904 and 905, finger-controlled springs 911 and 912, trip relay 908, and operating solenoid 907 which moves the master switch mechanism from position 0 toward position 1 against the restraining influence of spring 906.

Figure 10

Fig. 10 shows certain of the secondary switches included in the line secondary group LS of Fig. 2. The switches shown are the finder-action secondary switch A1, the connector-action secondary switch A11, the finder-action secondary switch D1, and the connector-action secondary switch D11.

The secondary switches are generally similar to the primary switches of Fig. 9. The principal difference is that each of the ten contact sets of one of these secondary switches contains four contact pairs, the contact pairs of a set corresponding respectively to the tip, ring, sleeve, and hold conductors of the associated primary link.

The line-secondary master switch LS—MS of Fig. 10 is similar to the line-primary master switch LP—MS of Fig. 9.

Figures 11 and 12

Figs. 11 and 12 show the circuit arrangement of the connector C1 of Fig. 2, the circuit arrangement of each of the other connectors being similar. The connector C1 includes line relay 1201, back-ridge retard coil 1202, release relay 1203, ring-cutoff relay 1204, trip relay 1205, switching relay 1206, busy relay 1207, series relay 1208, a sequence group of relays, a tens register TR, and a units register UR. The sequence group comprises driver relay 1209 and tens and units relays 1210 and 1211. Each of the registers TR and UR may be exactly similar to the hundreds register HR forming part of the selector S1 of Fig. 5.

Figures 13 and 14

Figures 13 and 14 show certain switches of the secondary group SS and the primary group SP of Fig. 2, together with their associated master switches SS—MS and SP—MS. These primary and secondary groups are generally similar to the above-discussed primary and secondary groups LP and LS, Figs. 9 and 10.

Figures 15 and 16

Figs. 15 and 16 show the selector-common equipment SCE. which is associated through cable 1600 with the primary and secondary switch groups SP and SS of Figs. 14 and 13, to control the setting up of connections from calling selectors through the associated portion of the selector switching stage.

The portion of selector-common equipment SCE shown in Fig. 15 is the start chain comprising relays 1501 to 1510. These relays are connected respectively to the ten start conductors in branch B1 of start cable 600 and are associated respectively with branches B1 to B0 of mark cable 300.

The portion of the selector-common equipment

SCE shown in Fig. 16 includes clear-out relay 1601, the primary distributor comprising relays 1602 to 1605, and the connector allotter comprising relays 1621 to 1630, 1631 to 1640, and reset relay 1641. The primary distributor and connector allotter of Fig. 16 are generally similar to the primary distributor of Fig. 7 and the selector allotter of Fig. 8, previously referred to.

Detailed Description

The disclosure having been described generally, a detailed description of the operation of the disclosed apparatus will now be given.

A. *Line #111 calls line #110*

If, for example, the subscriber on line #111 (Fig. 9) desires to call the subscriber on line #110 (Fig. 9), he removes his receiver (not shown); waits for dial tone; and then operates the dial of his usual calling device (not shown) in accordance with the digits (1, 1, and 0) in the desired number.

A1. *Marking the calling line*

When the receiver is removed at the substation on line #111, Fig. 9, the usual direct-current bridge is thereby closed across the conductors of the calling line, operating line relay 913 through contacts of cutoff relay 914. Line relay 913 places ground potential on the associated mark conductor 1 in branch B1 of cable 900 to thereby mark the associated line as calling, the last-named conductor being individual to the calling line.

Line relay 913 also grounds the associated start conductor ST in branch B1 of cable 900. As indicated, this start conductor is common to the ten lines making up the first subgroup of lines in the hundreds group.

A2. *Seizing line common equipment LCE*

Assuming that the line common equipment LCE of Figs. 7 and 8 is idle at this time, it is immediately seized and appropriated to the ten-line subgroup containing the calling line, as follows:

Under the assumed condition, the above grounding of the associated start conductor by line relay 913 results in the closure of the following circuit: from ground on start conductor ST in branch B1 of cable 900, through the winding of relay 711 of the connect group of common equipment LCE, the right-hand winding of relay 701 in the start chain, normally closed contacts controlled by the second right armature of relay 701, chain-end conductor 732, normally closed chain contacts controlled by the first left armatures of relays 710 to 701, 721, and 722, and through resistor 731, to the ungrounded negative pole of the exchange battery.

Relays 711 and 701 operate in series over the above-traced circuit. At its first right armature, relay 701 locks itself to the chain circuit through resistor 731, at the same time disconnecting the chain circuit extending to chain-end conductor 732. At its second right armature, relay 701 disconnects its winding from chain-end conductor 732, thereby completing the isolation of this conductor to prevent the operation of any further ones of the relays 701 to 720 for the time being.

A3. *Units selection*

By the above-noted operation of relay 711 of the connect group, mark conductors 1 to 0 of branch B1 of cable 900, being the mark conductors controlled by the line relays of the calling tens subgroup 1, are connected respectively to conductors 1 to 0 in the primary-mark branch BPM of cable 700 to control the positioning of the primary master switch LP—MS of group LP, Fig. 9, in accordance with the units designation (1) of the calling line.

With the mark conductors 1 to 0 in branch B1 of cable 900 now connected respectively to conductors 1 to 0 in branch BPM of cable 700, relay 951 (of the units-translator group comprising relays 951 to 960) operates to isolate contact 1 in the associated master-switch bank, at the same time grounding contacts 2 to 0 in the master-switch bank, through back contacts of relays 952 to 960.

If the master switch LP—MS (Fig. 9) is in any position other than the illustrated #1 position, lock magnet 909 is energized through wiper 902, bridging from one of the contacts in the master switch bank to the common strip 901. Upon the operation of lock magnet 909, the usual armature thereof (not shown) unlocks the shaft 903 of the master switch to allow it to be rotated toward position "0" of the master switch, or toward position "1" of the master switch, depending on the present condition of the master switch.

Consider for the moment an operation of lock magnet 909 when the master switch is in its illustrated position. When this occurs, the resultant unlocking of the shaft 903 of the master switch permits the master switch mechanism to be rotated in a clockwise direction, under the power of U spring 906, to pass the wiper 902 successively into engagement with the contacts thereof.

The operation of the master switch is terminated when wiper 902 reaches an ungrounded contact, whereupon lock magnet 909 restores to lock the master switch mechanism in its new position.

When the master switch is again started into operation by a new call, requiring a new position thereof, it continues to move toward the "0" position thereof.

When the "0" position of the master switch is reached, if there is ground potential on contact 0 in the master-switch bank, lock magnet 909 remains in an energized condition. Trip relay 908 is thereupon operated through the #0 spring 912 and its associated contact, spring 912 having been engaged and shifted by the #0 finger 905 of the master switch mechanism. When trip relay 908 operates, the armature thereof moves its spring 910 into engagement with its associated contact. At this time, the #1 finger 904 of the master switch is out of engagement with spring 911, whereby the free end of the spring 910 becomes latched by the retaining projection on spring 911, to thereby retain spring 910 latched operated until the master switch mechanism has been rotated in a counter-clockwise direction from its position 0 to its position 1.

With start magnet 909 maintained operated and armature spring 910 of trip relay 908 maintained latched, the operating solenoid 907 is energized, whereby the counter-clockwise movement of the master switch mechanism is caused to occur in the usual manner, against the tension of spring 906.

As the master switch LP—MS moves in a counter-clockwise direction, the bank contacts thereof are tested successively, and lock magnet 909 restores as soon as a contact is reached which

is marked by the absence of ground potential thereon. When this occurs, operating solenoid **907** is deenergized by the opening of the left-hand contacts of start magnet **909**. At the same time, the usual locking action is controlled by magnet **909** to lock the master switch mechanism in the position in which it then stands.

As the counter-clockwise master-switch movement caused by successive calls occurs, the master switch again reaches the illustrated position 1. Spring **910** of trip relay **908** is thereupon unlatched when spring **911** is encountered by finger **909**. Spring **910** disconnects operating magnet **907** to place the return movement of the master switch again under control of drive spring **906**.

By an operation such as above outlined, the master switch LP—MS, if not already in the desired #1 position now marked because of the described energized condition of relays **913**, **711** and **951**, is caused to move into the marked #1 position. In this position of the master switch, the usual plungers of all idle ones of the primary switches in group LP are aligned opposite the #1 groups of contacts thereof.

A4. *Selecting an idle primary switch*

The primary distributor comprising relays **723** to **726** is operated responsive to the closure of the outermost right-hand contacts of relay **701** to select the first idle one of the switches 1A to 1D (Fig. 9) in the subgroup of primary switches having access to the tens subgroup of lines containing the calling line.

The order of preference of these primary switches is from A to D. For the present purpose, it may be assumed that the first switch 1A of Fig. 9 is idle. In this event, the grounding of conductor 1 in branch BPD of cable **700**, at the outermost right-hand contacts of relay **701**, results in the extension of ground potential through the back contact of the outermost armature spring of the plunger-operating magnet **921** of switch 1A to conductor A in branch BPD of cable **700**, closing a circuit for the left-hand winding of the "A" relay **723** of the primary distributor. Under this condition, neither of the conductors B to D in branch BPD of cable **700** becomes grounded, and relays **724** and **725** are accordingly not operated. The primary distributor is thereby conditioned to select the first or "A" primary switch in the selected tens subgroup. At its left-hand contact, relay **723** closes a circuit for the operating winding of delay relay **726**, but the operation of this relay is delayed momentarily by the flow of current through its short-circuited left-hand winding.

At its first right armature, relay **723** applies ground potential to conductor **734**, at the same time disconnecting the normally grounded conductor **735** from ground potential. The grounding of conductor **734** closes a circuit, through the front contact of the third right armature of relay **701**, and over conductor **733**, for locking relay **723** energized by its right-hand winding. At the same time, the removal of ground potential from conductor **735** opens the initial circuit to the left-hand winding of relay **723** rendering such relay dependent upon the above-noted locking circuit. This provision insures that the setting of the primary distributor, once accomplished, will not be disturbed by changes that may take place within the primary group, including the release of a primary switch already operated, and including the operation of the primary switch (1A, Fig. 9) which has now been selected.

A5. *Tens selection*

Tens selection comprises setting the line secondary master switch LS—MS of Fig. 10 in accordance with the tens designation of the calling line, as determined by which of the relays **701** to **710** of the start chain energizes. The energization of start relay **701** predetermines that the secondary master switch of Fig. 10 will be set in its #1 position.

With relay **701** operated, and with relays **702** to **710** in normal position, the previously described grounding of conductor **734** at the first right armature of relay **723** of the primary distributor results in the extension of ground potential, over conductors 2 to 0 in branch BSM of cable **700**, to contacts 2 to 0 in the bank of master switch LS—MS of Fig. 10, contact 1 in such master switch bank being left ungrounded. As a result, the master switch LS—MS operates as previously described for the master switch LP—MS of Fig. 9 to move into the marked #1 position and thereby align the plungers of all idle secondary switches in group LS of Fig. 10 opposite the respective #1 contact sets thereof.

A6. *Allotting an idle selector*

Responsive to the operation of the second right armature of relay **723** of the primary distributor, ground potential is applied, through contacts of the unoperated transfer relay **722**, to conductor **736**, leading to the selector allotter shown in Fig. 8. It may be assumed that the selector link SL1, to which mark relay **801** of the selector allotter is individual, is idle at this time, and that relay **801** is in an unenergized condition. Accordingly, the placing of ground potential on conductor **736** closes a circuit through contacts of relay **801** for the associated connecting relay **811**, also individual to the selector link SL1. Relay **811** thereupon operates, thereby allotting the associated selector link SL1, Figs. 2 and 10, for operation.

Upon reference to Fig. 2, it will be noted that the selector link SL1 is multiply connected to switches A1 to D1 of the line secondary group LS. Of these four finder-action secondary switches, switches A1 and D1 are shown in Fig. 10, wherein only four of the eighty secondary switches of group LS are illustrated.

A7. *Operating secondary switch A1*

Upon the completion of the previously described distributor, master-switch, and allotter operations, connection is made with the selected primary switch by the secondary switch which corresponds in designation to the selected primary switch and which is associated with the allotted selector (S1). Operation of the secondary switch is followed by the operation of the selected primary switch to complete connection to the calling line.

The secondary switch to be operated in the present example is switch A1 (Figs. 2 and 10). Its operation occurs responsive to the extension of ground potential to conductor **737**. For this to occur, delay relay **726** must have operated responsive to the described operation of relay **723**.

With both master switches in marked position and the lock magnets **909** and **1909** restored, there is ground potential on conductor MSG in cable **700**. With delay relay **726** in operated position, this ground potential is extended to conductor **737** of the primary distributor. With the primary distributor having been set as previously described (the A relay **723** in operated condition

and the B and C relays 724 and 725 in normal condition), the ground potential on conductor 737 is extended, through contacts of the relays 725 and 724, to conductor A in group 750.

With selector allotter relay 811 in operated condition, the placing of ground potential on conductor A of group 750 results in the closure of a circuit, through contacts of relay 811, and over conductor A1 in the secondary allotter branch BSA of cable 700, for the pull-down winding of operating magnet 1021 of the line secondary switch A1 (Fig. 10). Magnet 1021, being the usual plunger-operating magnet, thereupon operates to cause the closure of the selected #1 set of contacts thereof to connect selector link SL1 to link L1A, extending by way of conductors in cable LA to the selected primary switch 1A of group LP (Fig. 9).

A8. *Operating primary switch 1A*

Responsive to the closure of the lower contact pair of contact set #1 of the now-operated switch A1 of group LS (Fig. 10), ground potential is placed on the hold conductor H of link L1A in cable LA, thereby closing an operating circuit for the pull-down winding of magnet 921 of switch 1A of the group LP (Fig. 9), by way of normally closed contacts controlled by the inner armature spring of such magnet. Plunger-operating magnet 921 now operates to cause closure of the contacts in the selected #1 set thereof, thereby interconnecting the tip, ring, and sleeve conductors of link L1A with the corresponding conductors of the calling line #111. At its inner armature spring and associated contacts, magnet 921 substitutes its high-resistance right-hand winding for its low-resistance left-hand winding to reduce holding current.

A9. *Preparing the selector S1 for operation*

The tip, ring, and sleeve conductors (T, R, and S) of calling line #111 have now extended to the corresponding incoming conductors of the allotted selector S1 (Fig. 5), through the #1 set of contacts of primary switch 1A (Fig. 9), tip, ring, and sleeve conductors of link L1A, contacts in the #1 set of secondary switch A1 (Fig. 10), and the tip, ring, and sleeve conductors (T, R, and S) in selector link S1 extending by way of cable 1000 to the selector S1 (Fig. 5).

In the selector S1, the windings of line relay 502 are normally connected to the incoming tip and ring conductors T and R of the selector link SL1, through contacts of switching relay 501. The left-hand winding of relay 502 is supplied with battery potential as indicated, while the right-hand winding of this relay is normally supplied with ground potential by way of the common dial-tone lead DT, on which dial-tone signalling current may be superimposed in the usual manner. Line relay 502 is accordingly in circuit with the calling line. Temporarily the right-hand winding of line relay 502 is shunted at the outer contacts of cutoff relay 914, but the left-hand winding of the selector line relay is energized in parallel with individual line relay 913.

Line relay 502 of the selector S1 now operates over the calling line. Upon so doing, it operates release relay 503 over conductor 506, through contacts of switching relay 501. At its first armature, relay 503 prepares an impulse circuit over conductor 514; at its second armature, it applies ground potential through contacts of busy relay 505 to conductor 507, and at its third and fourth armatures, it applies ground potential to the hold conductor H and sleeve conductor S respectively in the associated selector link SL1.

The placing of ground potential on hold conductor H of the selector link SL1 closes a locking circuit, for the right-hand winding of operating magnet 1021 of the secondary switch A1 of group LS to hold the line switch A1 operated after the operating circuit over the associated conductor A1 in cable 700 has been opened, as it is very shortly.

Responsive to the application of ground potential to the sleeve conductor S of link SL1, cutoff relay 914 operates to clear the conductors of the calling line, whereupon line relay 913 restores.

A10. *Clearing out line common equipment LCE*

The line common equipment LCE is now cleared out and returned to its illustrated normal condition. The normal clearing-out operation occurs in most cases responsive to the restoration of the line relay such as 913 of the calling line to thereby remove ground potential from the associated start conductor ST, whereupon relays 711 and 701 immediately restore, followed by the restoration of the other operated relays of the line common equipment LCE. Assume, however, that another line in the same tens subgroup is now in calling condition. In this event, ground potential is maintained on start conductor ST in branch B1 of cable 900, and relays 711 and 701 are maintained operated notwithstanding the described restoration of line relay 913 responsive to the operation of cutoff relay 914. The clearing-out operation, however, occurs as follows:

The described grounding of conductor H of link SLA results in the extension of ground potential therefrom to conductor H1 (see Fig. 10) in branch BSA of cable 700. Such ground potential is extended, through the front contact of the outermost left armature of the operated allotter relay 811 to the group-busy lead GBU in cable 700, thereby closing a circuit for the right-hand winding of group-busy relay 721. Group-busy relay 721 is retarded by having a normally short-circuited left-hand winding. Upon operating, after a slight interval, relay 721 opens the battery-supply connection (by way of resistor 731) to relays 701 to 720. When this occurs, relays 701 and 711 restore notwithstanding the continued grounded condition of start conductor ST in in branch B1 of cable 900.

Relay 723 is unlocked and restored responsive to the removal of ground potential from conductor 733 by relay 701. Delay relay 726 restores promptly responsive to the restoration of relay 723, as its retarding winding is opened when the relay is in operated condition.

Relay 811 of the selector allotter restores responsive to the removal of ground potential from conductor 736 by relay 723. Upon restoring, it disconnects the now-grounded conductor H1 in branch BSA of cable 700 from lead GBU and connects it to the left-hand winding of mark relay 801 of the allotter. When this occurs, relay 801 operates and locks its right-hand winding to the associated conductor controlled by reset relay 833 to insure that the selector S1 is not again taken for operation until the remaining selectors associated with the first hundreds group have been tested by the allotter.

The result of the disconnection of lead GBU in cable 700 is the restoration of group-busy relay 721. This completes the clearing out of the line common equipment LCE.

A11. *Dialing and hundreds digit 1*

Upon the described extension of the calling line over selector link SL1 to the selector S1, and the consequent clearing of the calling line by the described operation of cutoff relay **914**, the calling subscriber hears the usual dial-tone signal transmitted to the calling line from the common dial-tone lead DT (Fig. 5) through the right-hand winding of line relay **502**. He is thereby informed that he may now dial the desired digits (1, 1, and 0) in the desired number.

When the calling subscriber manipulates his calling device in accordance with the hundreds digit 1, a single momentary interruption is produced in the circuit of line relay **502**. Line relay **502** is thus restored once momentarily to transmit a single momentary impulse, through contacts of release relay **503**, to impulse conductor **514**. As a result of this impulse, driver relays A and B of the hundreds register HR operate in a manner to be described subsequently and cause the operation of relay 1 of the hundreds register to make connection with conductor 1 of cable G1.

In order that the complete operation of the hundreds register HR be understood at the outset, the detailed operation thereof will be described in connection with the dialing of the digit 0, which is the digit dialed when the tenth one of the hundreds groups is called. Preliminarily, it may be noted that (as shown in chart form in Fig. 17) relays 1 to 5 of register HR operate successively responsive to the first five impulses in a received series, relays 1 to 4 each restoring shortly after operation of the next succeeding relay, the overlap time being the length of a single impulse;

Relay 5, following its operation responsive to the fifth impulse, remains operated until the seventh impulse is received, whereupon it restores;

Relay 6 operates in response to the sixth impulse to perform a switching operation, and remains operated thereafter; and

Relays 1 to 4 are reoperated responsive to the seventh to tenth impulses respectively, relays 1 to 3 each restoring responsive to the operation of the next succeeding relay.

Series relay **504** responds to the first impulse of a series delivered over impulse conductor **514**. Being slow-restoring, as indicated, series relay **504** remains operated throughout the series of impulses. Release relay **503** also remains operated during the series of impulses, being slow-restoring as indicated.

A11*a*. *Control relays A and B*

The first impulse delivered to conductor **514** passes through contacts of relay B of the hundreds register HR to the right-hand winding of the associated relay A. Relay A thereupon operates, closing a locking circuit for its right-hand winding in series with the right-hand winding of relay B, to ground on conductor **507** (grounded at this time through its connection to the normally grounded conductor **506**, through contacts of relays **505** and **503**). Relay B is not operated during the continuance of the impulse for its right-hand winding is short-circuited until the impulse is terminated.

Upon the termination of the first impulse, the right-hand winding of relay B is energized in the locking circuit of the right-hand winding of relay A, whereupon relay B operates and transfers impulse conductor **514** from the right-hand windings of relays A and B to the left-hand windings thereof.

With relay B in operated condition, when the second impulse arrives over conductor **514**, a holding circuit is thereby established for the left-hand winding of relay B. At the same time, a restoring circuit is established for the left-hand winding of relay A, through the inner left contact pair thereof. Being differential, as indicated, relay A immediately restores. When it does so, it disconnects its left-hand winding and open-circuits the right-hand windings of relays A and B. Relay B is maintained operated for the duration of the second impulse by current flowing through its left-hand winding.

When the second impulse is terminated, relay B restores responsive to the consequent deenergization of its left-hand winding. Relays A and B are again in their illustrated normal condition.

The above-described operation of relays A and B of Fig. 5 is repeated over and over as the impulses arrive. That is, relay A is operated at the beginning of each odd impulse, and relay B is operated at the end thereof. Relay A is restored at the beginning of each even impulse and relay B is restored at the end thereof. The times of operation and restoration of relays A and B with respect to the controlling impulses are indicated in chart form in Fig. 17.

A11*b*. *Counting relays 1 to 6*

When relay A operates at the beginning of the first impulse, it transfers the grounded conductor **507** from even conductor **511** into connection with odd conductor **512**, thereby closing an operating circuit through contacts of relays 5, 4, and 2 for relay 1. At its right-hand contacts, relay 1 prepares a self-locking circuit by connecting its winding to conductor **509**.

When relay B operates at the end of the first impulse, it transfers the grounded conductor **507** from even locking conductor **510** to odd locking conductor **509**, thereby completing the prepared locking circuit for relay 1 while the initial circuit thereof is still intact.

When relay A restores at the beginning of the second impulse over conductor **514**, it transfers the grounded conductor **507** from the odd conductor **512** back to the even conductor **511**. The initial circuit of relay 1 is thereby opened, but this relay remains locked operated to conductor **509**. Responsive to the grounding of even conductor **511**, a circuit is closed through contacts of relays 5 and 3, and 1 for relay 2. Relay 2 thereupon operates and prepares a locking circuit for itself to even locking conductor **510**.

When relay B restores at the end of the second impulse, it reconnects even locking conductor **510** to the grounded conductor **507**, and then disconnects odd locking conductor **510**. Relay 2 thereby first becomes locked operated, following which relay 1 is unlocked and restored, opening the initial circuit of relay 2 at the front contact of its first left armature.

As the impulses continue to arrive, and the above-described operations of relays A and B are repeated, relay 3 is operated over odd conductor **512** at the beginning of the third impulse and relay 4 is operated over even conductor **511** at the beginning of the fourth impulse. Relay 2 is unlocked and restored when relay B operates at the end of the third impulse, and relay 3 is unlocked and restored when relay B restores at the end of the fourth impulse.

Relays 5 and 6 are operated successively responsive to the receipt of the fifth and sixth impulses respectively. Relay 5 is operated over odd conductor **512** and through contacts of relay 4, while relay 6 is operated over even conductor **511** and through contacts of relay 5. Relay 6 is locked operated, at the front contact of its first armature, directly to grounded conductor **507**, whereby it remains operated until the register HR is cleared out.

Relay 4 is unlocked and restored when relay B transfers locking potential from conductor **510** to conductor **509** at the end of the fifth impulse, but relay 5 remains locked operated until the beginning of the seventh impulse, by operations as follows:

The initial operation of relay 5 occurs when relay A reoperates at the beginning of the fifth impulse, at which time relay B is in a restored condition.

When relay B reoperates at the end of the fifth impulse, it again grounds conductor **509**, closing a locking circuit thereover for relay 5, through the front contact of the second right armature of relay A, and the right-hand contacts of relay 5.

When relay A restores at the beginning of the sixth impulse (at which time relay 6 is operated as previously stated), it transfers the locking circuit of relay 5 from conductor **509** directly to conductor **507**, whereby relay 5 is not unlocked and restored when relay B restores at the end of the sixth impulse.

When relay A reoperates at the beginning of the seventh impulse, it transfers the locking circuit of relay 5 back from conductor **507** to conductor **509**. Relay B is then in a restored condition, and conductor **509** is consequently disconnected. Relay 5 is accordingly unlocked and restored at the beginning of this impulse, the seventh, as is indicated in chart form in Fig. 17.

When relay A reoperates at the beginning of the seventh impulse, and relay 5 restores as described, relays 2 and 4 having been restored, relay 1 is reoperated over odd conductor **512** and again prepares to lock itself to the odd locking conductor **509**, which becomes grounded again when relay B operates at the end of the seventh impulse.

When relay A restores at the beginning of the eighth impulse and again grounds even conductor **511**, relay 2 is reoperated, through contacts of the restored relays 5 and 3 and through contacts of the reoperated relay 1. The reoperation of relay 2 is followed by the restoration of relay 1, when relay B restores at the end of the eighth impulse to transfer locking potential from odd conductor **509** back to even conductor **510**.

Relays 3 and 4 are reoperated successively responsive to the ninth and tenth impulses respectively, relay 3 being operated over conductor **512** and relay 4 being operated over conductor **511**. Relay 2 is unlocked and restored when relay B reoperates at the end of the ninth impulse. Relay 3 is unlocked and restored when relay B restores at the end of the tenth and final impulse in the series.

A11c. *Features of register HR*

The number of relays in the hundreds register HR is reduced by the described arrangement rendering driver relays A and B common to the counting relays 1 to 6, and is further reduced by the arrangement for reoperating relays 1 to 4 to record the seventh to tenth impulses.

A further feature of the register arrangement is that only simple "make" contacts are provided on relays 1 to 5 for interconnecting the hundreds-register conductor HR in branch B1 of cable **550** with the selected one of the conductors 1 to 0 in cable G1. Since the associated conductors 1 to 0 in cable G1 are common to selectors S1 to S10, the concerned contact arrangement on the relays of the hundreds register HR must be such that the associated conductors 1 to 0 are not interconnected with each other or with any other source potential during the counting operation. If this precaution is not observed, a controlling operation occurring over one or another of the associated conductors 1 to 0 would likely be interfered with by the counting operation occurring in another selector. The way in which this contingency is avoided will now be discussed.

The hundreds-register conductor HR in branch B1 of cable **550** is normally open at contacts of relay **310** of the selector chain SC1 and remains open until the selector chain is rendered temporarily individual to the selector S1, as will be hereinafter described. The said conductor HR is joined directly with conductor **524** associated with the hundreds register, and conductor **523** is joined to conductor **524** through normally closed contacts of series relay **504**.

During the receipt of a series of impulses, relay **504** is maintained operated and maintains conductors **523** and **524** disconnected from each other. The connecting contacts of the odd-numbered counting relays 1, 3, and 5 of register HR are associated with conductor **523**, while the contacts of the even-numbered relays 2 and 4 are associated with conductor **524**. By this arrangement, an odd-numbered counting relay and an even-numbered counting relay may both be in operated condition at the same time without interconnecting two of the conductors 1 to 0.

Conductors **523** and **524** are provided with normally connected branches **515** and **517**, respectively, which are effective when the recorded digit has any value of from 1 to 5. For values of the recorded digits from 6 to 0, branches **516** and **518** are substituted, by the operation of relay 6.

As previously noted, Fig. 17 shows the code in accordance with which the relays 1 to 6 of the hundreds register HR are operated for the various digit values of from 1 to 0. From this code, it will be observed that digit values 1 to 5 call for the operation of relays 1 to 5 respectively, all other relays being restored. Digit value 6 calls for the operation of relays 5 and 6, while digit values 7 to 0 call for the reoperation of relays 1 to 4 respectively, along with the operation of relay 6.

In the present example, wherein the number being dialed is #110, the hundreds digit dialed on the calling line #111 (Figs. 2 and 9) is the digit 1, represented by a single impulse. Accordingly, counting relay 1 of the hundreds register HR is the only one of the relays 1 to 6 in operated condition at the end of the hundreds digit.

A12. *Seizing selector chain SC1*

When series relay **504** restores at the end of the dialing of the hundreds digit 1, the back contact of the first armature thereof rejoins conductors **523** and **524**, while the back contact of the second armature of series relay **504** extends ground potential to conductor ST in branch B1 of cable **550**, such back contact having become grounded by the operated one of counting relays 1 to 5 (relay 1 in the present example).

If the selector chain SC1 is idle when series relay **504** restores, the consequent grounding of conductor ST in branch B1 of cable **500** results

in the operation of relay 301 thereof (individual to the selector S1), through normally closed contacts controlled by the second left armature of relay 301, chain-end conductor 315, chain contacts of relays 310 to 301, conductor 314, and thence to battery through the winding of relay 311 and the left-hand winding of relay 312.

Cycle-timer relays 311 and 312 operate in a manner to be described hereinafter to apply ground potential to busy conductor 313 only in the event that all paths available from the selector S1 to the called hundreds group are in use.

When relay 301 operates it locks its winding directly to chain-supply conductor 314 and disconnects conductor 314 from chain-end conductor 315 to preclude operation of any one of the relays 302 to 310 for the time being.

A13. *Marking the calling selector*

At the back contact of its third left armature, relay 301 (individual to the calling selector S1, Fig. 5) disconnects ground from conductor 1 in the associated branch B1 of mark cable 300, leaving conductors 2 to 0 in such branch grounded, thereby imposing a marking condition on the conductors in such branch indicative of the fact that the currently calling selector is the selector S1 (Fig. 5).

A14. *Marking the called hundreds group*

At the front contact of its first right armature, relay 301 grounds conductor HR in the associated branch B1 of cable 550, thereby extending ground potential, by way of contacts of series relay 504, conductor 513, contacts of relay 6, conductor 515, and contacts of the operated counting relay 1, to the selected conductor 1 in cable G1. The ground potential on conductor 1 in cable G1 is extended, by way of the first terminal in terminal strip TS1 (Fig. 6), to conductor 1 in branch B1 of start cable 600, thereby marking hundreds group 1 as called.

A15. *Seizing selector common equipment SCE*

Assuming that the selector common equipment SCE of Figs. 15 and 16 (being the selector common equipment individual to the called hundreds group 1) is idle at this time, it is immediately seized and appropriated to the group of ten selectors (S1 to S10) containing the calling selector S1 of Fig. 5, as follows:

Under the assumed condition, the described grounding of conductor 1 in branch B1 of start cable 600 closes an operating circuit through start chain relay 1501, by way of normally closed contacts controlled by the second right armature of relay 1501, chain-end conductor 1515, chain contacts of relays 1501 to 1510, chain-supply conductor 1511, contacts of clearout relay 1601, to battery through resistor 1643. Relay 1501 locks itself to the chain-supply conductor 1511, through chain contacts of relays 1502 to 1510, at the same time isolating chain-end conductor 1515 to preclude operation for the time being of any one of the relays 1502 to 1510.

A16. *Setting primary master switch SP—MS*

As a further result of its operation, relay 1501 connects conductors 1 to 0 in branch B1 of mark cable 300 respectively to conductors 1 to 0 in branch BPM of cable 1600, thereby connecting the contacts 1 to 0 in the bank of the selector primary master switch SP—MS (Fig. 14) respectively to the back contacts of relays 301 to 310 of selector chain SC1 (Fig. 3). By this operation (relay 301 being the only one of these relays operated), the first contact in the bank of master switch SP—MS is left ungrounded, while all the other contacts in the master switch bank are grounded. The master switch SP—MS accordingly operates as described for master switch LP—MS (Fig. 9) to align the plungers of the associated selector primary switches opposite their respective #1 contact sets.

A17. *Selecting an idle primary switch*

At the front contact of its fourth right armature, relay 1501 applies ground potential from the normally grounded conductor 1514 to conductor 1 in the primary distributor branch BPD of cable 1600 to cause the primary distributor of Fig. 10 to select an idle one of the associated primary switches having access to the ten selectors including the calling selector S1 (Fig. 5). These primary switches are switches 1A to 1D of group SP (Figs. 2 and 14). Assuming that primary switch 1A (shown in circuit diagram in Fig. 14) is idle, the above grounding of conductor 1 in branch BPD of cable 1600 results in the extension of ground potential, through the second right armature spring of magnet 1421 of switch 1A, to conductor A in the branch BPD of cable 1600, conductors B, C, and D in such branch remaining ungrounded at this time. By this operation, the A relay 1602 of the associated primary distributor is operated, the associated B and C relays 1603 and 1604 remaining in normal position. The concerned A primary switch 1A of Fig. 14 is accordingly selected, for conductor A in cable 1600 remains connected.

Upon operating, relay 1602 applies ground potential to conductor 1644, thereby energizing the right-hand winding of delay relay 1605, causing the latter relay to operate after a slight interval. Additionally, relay 1602 applies ground potential to conductor 1513, at the same time removing ground potential from the normally grounded conductor 1514. The initial operating circuit of relay 1602 is thereby opened, but this relay now remains operated in a locking circuit, from ground on conductor 1513, through the front contact of the third right armature of relay 1501, conductor 1512, to battery through the right-hand winding of relay 1602.

A18. *Setting secondary master switch SS—MS*

The contacts in the bank of master switch SS—MS (Fig. 13) are connected respectively to conductors 1 to 0 in the secondary mark branch BSM of cable 1600, and are connected thereby to the back contacts of the third right armatures of relays 1501 to 1510 respectively. With relay 1501 operated, and relays 1502 and 1510 not operated, the grounding of conductor 1513 by the described operation of relay 1602 causes master switch SS—MS to operate as previously described to align the plungers of the idle selector secondary switches in group SS opposite their respective #1 contact sets.

A19. *Allotting an idle connector*

The connector allotter of Fig. 16, including relays 1621 to 1641, operates to allot an idle connector responsive to the described grounding of conductor 1644 by primary-distributor relay 1602. When conductor 1644 is grounded, the first one of the relays 1631 to 1640 associated with a connector whose corresponding one of the relays 1621 to 1630 is in restored condition is operated

to allot such connection. The connector allotter of Fig. 16 is similar to the selector allotter of Fig. 8 and operates in the same manner.

Assuming that the connector C1 shown in Fig. 2, part 1, and in circuit detail in Figs. 11 and 12, is idle at this time, and that the allotter control relay 1621 individual thereto is in restored condition, the grounding of conductor 1644 closes a circuit, through contacts of relay 1621, for relay 1631. Relay 1631 thereupon operates to allot the said connector C1 for operation.

A20. *Preparing the allotted connector C1 for operation*

Upon the described operation of relay 1631, a circuit is closed from battery through resistor 1642, contacts of relay 1631, tip conductor T1 in branch BC of cable 1600, tip conductor T of connector link CL1 (joined to the said conductor C1 at the switch A1, Fig. 13), to ground through the left-hand winding of line relay 1201 of the connector C1. Line relay 1201 now operates, followed by the operation of release relay 1203 to prepare the connector for operation. This operation includes the grounding of local conductor 1313, to which the hold conductor H in connector link CL1 is joined. It further includes the grounding of sleeve conductor S in connector link CL1 and the preparation of an impulse circuit over conductor 1314, leading to the tens register TR and the units register UR, by way of the sequence group of relays.

A21. *Operating selector-secondary switch A1*

Upon the completion of the described distributor, master-switch, and allotter operations, selector-secondary switch A1 of group SS (Fig. 13) is caused to operate, responsive to energization of its operating magnet 1301 over the following circuit: from ground through the right-hand contacts of lock magnets 1309 and 1409 in series, conductor MSG in cable 1600, contacts of the operated delay relay 1605 of the primary distributor, contacts of the unoperated relays 1604 and 1603, conductor A in cable 1610, contacts of the operated connector-allotter relay 1631, conductor A1 in branch BC of cable 1600, and thence to battery through the left-hand winding of magnet 1301.

Upon operating, magnet 1301, through the action of the usual plunger thereof (not shown), closes the selected # 1 contacts of the switch A1, connecting connector link CL1 of the allotted connector C1 to link 1 in cable A, being the link extending to primary switch 1A of group SP (Fig. 14).

A22. *Operating selector-primary switch 1A*

Responsive to the operation of selector-secondary switch A1, magnet 1421 of selector primary switch 1A (Fig. 14) is operated over the following circuit: from ground through the lowermost contact pair in contact set 1 of the said switch A1 of Fig. 13, hold conductor H in link 1 of cable A, normally closed contacts controlled by the first right armature spring of magnet 1421, and thence to battery through the left-hand winding of magnet 1421. By the operation of magnet 1421, the selected #1 set of contacts of switch 1A of Fig. 14 are closed, thereby connecting the incoming tip, ring, and sleeve conductors of said switch with the corresponding conductors of the selector multiple SM1, being the outgoing conductors of the calling selector S1 of Fig. 5.

A23. *Switching through at selector S1*

Upon the described operation of the secondary and primary switches of Figs. 13 and 14, switching relay 501 of the selector S1 is operated over the following circuit path: from ground through contacts of the operated release relay 1203 of conductor C1, sleeve conductor S of the connector link CL1, sleeve contacts in the #1 contact set of switch A1 (Fig. 13), sleeve conductor S of link 1 in cable A, sleeve contacts in set #1 of the operated primary switch 1A (Fig. 14), sleeve conductor S in selector multiple SM1, and thence to battery through the winding of switching relay 501. Upon operating, relay 501 joins sleeve conductor S of selector multiple SM1 to sleeve conductor S of the selector link SL1 at the front contact of its third right armature; at its fourth and fifth armatures, relay 501 disconnects the incoming ring and tip conductors of the selector link SL1 from the windings of line relay 502 and transfers them to the corresponding conductors in the selector multiple SM1, now extended through contacts of switches 1A and A1 of Figs. 14 and 13 to the corresponding conductors in connector link CL1 incoming to the connector C1 of Fig. 12. Line relay 1201 of the connector C1 is accordingly held operated from the calling line after the initial energizing circuit thereof becomes opened when the common equipment of Figs. 15 and 16 clears out, as it shortly does.

In the selector S1, line relay 502 restores responsive to being disconnected by relay 501. Its restoration is followed shortly by the restoration of release relay 503. The latter relay removes ground potential at one point from hold conductor H in link SL1, but this conductor is maintained grounded thereafter at the front contact of the second armature of relay 501. The original ground connection is removed from sleeve conductor S in link SL1, but such conductor remains grounded by its connection with conductor S of selector multiple SM1.

The operated relays of hundreds register HR are released and cleared out responsive to the removal of ground potential from conductor 506 at the first armature of relay 501, as locking conductor 507 of the hundreds register derives ground potential from conductor 506.

A24. *Clearing out selector chain SC1*

The selector chain SC1 of Fig. 3 is cleared out responsive to the clearing out of the hundreds register HR, when counting relay 1 restores and removes ground potential from conductor ST in branch B1 of cable 500 to thereby open-circuit and restore the operated selector chain relay 301.

A25. *Clearing out selector common equipment SCE*

The clearing out of selector common equipment SCE is initiated by the restoration of counting relay 1 of hundreds register HR and the consequent removal of ground potential from conductor 1 in cable G1, and consequently from conductor 1 in branch B1 of start cable 600. Start-chain relay 1501 of equipment SCE is open-circuited and restored responsive to the latter operation. Distributor relay 1602 is thereby unlocked and restored, followed by the restoration of relays 1605 and 1631 to complete the clearing-out operation.

An alternative clearing-out operation ensues when, for any reason, the operating ground potential for the operated one of the start chain relays 1501 to 1510 is not promptly removed.

With an allotter relay such as 1631 in operated condition, when the associated connector is prepared for operation as hereinbefore described, the following circuit is closed for clear-out relay 1601: from ground through contacts of the operated release relay 1203, hold conductor H in connector link CL1, conductor H1 in branch BC of cable 1600, contacts of the operated relay 1631, and thence to battery through the right-hand winding of clear-out relay 1601. The operation of relay 1601 is retarded momentarily by the normally short-circuited left-hand winding thereof to permit the described normal clearing-out operation to occur. Upon operating, relay 1601 open-circuits its left-hand winding to render it quick-releasing. Additionally, it disconnects battery supply resistor 1643 from chain-supply conductor 1511, thereby clearing out any operated one of the relays 1501 to 1510. Subsequently, when relay 1631 restores incident to the initiated alternative clearing-out operation, it open-circuits and restores clear-out relay 1601.

The described restoration of relay 1631, incident to the clearing-out operation, opens the previously traced initial energizing circuit for line relay 1201 of the connector C1, leaving the two windings of line relay 1201 energized in series over the calling line.

A26. *Setting the connector C1*

Following the dialing of the hundreds digit 1, with the described results, the calling subscriber dials the tens and units digits 1 and 0 in the desired number, causing the tens register TR (Fig. 12) and the units register UR (Fig. 11) to record such digits, as will now be described.

A26a. *Operating the sequence relays*

Each time a digit is dialed, line relay 1201 transmits a corresponding number of impulses through the left-hand contacts of the operated release relay 1203 and through contacts of relay 1207 to impulse conductor 1214. The sequence group, comprising driver relay 1209 and tens and units relays 1210 and 1211, operates to transmit the first train of impulses over tens conductor 1215 to the tens register TR, and to transmit the following series of impulses over conductor 1216 to the units register UR. The operation of the sequence group is controlled by series relay 1208, which operates responsive to the first impulse of a series delivered over conductor 1214, and, being slow restoring, remains operated until the last impulse of the series is terminated.

Upon operating at the beginning of the tens series of impulses, series relay 1208 operates tens relay 1210 of the sequence group over the following circuit: from ground on local conductor 1213 (grounded by release relay 1203), through contacts of busy relay 1207 to conductor 1217, and thence through the front contact of the first right armature of series relay 1208, back contact of the first right armature of driver relay 1209, and contacts of units relay 1211, to battery through the winding of tens relay 1210. Relay 1210 thereupon operates. When it does so, it closes a locking circuit for itself, from ground on conductor 1217, through the left-hand winding of driver relay 1209, first left armature of relay 1210 and its front contact, contacts of units relay 1211, and thence to battery through the winding of relay 1210. Driver relay 1209 remains unaffected by the closing of this locking circuit so long as series relay 1208 remains operated and

maintains the initial circuit of relay 1210 established.

When series relay 1208 restores at the end of the tens digit and opens the initial circuit of relay 1210, the locking circuit thereof becomes effective to energize the left-hand winding of driver relay 1209, whereupon relay 1209 operates, and tens relay 1210 remains locked operated.

When series relay 1208 operates at the beginning of the units series of impulses, it extends ground potential (from the grounded conductor 1217) through the first right armature and front contact of driver relay 1209 to the right-hand winding of the driver relay, thereby establishing a holding circuit for such winding. A branch of this holding circuit extends, through contacts of the operated tens relay 1210, to the winding of units relay 1211. Units relay 1211 is accordingly operated. It locks itself, through the front contact of its second left armature, directly to conductor 1217. At the back contact of its first left armature, it open-circuits and restores tens relay 1210, at the same time open-circuiting the left-hand winding of driver relay 1209. Relay 1210 thereupon restores, but driver relay 1209 remains operated through its right-hand winding as long as relay 1208 remains operated.

At the end of the units series of impulses, driver relay 1209 is open-circuited and restored by series relay 1208, leaving units relay 1211 locked operated.

A26b. *Registering the tens digit*

The series of impulses, delivered over impulse conductor 1214 by line relay 1201, constituting the tens digit is transmitted through contacts of the then unoperated relays 1209 and 1211, over tens conductor 1215, to the tens register TR. The tens register TR is similar to the hundreds register HR of Fig. 5, and it accordingly responds in the previously described manner to record the tens digit 1. The first counting relay 1 of the tens register TR is operated, the other counting relays 2 to 6 remaining restored. A marking circuit is thus prepared over conductor 1 in branch BTM of cable 700.

A26c. *Registering the units digit*

When the series of impulses representing the units digit is transmitted over conductor 1214, driver relay 1209 is in an operated condition as previously described. Accordingly, the impulses are transmitted through the front contact of the second right armature of relay 1209, and over units conductor 1216, to the units register UR (Fig. 11). The units register UR is likewise similar to the hundreds register HR of Fig. 5, and it accordingly operates as previously described. Since the units digit dialed is the digit 0, counting relays 4 and 6 of the units register UR are in energized condition at the end of the units digit, preparing for the extension of marking potential over conductor 0 in units-mark cable UM.

A27. *Seizing common equipment LCE through the connector chain*

When driver relay 1209 restores as described at the end of the units digit, ground potential, through contacts of relays 1211 and 1209, is placed on start conductor ST of branch BC1 of cable 700, being the branch of this cable individual to connector C1. If the line common equipment LCE of Figs. 7 and 8 is idle, it is there-

upon seized through the connector chain of Fig. 8, as follows:

The placing of ground potential on start conductor ST of branch BCI of cable 700 operates relays 821 and 722 in series over the following circuit: from ground on the conductor ST associated with relay 821, through the winding of relay 821, normally closed contacts controlled by the second right armature of relay 821, the associated chain-end conductor, normally closed chain contacts controlled by the first right armatures of relays 830 to 821, transfer relay 722, normally closed contacts controlled by the second right armature of relay 722, chain-end conductor 732, chain contacts of relays 710 to 701, 721 and 722, and thence to battery through chain-supply resistor 731.

Upon operating over the above-traced circuit, transfer relay 722 locks itself directly to resistor 731 and isolates chain-end conductor 732 to preclude operation of any one of the relays 701 to 710 for the time being; it joins conductor PO in cable 700 to conductor 852; and it disconnects conductor 736 to prevent the selector allotter comprising relays 801 to 820, and 833, from operating. The common equipment LCE is thereby changed over from finder action to connector action.

When connector-chain relay 821 (individual to the connector CI) operates over its above-traced circuit, it closes a self-locking circuit in series with relay 722 over a more direct circuit path, at the same time isolating the associated chain-end conductor to preclude operation of any one of the remaining connector chain relays 822 to 830 for the time being. At its left-hand armatures and front contacts, relay 821 connects up conductors TR, UR, BU, SW and S, in the associated branch BCI of cable 700, and it connects up conductors AII, BII, CII, and DII in branch BCS of cable 700, the latter conductors being the initial operating conductors for the secondary switches bearing the corresponding designations in group LS of Figs. 2 and 10. Secondary switches AII to DII are for the individual use of connector C in extending calls therefrom to called lines.

A28. *Units selection*

With connector chain relay 821 operated, ground potential is thereby placed on the units-register conductor UR in branch BCI of cable 700, thereby extending ground potential to conductors 1220 and 1221 associated with the units register UR (Fig. 11). With counting relays 6 and 4 of the units register UR in operated condition, the ground potential on conductor 1220 is extended through the front contact of the second right armature of the said relay 6, and through the front contact of the second right armature of relay 4, to conductor 0 in units-mark cable UM, thereby operating relay 960 of the translator group comprising relays 951 to 960. When it operates, relay 960 isolates bank contact 0 of the master switch LP—MS, and extends ground potential, through the back contacts of relays 951 to 959, to each of the bank contacts 1 to 9 of the master switch. The master switch LP—MS thereby operates as previously described to align the plungers of all idle associated primary switches in group LP opposite their respective #0 contact sets, being the contact sets associated with the called line #110.

A29. *Tens selection*

With connector-chain relay 821 operated, ground potential is thereby applied to the tens-register conductor TR in branch BCI of cable 700, thereby extending ground potential to conductors 1218 and 1219, associated with the tens register TR (Fig. 12). With relay 1 of the tens register TR operated, and relays 2 to 6 thereof in restored condition, the ground potential on conductor 1219 is extended, through the back contact of the third right armature of the associated relay 6, and the front contact of the third right armature of relay 1, to conductor 1 in the tens-mark branch BTM of cable 700, thereby energizing the left-hand winding of relay 701 of the start chain shown in Fig. 7. Relay 701 is operated at this time without relay 711 of the connect group operating. At its third right armature, relay 701 isolates conductor 1 in the secondary mark branch BSM of cable 700 and prepares to extend ground potential to bank contacts 2 to 0 of secondary master switch LS—MS (Fig. 10), subject to operation, as previously described, of relay 723 of the primary distributor.

A30. *Selecting an idle primary switch*

With start chain relay 701 again operated (this time for connector action instead of for finder action), the associated primary switches 1A and 1D of group LP (Figs. 2 and 9) are again tested and the primary distributor of Fig. 7 is positioned in accordance with the first idle one thereof. In the present example, switch 1A of the group LP is in use in extending calling line #111 as previously described and operating magnet 921 thereof is accordingly in an energized condition. It may be assumed that switches 1B and 1C of group LP (Fig. 9) are also busy, while switch 1D is idle. Under this condition, when relay 701 grounds the associated conductor 1 in branch BPD of cable 700 (by way of the normally grounded conductor 735), ground potential is extended through the front contacts of the third right armature springs of the operating magnets 921 to 923, and the back contact of the third right armature spring of magnet 924 (of switch 1D) to conductor D in branch BPD of cable 700, thereby energizing the right-hand winding of C relay 725 in series with the left-hand winding of the B relay 724 of the primary distributor. Upon operating, relays 724 and 725 each prepares a self-locking circuit over conductor 733 and closes a local energizing circuit for the A relay 723. Relays 725 and 724 operate jointly to disconnect conductor 737 from conductor A in group 750 and transfer it into connection with conductor D thereof, thereby selecting primary switch 1D, Fig. 9.

Relay 723 operates responsive to the operation of relays 724 and 725; followed a short time later by the operation of delay relay 726.

The operation of relay 723 results in the termination of the primary selecting operation, for ground potential is placed on conductor 734 and removed from conductor 735. The ground potential on conductor 734 locks relays 723 to 725 operated.

A31. *Setting master switch LS—MS*

The ground potential on conductor 733 is extended through contacts of relays 702 to 710 to contacts 2 to 0 in the bank of master switch LS—MS (Fig. 10), setting such master switch in position 1 to thereby align the plungers of the idle line switches in group LS opposite their respective #1 contact sets.

A32. *Operating secondary switch D11*

Primary switch 1D of group LP having been selected, secondary switch D11 of group LS of Fig. 10 (associated with the calling connector C1 of Figs. 11 and 12) is operated over the following circuit path upon the completion of the previously described selecting and master-switch operations: from ground, through the right-hand contacts of lock magnets 1009 and 909, master-switch-ground conductor MSG in cable 700, contacts of delay relay 726, conductor 737, contacts of the operated relays 725 and 724, conductor D of group 750, contacts of the operated connector-chain relay 821, conductor D11 in branch BCS of cable 700, and thence to battery through the left-hand winding of operating magnet 1024 of connector-action secondary switch D11 of group LS (Fig. 10). By the operation of magnet 1024, the selected #1 contact set of switch D11 is closed to interconnect the tip, ring and sleeve conductors T, R, and S of connector multiple CM1 with the corresponding conductors of link L1D in cable LD, being the link extending to the selected primary switch 1D of group LP (Fig. 9).

A33. *Operating primary switch 1D*

The hold conductor H in link L1D of cable LD is grounded at the lowermost contact pair of the closed contact set of secondary switch D11, thereby closing a circuit, through contacts controlled by magnet 924 of primary switch 1D, for the left-hand winding of such magnet. By the resulting operation of magnet 924, the selected #0 contact set of switch 1D is closed, thereby interconnecting the tip, ring, and sleeve leads of link L1D with the corresponding conductors of the called line #110.

A34. *Testing the called line*

The common test relay 831 now tests the called line. If the called line is idle, there is no ground potential on the sleeve lead thereof, in which case the following test circuit is effectively established, by the described operation of switches D11 and 1D (Figs. 10 and 9): from ground, through test relay 831, contacts of relay 821, sleeve conductor S in branch BC1 of cable 700, sleeve conductor S (Fig. 12) of connector multiple CM1, sleeve contacts of set #1 of switch D11 (Fig. 10), sleeve lead of link L1D, sleeve contacts of set #0 of switch 1D (Fig. 9), sleeve lead of called line #110, and to battery through cutoff relay 916.

Cutoff relay 916 operates over the traced test circuit to clear the called line. Test relay 831 operates to prepare a circuit for switching relay 1206 of the calling connector.

A35. *Seizing the called line*

Operations looking toward seizing the called line, if idle as assumed, are initiated by the operation of magnet 924 of the primary switch 1D (Fig. 9), which closes the following circuit: from ground extended to conductor D of group 750 over a previously traced circuit path, and thence through contacts of the operated relay 701 to conductor D1 in branch BPO of cable 700, front contact of the second right armature of magnet 924, primary-operated conductor PO of cable 700, left-hand contacts of the operated transfer relay 722, conductor 852, and thence to battery through the right-hand winding of delay relay 832. Responsive to the closure of this circuit, and after an interval sufficient to permit the described line-testing operation to occur, delay relay 832 operates and applies ground potential to conductor 853. Busy relay 1207 (in connector C1) is thereby operated, through contacts of the operated relay 821, and over busy lead BU in branch BC1 of cable 700, and switching relay 1206 is thereby operated, through contacts of the operated relays 831 and 821, and over switching conductor SW in branch BC1 of cable 700.

Upon operating, each of the relays 1206 and 1207 locks itself to the grounded local conductor 1213.

At the front contact of its second left armature, switching relay 1206 applies ground potential to the hold conductor H in connector multiple CM1 to maintain operating magnet 1024 of switch D11 (Fig. 16) locked operated after its initial operating circuit is opened upon the clearing out of common equipment LCE.

At the front contact of its third right armature, relay 1206 applies ground potential directly to the associated outgoing sleeve lead to maintain the called line guarded and cutoff relay 916 operated after the common equipment is cleared out.

At its outermost left armature, relay 1206 opens a point in the busy signalling circuit and prepares a ringing tone circuit, while at the front contacts of its fourth and fifth left armatures, it closes the ringing circuit to the tip and ring conductors of the called line by way of the corresponding conductors of the connector multiple CM1.

Ringing current from the common ringing lead 1212 is now intermittently projected over the tip conductor of the called line, a return path being provided over the ring conductor of the called line through the winding of trip relay 1205. Trip relay 1205, being of the usual retarded type, does not respond to the flow of alternating current, the flow of direct current being precluded by the usual condenser in the ringer circuit (not shown) on the called line.

During the ringing operation, a portion of the applied ringing current reaches the calling line by way of the small-capacity condenser interconnecting the outermost left armatures of relays 1204 and 1206, giving the calling subscriber the usual ringing signal.

A36. *Clearing out the common equipment LCE*

Upon operating, in addition to locking itself operated as described, busy relay 1207 attempts to apply a busy-tone signal to the calling line at the front contact of its second left armature, but is prevented from doing so by the described operation of switching relay 1206; at the back contact of its right armature, relay 1207 opens impulse lead 1214 to prevent the transmission of further impulses thereover in the event that the calling subscriber should again actuate his calling device; and at the back contact of its first left armature, it disconnects ground potential from conductor 1217 thereby causing the associated registers TR and UR to clear out, as well as restoring any operated ones of the relays 1209 to 1211 of the sequence group.

Responsive to the restoration of units relay 1211 of the sequence group, ground potential is removed from start conductor ST in branch BC1 of cable 700, thereby open-circuiting and restoring relays 821 and 722.

Relays 960 and 701 restore responsive to the described clearing out of registers TR and UR (Figs 12 and 11). Ground potential is removed from conductor 733 at the front contact of the third right armature of relay 701, thereby unlocking and restoring primary-distributor relays

723 to 725, as a result of which delay relay 726 restores. Delay relay 832 restores responsive to the opening of the front contact of the left armature of relay 722, completing the clearing out of the common equipment LCE.

A37. *Answering*

When the called subscriber on line #110 (Fig. 9) removes his receiver to answer the call, the closure of the usual direct-current bridge across the conductors of the called line results in the operation of trip relay 1205 over the ringing circuit. Ring-cutoff relay 1204 is operated by trip relay 1205 and locks itself to the grounded local conductor 1213. At the back contacts of its second, third, and fourth armatures, relay 1204 opens the ringing-tone circuit and the ringing circuit, while it completes the talking circuit at the front contacts of its third and fourth armatures. Back bridge retard coil 1202 supplies talking current to the transmitter on the called line, while line relay 1201 supplies talking current to the calling line.

The calling and called subscribers may now converse with each other as desired.

It will be recalled that the completed connection is from calling line #111 (Fig. 9), through contacts of the operated primary switch 1A of group LP, tip and ring conductors of link L1A in cable LA, contacts of the operated switch A1 of group LS (Fig. 10), tip and ring conductors of selector link SL1 in cable 1000, contacts of the operated switching relay 501 of the selector S1 (Fig. 5), tip and ring conductors of selector multiple SM1 in cable 500, contacts of the operated primary switch of 1A of group SP (Fig. 14), tip and ring conductors of link 1 in cable A, contacts of the operated secondary switch A1 (Fig. 13), tip and ring conductors of connector link CL1, the illustrated talking condensers of the connector C1 (Fig. 12), contacts of the operated relays 1204 and 1206, tip and ring conductors of the connector multiple CM1 in cable 1050, contacts of the operated secondary switch D11 of group LS (Fig. 10), link L1D in cable LD, and thence, through contacts of the operated switch 1D of group LP (Fig. 9), to the tip and ring conductors of called line #110.

A38. *Clearing out the established connection*

When the conversation is terminated and the concerned subscribers replace their receivers, the established talking connection is cleared out by operations substantially as follows:

Line relay 1201 restores responsive to the receiver being replaced on the calling line, followed a moment later by the restoration of release relay 1203.

A38a. *Clearing out the connection from the calling line*

Responsive to the opening of the front contact of the second left armature of release relay 1203, ground potential is removed from the associated sleeve conductors of the incoming connector link CL1, thereby open-circuiting and restoring switching relay 501 of the selector S1 (Fig. 5) and cutoff relay 913 of the calling line (Fig. 9).

Responsive to the opening of the front contact of the first left armature of release relay 1203, ground potential is removed from local conductor 1213 and consequently from the associated hold conductor H of the incoming connector link CL1. The removal of ground potential from hold conductor H of the connector link CL1 opens the holding circuit previously existing thereover for magnet 1301 of secondary switch A1 (Fig. 13), through the locking contacts of such magnet and both windings thereof in series. Switch A1 accordingly restores, thereby removing ground potential from hold conductor H of link 1 in cable A, opening the holding circuit of operating magnet 1421 of switch 1A (Fig. 14). Such switch 1A accordingly restores.

Responsive to the restoration of switching relay 501 of selector S1 (Fig. 5), ground potential is removed from hold conductor H of the selector link SL1, thereby opening the holding circuit of magnet 1021 of switch A1 of group LS (Fig. 10). Such switch A1 thereupon restores and removes ground potential from the hold conductor H of link L1A in cable LA. The holding circuit of magnet 921 of primary switch 1A (Fig. 9) is thereby opened, whereupon such switch 1A restores to disconnect the calling line #111 from link L1A.

A38b. *Clearing out the connection to the called line*

Referring again to the connector C1 of Figs 11 and 12, a further result of the described removal of ground potential from local conductor 1213 (by release relay 1203) is the restoration of ring-cutoff relay 1204 and switching relay 1206. The opening of the front contact of the third left armature of relay 1206 removes ground potential from sleeve conductor S of connector multiple CM1, thereby open-circuiting and restoring cutoff relay 916 associated with the called line.

The opening of the front contact of the second left armature of relay 1206 results in the removal of ground potential from the hold conductor H of connector multiple CM1, thereby opening the holding circuit of operating magnet 1024 of switch D11 (Fig. 10). Switch D11 is thereby restored to remove ground potential from conductor H of link L1D extending to switch 1D of group LP (Fig. 9). Magnet 924 of switch 1D is thereby deenergized, whereupon the switch 1D restores to break the connection between the tip, ring, and sleeve conductors of link L1D and the corresponding conductors of the called line #110.

The previously established connection is thus cleared out and the apparatus involved therein is available for further use.

A39. *The called line is busy*

Referring again to the previously described operations wherein a call is made from line #111 to line #110 of Fig. 9, and particularly to the testing of the called line, a description will now be given of the results which follow if the called line is busy when tested.

If the called line #110 of Fig. 9 is busy, there is a ground potential on the sleeve conductor thereof to maintain cutoff relay 916 operated, whether the line is busy as a calling line or as a called line.

In this event, when the previously traced test circuit is established for cutoff relay 916 (individual to the called line) in series with common test relay 831 in the line common equipment LCE of Figs. 7 and 8, relay 831 fails to operate because its winding is shunted by the ground connection to the sleeve conductor of the called line. Under this condition, there is no circuit prepared for switching relay 1006 and this relay is not operated along with busy relay 1207. As a result, busy relay 1207 operates alone, as its previously

traced operating circuit is independent of the contacts of test relay 831.

When busy relay 1207 operates, with switching relay 1206 not operated, the ringing circuit is not closed to the called line, and a busy signalling circuit is completed from the common busy-tone lead BT, through the front contact of the second left armature of busy relay 1207, and through the outermost back contacts of relays 1206 and 1204, to the associated tip talking conductor, thereby transmitting a busy tone to the calling line to inform the subscriber thereon that the desired connection cannot be completed for the time being.

As previously described, busy relay 1207 locks itself to the grounded conductor 1213 and disconnects such conductor from conductor 1217, thereby clearing out the associated sequence group of relays, as well as the tens register TR and the units register UR.

The previously described clearing-out operation of common equipment LCE occurs responsive to the removal of ground potential from conductor ST in branch BC1 of cable 700 incidental to the clearing out of the sequence group comprising relays 1209 to 1211. As a result of this clearing-out operation, the initial operating circuit of magnet 1024 of secondary switch D11 (Fig. 10) is opened, whereby such secondary switch releases because switching relay 1206 has not been operated to close a holding circuit therefor, as is the case when the called line is idle. The release of the secondary switch D11 of Fig. 10 is followed by the release of the operated primary switch 1D of Fig. 9, completing the clearing out of the connection to the called line.

Responsive to the receiver being replaced on the calling line, the connection from the calling line to the connector C1 is cleared out as previously described.

B. Alternative operations

Operations alternative to those hereinbefore described will now be considered to enable a more complete understanding to be had of the operation of the system as a whole.

B1. *Calls from and to other tens groups*

As previously noted, cable 900, extending from the line equipment of Fig. 9 to Fig. 7, has ten branches (B1 to B0), each such branch containing a tens (or start) conductor and ten units (or mark) conductors, as is illustrated in detail in Fig. 9 for the branch B1. When a call is originated on a line included in a tens group other than the one associated with branch B1 in Fig. 9, the start conductor in the concerned other branch of cable 900 is thereupon grounded to cause some other pair of relays (such as 719 and 709) in the line common equipment to operate to thereby prepare for the extension of the calling one of the ten lines in the associated tens group. For example, if the calling line is located in the ninth tens group of lines, relays 719 and 709 are the ones operated. Relay 719 connects the ten associated individual mark conductors respectively to conductors 1 to 0 in the primary-mark branch BPM of cable 700 to cause the master switch LP—MS (Fig. 9) to be set in accordance with which line in the concerned tens group is the calling line.

At the back contact of its third right armature, relay 709 isolates conductor 9 in secondary mark branch BSM of cable 700, thereby predetermining that line secondary master switch LS—MS (Fig. 10) will be set in its #9 position. At its outermost right-hand pair of contacts, relay 709 grounds conductor 9 in branch BPD of cable 700 to thereby place the primary distributor of Fig. 7 under the control of line primary switches 9A to 9D (Fig. 2), serving the ninth tens group of lines, the one containing the calling line.

The succeeding operations may be as hereinbefore described.

With respect to calls terminating in other tens groups, it will be recalled that relay 701 is energized through its left-hand winding when conductor 1 in branch BPM of cable 700 is energized incident to a call to a line of the first tens group. When a line is called in another of the tens groups, the concerned one of the relays 702 to 710 is energized over the associated one of the conductors in branch BPM to thereby cause the call to be completed to the called line in the associated tens group.

B2. *Selecting other primary switches*

Referring again to switches 1A to 1D of group LP (Figs. 2 and 9), it will be recalled that the first idle one of these switches (when the call concerns the associated tens group) is selected by an operation of the primary distributor of Fig. 7. The distributor operation was initiated, it will be recalled, responsive to the grounding of conductor 1 in branch BPD of cable 700, at the outermost right-hand contact pair of relay 701. If switch 1A of Fig. 9 is idle, such ground potential is extended through contacts of magnet 921 thereof to conductor A in group BPD, as described; if switch 1A of Fig. 9 is busy and the associated switch 1B is idle, the ground potential is extended through contacts of the operated magnet 921 and contacts of the unoperated magnet 922 to the associated conductor B; if switches A and B are both busy and switch C is idle, the ground potential is extended to the associated conductor C; and if switches 1A to 1C are busy and switch 1D is idle, the ground potential in question is extended to conductor D in the said branch BPD of cable 700.

Considering now the primary distributor of Fig. 7; ground potential on conductor A in branch BPD of cable 700 causes the A relay 723 to operate with results as previously described, in which case relays 724 and 725 remain unaffected and conductor 737 remains connected to conductor A of group 750 to cause the A secondary switch of the concerned trunk line to be operated to thereby cause operation of the A primary switch associated with the concerned tens group.

When conductor B in branch BPD of cable 700 is grounded in place of conductor A, the B distributor relay 724 operates and shifts conductor 737 from in connection with conductor A of group 750 into connection with conductor B, to cause a B secondary switch to be operated; when conductor C in the concerned branch BPD is grounded, the C relay 725 operates to transfer conductor 737 to conductor of group 750, to cause the concerned C secondary switch to be operated; and when the D conductor of the said branch BPD is grounded, the B and C relays 724 and 725 are energized in series, thereby shifting conductor 737 into connection with the D conductor of group 750, to cause operation of the concerned D secondary switch.

It is to be noted that the A relay 723 is operated in a local circuit responsive to the operation of either of the associated relays 724 and 725, for the purposes hereinbefore described.

From the description hereinbefore given, it

will be understood that the primary distributor of Fig. 16 (comprising relays 1602 to 1605) forming part of the selector common equipment SCE of Figs. 15 and 16 operates in the same manner as the primary distributor of Fig. 7 to select the first idle one of the four primary switches with which any given call may be concerned.

B3. *All line primaries busy*

The operations occurring when a call is attempted to or from a tens group of lines when all four of the primary switches assigned thereto are busy, will now be described. For this purpose, it may be assumed that relay 701 of the line common equipment LCE of Figs. 7 and 8 is energized as previously described, either pursuant to a call from one of the ten associated lines, or pursuant to a call to one of these lines, at a time when all four of the associated primary switches 1A to 1D (Fig. 9) are busy. Under this condition, when conductor 1 in branch BPD of cable 700 is grounded at the front contact of the fourth right armature of relay 701, ground potential is extended therethrough, and through contacts of the operated magnets 921 to 924, to group-busy conductor GBU in cable 700. A circuit is thereby closed for the operating winding of group-busy relay 721, causing relay 721 to operate after a slight interval. Upon so doing, it disconnects battery-supply resistor 731 from the right-hand windings of relays 701 to 710 and consequently from the windings of relays 711 to 720. If a finder-action call is being handled, the operated one of the relays 701 to 710 is thereby restored (along with its associated relay 711 to 710) causing the line common equipment LCE of Figs. 7 and 8 to clear out as previously described.

On the other hand, if the concerned relay 701 to 710 is energized through its left-hand winding pursuant to the completion of a connection through the connector switching stage as previously described, such relay is not directly restored by the operation of group-busy relay 721. At the front contact of its second left armature, relay 721 grounds the common busy conductor 853, thereby extending ground, through contacts of the operated one of the connector-chain relays 821 to 830, to the busy lead BU in the associated one of the cable branches BC1 to BC10. The busy relay (such as 1207) in the concerned connector thereupon operates, initiating a clearing-out operation as previously described, and returning a busy signal to the calling line.

B4. *Alloting other selectors*

Further consideration will now be given to the selector allotter comprising relays 801 to 820 and 833, forming part of the line common equipment LCE of Figs. 7 and 8.

It was described hereinbefore that, with all of the relays of the allotter in their illustrated restored position, the grounding of allotter conductor 736 pursuant to the extension of a connection by finder action results in the energization of connecting relay 811 through contacts of relay 801, to allot the associated selectors S1 (Fig. 3). It was further explained that relay 801 operates (following the described restoration of relay 811) over the associated conductor H1, interconnected with the hold conductor H of the associated selector link SL1 (see Fig. 10).

Upon operating, marking relay 801 closes a locking circuit for its right-hand winding controlled by reset relay 833, whereby relay 811 cannot be reoperated to allot the associated selector S1 of Figs. 2 and 5 until all of the other selectors (S2 to S10) assigned to the concerned hundreds group have had their turn. The disclosed selector allotter is accordingly of the type known as a progressive allotter.

When all of the concerned selectors have had their turn and all of the marking relays 801 to 810 have operated and become locked by their right-hand windings, a circuit is prepared over conductor 736 for reset relay 833.

Upon the initiation of the next finder action controlled through the equipment LCE of Figs. 7 and 8, the consequent grounding of conductor 736 results in the closure of a circuit through contacts of the operated relays 801 to 810 for reset relay 833. Relay 833 thereupon operates and opens the locking circuit of the right-hand windings of all of the relays 801 to 810. When this occurs, each such relay restores provided its left-hand winding is not in an energized condition, as it is in the event that the associated selector is busy at the moment. Ordinarily, most of the selectors are idle at the time reset relay 833 operates, wherefore most of the relays 801 to 810 restore. Upon the restoration of any one of them, the operating circuit of reset relay 833 is opened. Reset relay 833 is slow-restoring as indicated to give time for all of the relays 801 to 810 associated with idle selectors to unlock and restore.

The one of the connecting relays 811 to 820 associated with the first idle selector in the order of preference is now operated over conductor 736 to allot the associated selector, following which the operation proceeds substantially as described hereinbefore.

B5. *All selectors busy*

In the comparatively rare event that all of the selectors are busy when reset relay 833 operates as previously described, none of the relays 801 to 810 restores, wherefore the circuit for reset relay 833 remains established. In this event, the ground potential on conductor 736 is extended, through contacts of the operated relays 801 to 810, and through contacts of the operated relay 833, to the group-busy conductor GBU in cable 700, thereby closing a circuit for the right-hand winding of the slow-operating group-busy relay 721. Group-busy relay 721 operates after a slight interval and clears out the common equipment LCE as previously described.

B6. *All selector primaries busy*

Consideration will now be given to the operations resulting when all of the four primary switches having access to the calling selector in the called portion of the selector switching stages are busy. For this purpose, it will be considered again that the selector S1 of Fig. 5 is taken for use, and that the hundreds digit 1 is dialed as previously described. Relay 301 of the selector chain SC1 is operated as described to isolate conductor 1 in branch B1 of cable 300, and to ground conductor HR in branch B1 of cable 500, to thereby extend ground potential through the hundreds register HR of Fig. 5 to conductor 1 in cable G1, and thence to conductor 1 in branch B1 of start cable 600. Relay 1501 of the selector common equipment SCE of Figs. 15 and 16 is thereby operated, as described. The primary switches in the called portion of the selector switching stage which have access to the calling selector S1 of Fig. 5 (by way of the selector multiple SM1 in cable 500) are the selector primary switches 1A to 1D in group SP (Figs. 2 and 14).

If all four of these primary switches are busy, magnets 1421 to 1424 are all in operated condition. In this event, the previously described grounding of conductor 1 in branch BPD of cable 1600, by relay 1501, does not result in the extension of ground potential to any one of the conductors A to D in such cable branch. Accordingly, none of the relays 1602 to 1605 of the primary distributor of Fig. 16 is operated, as a result of which operations in the selector common equipment SCE are at a stand-still.

Under the assumed conditions, the cycle timer (comprising relays 311 and 312) associated with the selector chain SC1 of Fig. 3 operates to secure the operation of busy relay 505 in the selector S1 and the clearing out of the associated hundreds register HR to free the selector common equipment.

As previously described, the operating circuit for any one of the relays 301 to 310 includes the battery-supply conductor 314, the winding of relay 311, and the left-hand winding of relay 312. Relay 311 operates promptly over conductor 314, along with the operation of relay 301 in the assumed example. Upon so doing, it disconnects the common busy conductor 313 from the second right armature of relay 312. Cycle-timer relay 312 is retarded in its operation because its right-hand winding is normally short-circuited.

Upon operating, a moment later, relay 312 opens the normal short circuit of its right-hand winding to render it quick-restoring, and it short-circuits the winding of relay 311, to cause relay 311 to restore a short time later. At the same time, relay 312 prepares to apply ground potential to conductor 313, subject to the subsequent restoration of relay 311.

When the short-circuited cycle-timer relay 311 restores, after a slight interval, the common busy conductor 313 becomes grounded through contacts of the restored relay 311 and contacts of the operated relay 312. It will be understood that this operation of the cycle timer is sufficiently slow that the normal selector-stage operations as previously described have time to occur before the common busy conductor 313 is grounded as above described, and that the cycle-timer relays clear out without grounding this conductor when no busy condition is encountered in the selector switching stage.

The described grounding of conductor 313, with selector chain relay 301 operated, results in an extension of ground potential to busy conductor BU in branch B1 of cable 500, closing an operating circuit for busy relay 505 of the calling selector S1. Relay 505 locks itself to the grounded hold conductor H of the selector link SL1, grounded at contacts of the operated release relay 503, whereby it is held operated until selector S1 is released and cleared out.

At the back contact of its first armature, busy relay 505 disconnects ground potential from conductor 507 of the hundreds register HR, thereby open-circuiting and restoring all operated relays of such hundreds register. When this occurs, ground potential is removed from start conductor ST in branch B1 of cable 500. This permits relays 301 and 312 to restore, returning the selector chain SC1 and associated cycle timer to their illustrated normal condition.

The selector common equipment SCE of Figs. 15 and 16 clears out responsive to the restoration of the operated relay 1501, responsive in turn to the described clearing out of the hundreds register HR of Fig. 5.

At its outermost armature and associated contacts, busy relay 505 substitutes the common busy-tone lead BT for the dial-tone lead DT. A busy-tone signal may be superimposed on ground potential on lead BT, to thereby transmit a busy-tone signal to the calling line, indicative of the busy condition.

When the receiver is subsequently replaced on the calling line, line relay 502 restores, followed a moment later by the restoration of release relay 503. Release relay 503 thereupon disconnects ground potential from leads H and S of the selector link SL1, restoring busy relay 505 and causing the release of the operated secondary and primary switches of the line-finder stage. Series relay 504 and relay A of the hundreds register HR are incidentally operated momentarily pending the restoration of release relay 503, but they restore responsive to the opening of the front contact of the first armature of relay 503.

B7. *Allotting other connectors*

From the description hereinbefore given, it will be apparent that the connector allotter, comprising relays 1621 to 1640 and 1641, operates substantially as described for the similar selector allotter of Fig. 8, comprising relays 801 to 820 and 833. It was previously described how the connector C1 of Fig. 12 is allotted by the operation of connecting relay 1631 when the associated mark relay 1621 is in a restored condition. It will be clear that the concerned other ones of the relays 1632 to 1640 are operated in their turn to allot idle ones of the connectors C2 to C10, and that reset relay 1641 operates responsive to the next grounding of conductor 1644 after all of the relays 1621 to 1630 have been energized and locked, thereby restoring the ones of the relays 1621 to 1639 corresponding to connectors then idle.

B8. *All connectors busy*

If all of the connectors are busy when reset relay 1641 operates as described, none of the relays 1621 to 1630 restores, for each of them is maintained operated by its left-hand winding, energized over its associated H conductor in branch BC of cable 1600. None of the connecting relays 1631 to 1640 is accordingly operated, and the operations in the selector common equipment SCE are at a stand-still. In this event, the cycle-timer relays of the concerned selector chain (such as relays 311 and 312 of the selector chain SC1) operate as described. As a result, the busy relay of the calling selector is operated and the hundreds register thereof is cleared out, permitting the common equipment SCE of Figs. 15 and 16 to clear out.

B9. *Calls from and to other hundreds groups*

Calls from hundreds groups other than the previously considered hundreds group 1 are handled through the concerned ones of the selector groups of Fig. 2 part 2, such as S11 to S20, and so forth, to the group comprising selectors S91 to S100. Each such group of ten selectors is provided with its own selector chain similar to the selector chain SC1 shown in detail in Fig. 3. Selector chains SC2, SC9, and SC10 are indicated in Fig. 3, each having its own associated branch of the mark cable 300. Each such branch contains ten mark conductors, such as is indicated for the branch B1 of cable 300 associated with the selector SC1.

In the selector common equipment SCE, for example (Figs. 15 and 16), each of the branches

of cable 300 extends to the illustrated contacts of the relays 1501 to 1510, each such relay corresponding therefore to a separate selector chain.

The previously described arrangement of the start conductors illustrated particularly in Figs. 4 and 6 is such that, when the digit 1 is dialed, for example, the one of the relays 1501 to 1510 of the start chain which operates is dependent upon the tens group in which the calling selector is located. For example, if any one of the selectors S1 to S10 is calling, conductor 1 in branch B1 of start cable 600 is grounded to thereby operate relay 1501 to connect up the conductors in branch B1 of cable 300, controlled by the associated selector start chain SC1. Similarly, if a selector in the second group (comprising selectors S11 to S20) is calling the first hundred, the grounding of conductor 1 in group cable G2 results in the extension of ground potential to start conductor 2 in branch B1 of cable 600, thereby operating the second start-chain relay 1502 to connect up the conductors controlled by the second selector chain SC2 of Fig. 3. The same arrangement holds true for the remaining selector groups and the remaining ones of the start-chain relays 1501 to 1510.

It is apparent that the same arrangement is provided for calls to each of the other hundreds groups. For example, the start conductors 1 to 0 (see Figs. 4 and 6) in branch B2 of start cable 600 (the branch specific to the second hundreds group) represent the digit-2 conductors of the respective group cables G1 to G10; the conductors in branch B3 of cable 600 represent the digit-3 conductors in group cables G1 to G10; and so forth, to the tenth branch B0 of cable 600, wherein the conductors represent the digit-0 conductors in group cables G1 to G10 respectively.

With each of the other hundreds supplied with equipment as illustrated for hundreds group 1, calls to the other hundreds groups are handled exactly as described, except that in each case a different one of the conductors in the concerned one of the cables G1 to G10 of Figs. 3 to 6 is grounded by the concerned one of the hundreds registers such as HR of Fig. 5.

If desired, a distributing frame may be interposed, as indicated in Figs. 3 and 5, between the selector links SL1 to SL100 and the selectors S1 to S100. The indicated jumpers on such distributing frame may interconnect the selector links with the selectors in any desired other arrangement. One such other arrangement is to connect selector links SL1, SL11, SL21, etc., to SL91, respectively, to selectors S1 to S10; connect selector links SL2, SL12, SL22, etc. to SL92, respectively, to selectors S11 to S20, and so forth. Such an arrangement disperses the traffic from each hundreds group through all the selector groups.

I claim:

1. In a switching system, a group of lines having a group of primary switching devices associated therewith; a group of trunk lines having a group of secondary switching devices associated therewith; a group of line links interconnecting said primary switching devices with said secondary switching devices; said lines, said primary switching devices, and the primary end of said line links being divided into subgroups; the primary switching devices of any subgroup being effective to interconnect any line in such subgroup with any line link in the same subgroup; the secondary switching devices being effective to interconnect any line link with any trunk line; said lines having call numbers assigned respectively thereto; each such number including a subgroup digit indexing the subgroup containing the line to which it is assigned, and followed immediately by a line digit indexing the line in that subgroup; and means responsive to the calling of any one of said numbers for operating one of said secondary switching devices to connect one of said trunk lines to an idle line link extending to the indexed subgroup, and for operating a primary switching device therein to connect such line link to the indexed called line.

2. In a switching system, a group of lines having a group of primary switching devices associated therewith; a group of trunk lines having a group of secondary switching devices associated therewith; a group of line links interconnecting said primary switching devices with said secondary switching devices; said lines, said primary switching devices, and the primary end of said line links being divided into subgroups; the primary switching devices of any subgroup being effective to interconnect any line in such subgroup with any line link in the same subgroup; the secondary switching devices being effective to interconnect any line link with any trunk line; said trunk lines comprising originating trunk lines and terminating trunk lines; means responsive to the origination of a call on any one of said lines for extending connection therefrom, through a primary switching device and any idle line link of the concerned subgroup, and through a secondary switching device, to an idle originating trunk line; said lines having call numbers assigned respectively thereto; and means responsive to the calling of any one of said numbers for extending connection from one of said terminating trunk lines, through a secondary switching device and any idle line link in the subgroup containing the called line, and through a primary switching device therein, to the called line.

3. In a switching system, a group of lines having a group of primary switching devices associated therewith; a group of trunk lines having a group of secondary switching devices associated therewith; a group of line links interconnecting said primary switching devices with said secondary switching devices; said lines, said primary switching devices, and the primary end of said line links being divided into primary subgroups; the switching devices of any primary subgroup being effective to interconnect any line in such subgroup with any line link in the same subgroup; the secondary end of said line links and said secondary switching devices being divided into secondary subgroups; each secondary subgroup containing line links extending respectively to said primary subgroups; the switching devices of any secondary subgroup being effective to interconnect any line link in such secondary subgroup with any one of said trunk lines.

4. In a switching system as set forth in claim 3, the switching devices of any primary subgroup being individual respectively to the associated line links, and having selective positions corresponding respectively to the associated lines; the switching devices in any secondary subgroup being individual respectively to said trunk lines, and having selective positions corresponding respectively to the primary subgroups.

5. In a switching system as set forth in claim 3, said group of trunk lines including originating trunk lines and terminating trunk lines; means responsive to the origination of a call on one of said lines for interconnecting such lines with an idle originating one of said trunk lines, by way

of a primary switching device, any idle line link in the concerned primary subgroup, and a secondary switching device; and means effective upon a call to one of said lines over one of said terminating trunk lines for interconnecting such terminating trunk line with the called line by way of a secondary switching device, any idle line link in the concerned primary subgroup, and a primary switching device.

6. In a switching system as set forth in claim 3, the switching devices in any secondary subgroup being individual respectively to said trunk lines, and having selective positions corresponding respectively to the primary subgroups; and means common to all said secondary switching devices and capable of acting physically upon any one of them to bring it into any one of its said selective positions.

7. In a switching system as set forth in claim 3, a distributor common to the primary subgroups; means effective when one of said lines is to be interconnected with one of said trunk lines, by way of an idle one of the line links of the concerned subgroup, for associating said distributor individually with such line links; said distributor being thereafter effective to select an idle one of such line links and to direct the completion of the desired connection therethrough.

8. In a switching system, lines having primary switching devices associated therewith; trunk lines having secondary switching devices associated therewith; line links interconnecting the primary switching devices with the secondary switching devices; the primary switching devices being effective to interconnect said lines individually with the line links; the secondary switching devices being effective to interconnect the line links individually with the trunk lines; means responsive to the origination of a call on any one of said lines for operating a secondary switching device to interconnect an idle trunk line with an idle line link; and means responsive thereto for operating a primary switching device to interconnect the last-named line link with the calling line.

9. In a switching system, lines having primary switching devices associated therewith; trunk lines having secondary switching devices associated therewith; line links interconnecting the primary switching devices with the secondary switching devices; the primary switching devices being effective to interconnect said lines individually with the line links; the secondary switching devices being effective to interconnect the line links individually with the trunk lines; said lines having call numbers assigned respectively thereto; means responsive to the origination of a call on any one of said lines, and responsive to the calling of any one of said call numbers, for operating one of said secondary switching devices to interconnect one of said trunk lines with an idle one of said line links; and means responsive thereto for operating one of said primary switching devices to interconnect the last-named line link with the calling line, or with the called line, as the case may be.

10. In a switching system including a selector stage having a group of trunk lines incoming thereto and groups of trunk lines outgoing therefrom; selector links; primary switching devices for interconnecting said incoming trunk lines with said selector links; secondary switching devices for interconnecting said selector links with said outgoing trunk lines; said incoming trunk lines, said primary switching devices, and the primary end of said selector links, being divided into primary subgroups; means controlled over any calling one of said incoming trunk lines for selecting any desired one of said groups of outgoing trunk lines; means responsive to such selection for rendering the primary subgroup containing the calling trunk line, and the selected group of outgoing trunk lines, temporarily individual to each other; extending means thereupon effective for interconnecting the calling trunk line with an idle selector link in the concerned primary subgroup, and for interconnecting such selector link with an idle trunk line in the selected outgoing group; mark conductors individual respectively to said incoming trunk lines; means for temporarily impressing a distinctive marking conditon on the mark conductor of a callng trunk line while the concerned primary subgroup is temporarily individualized with the selected outgoing group; the said interconnection of the calling trunk line with an idle selector link being controlled by said distinctive marking condition.

11. In a switching system as set forth in claim 10, means for preventing the said distinctive marking condition from being impressed on more than one mark conductor of the same primary subgroup at the same time.

12. In a switching system including a selector stage having a group of trunk lines incoming thereto and groups of trunk lines outgoing therefrom; selector links; primary switching devices for interconnecting said incoming trunk lines with said selector links; secondary switching devices for interconnecting said selector links with said outgoing trunk lines; said incoming trunk lines, said primary switching devices, and the primary end of said selector links, being divided into primary subgroups; said primary subgroups of incoming trunk lines being provided respectively with primary subgroups of start conductors; the start conductors of any primary subgroup being common to the incoming trunk lines of such subgroup, and extending respectively to said groups of outgoing trunk lines; means controlled over any calling one of said incoming trunk lines for impressing a starting potential on any desired one of the start conductors of the concerned primary subgroup; means responsive thereto associated with the group of outgoing trunk lines to which such start conductor extends for operating a secondary switching device to interconnect an idle one of the concerned group of outgoing trunk lines with an idle selector link in the primary subgroup containing the calling trunk line; and means for operating a primary switching device in the concerned primary subgroup to interconnect the last-named selector link with the calling trunk line.

13. In a switching system as set forth in claim 12, mark conductors individual respectively to said incoming trunk lines; means for impressing a distinctive marking condition on the mark conductor of the said calling incoming trunk line; the said means for operating a primary switching device as set forth being controlled by said distinctive marking condition.

14. In a switching system as set forth in claim 12, mark conductors individual respectively to said incoming trunk lines; means for impressing a distinctive marking condition on the mark conductor of the said calling incoming trunk line; the said means for operating a primary switching device as set forth being controlled by said distinctive marking condition; and means for insuring that said starting potential will be

impressed on only one start conductor of a primary subgroup at a time, and that said distinctive marking potential will be impressed on only one mark conductor of a primary subgroup at a time.

15. A group of relays for counting the number of impulses in a series, said relays including a plurality of double-count relays, a transition relay, and a transfer relay; the impulse-counting capacity of the group being equal to the total number of said relays, plus the number of double-count relays; means responsive to the impulses in a series at least equal to the total number of relays for operating said relays responsive respectively to successive impulses, the double-count relays being operated first followed by said transition relay, followed in turn by said transfer relay, means for releasing any double-count relay responsive to the next impulse of the series; means effective when the impulses in a series exceed the total number of relays for reoperating said double-count relays successively responsive respectively to the impulses succeeding the operation of said transfer relay, and means responsive to the first reoperate impulse for restoring said transition relay, while leaving said transfer relay operated.

16. In a group of counting relays as set forth in claim 15, pairs of conductors associated respectively with said double-count and transition relays, and means controlled jointly by any one of such relays and said transfer relay for selecting one conductor or another of the concerned pair.

17. In a group of counting relays as set forth in claim 15, each of said relays except the transfer relay being effective to make connection with a separate pair of conductors while operated, and means for rendering one conductor or another of a connected pair effective according to whether the transfer relay has, or has not, been operated.

18. In combination, lines divided into groups, groups of line links associated respectively with said groups, said line links handling all calls to and from said lines, a group of originating trunks and a group of terminating trunks, means responsive to a calling condition on any line in any group for connecting such line with any idle line link in the associated group and for connecting such line link with any idle one of said originating trunks, and means responsive to any one of said lines being called over any one of said terminating trunks for connecting such trunk to any idle line link in the concerned group and for connecting such line link to the called line.

19. In combination, lines divided into groups, groups of line links associated respectively with said groups, said line links handling all calls from said lines, a group of trunks, means responsive to a calling condition on any line in any group for connecting such line with any idle line link in the associated group and for connecting such line link with any idle one of said trunks.

20. In a switching system, a switching group including lines, line links, and primary and secondary switches; trunks incoming to the group; said lines, primary switches, and line links, being divided into primary subgroups, the switches in any primary subgroup being effective to interconnect any line link of such subgroup with any line thereof; said secondary switches being effective to interconnect any one of said trunks with any one of said line links, each of said lines having a separate call number assigned thereto containing two digits serving to distinguish such line from all other lines of the group, means controlled over a calling line for seizing any idle one of said trunks incidental to a call to any desired called one of said lines and for transmitting the call number of the called line to the seized trunk, and means responsive thereto for operating a secondary switch to connect the seized trunk with an idle line link in the primary subgroup containing the called line and for operating a primary switch in such subgroup to connect the last-named line link with the called line.

21. In a switching system, a switching group including lines, line links, and primary and secondary switches; trunks incoming to the group; said lines, primary switches, and line links, being divided into primary subgroups, the switches in any primary subgroup being effective to interconnect any line link of such subgroup with any line thereof; said secondary switches being effective to interconnect any one of said trunks with any one of said line links, each of said lines having a separate call number assigned thereto, means controlled over a calling line for seizing any idle one of said trunks incidental to a call to any desired called one of said lines and for transmitting the call number of the called line to the seized trunk, means dependent upon the receipt of a sufficient portion of the call number to distinguish the called line from all other lines of the group for operating a secondary switch to connect the seized trunk with an idle line link in the primary subgroup containing the called line, and means for operating a primary switch in the concerned subgroup to connect the last-named line link with the called line.

22. In a switching system, a switching group including lines, line links, and primary and secondary switches; trunks incoming to the group; said lines, primary switches, and line links, being divided into primary subgroups, the switches in any primary subgroup being effective to interconnect any line link of such subgroup with any line thereof; said secondary switches being effective to interconnect any one of said trunks with any one of said line links, each of said lines having a separate call number assigned thereto, means controlled over a calling line for seizing any idle one of said trunks incidental to a call to any desired called one of said lines and for transmitting the call number of the called line to the seized trunk, and means responsive to the transmission of the final digit necessary to distinguish the called line from all other lines of the group for operating a secondary switch to connect the seized trunk with an idle line link in the primary subgroup containing the called line, and means for operating a primary switch in the concerned subgroup to connect the last-named line link with the called line.

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