June 20, 1944. G. R. EATON 2,351,808

AUTOMATIC TELEPHONE SYSTEM

Filed Sept. 24, 1941 31 Sheets-Sheet 1

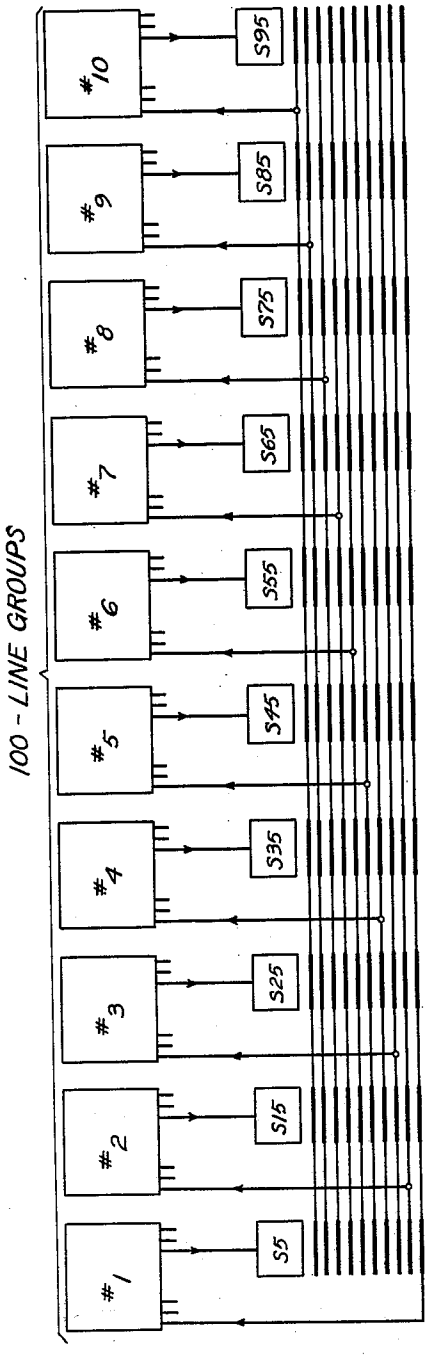

Fig. I

Inventor:
George R. Eaton
By C. C. Soper
Atty.

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AUTOMATIC TELEPHONE SYSTEM

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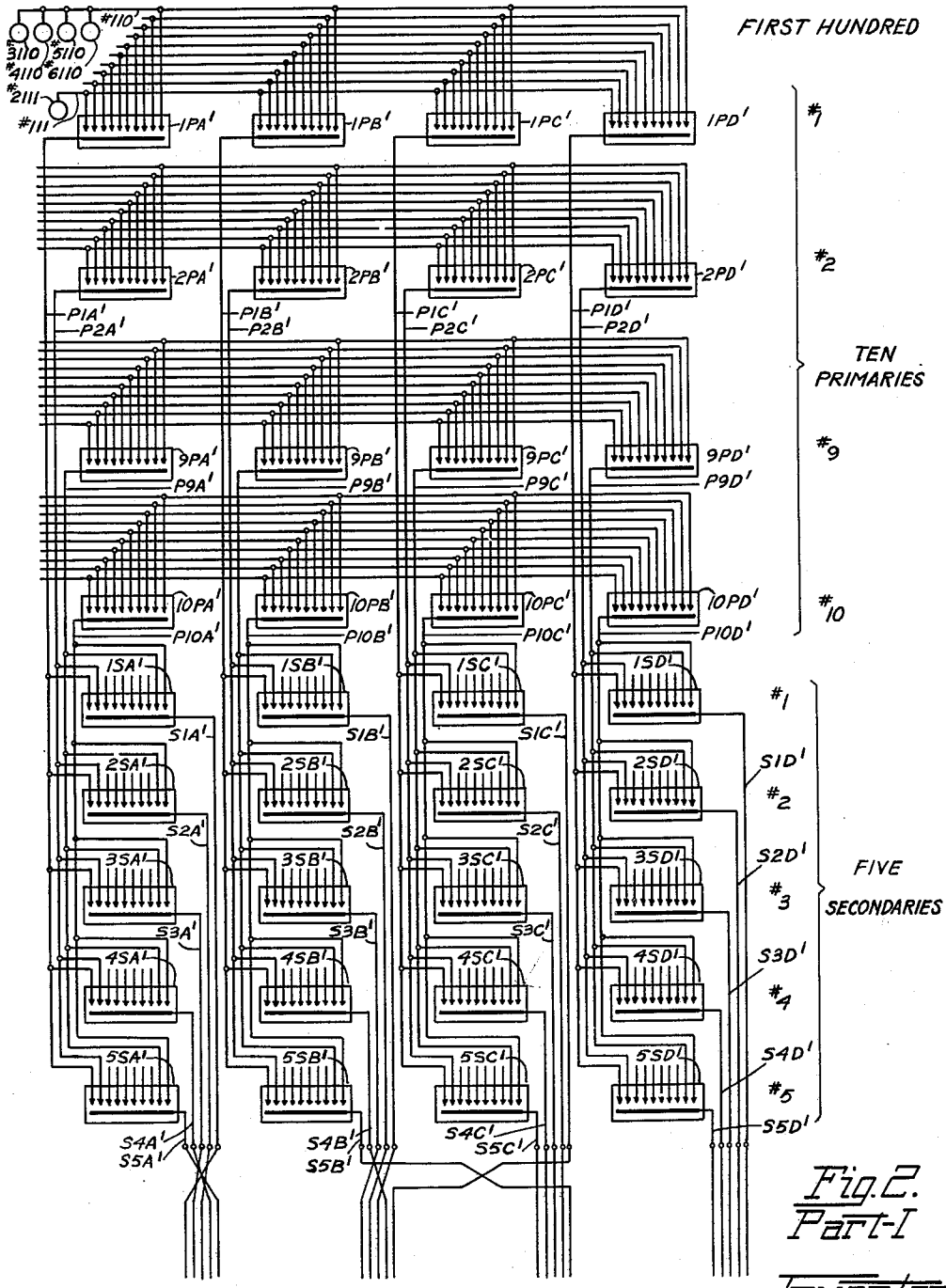

Fig. 2. Part-I

Inventor:
George R. Eaton
By C. P. Sofen
Atty

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AUTOMATIC TELEPHONE SYSTEM

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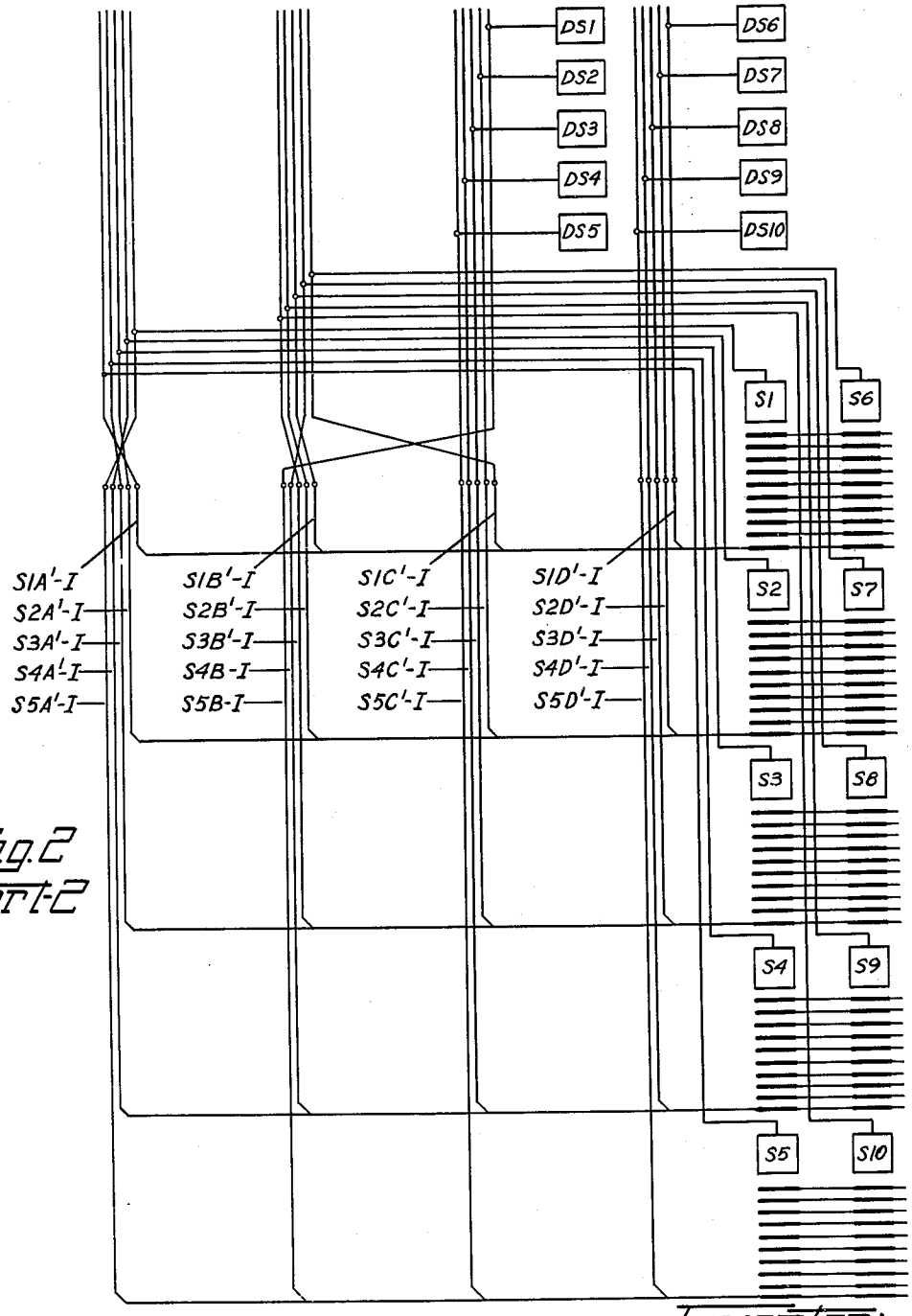

Fig. 2
Part-2

Inventor:
George R. Eaton
By C. P. Sofer
Atty.

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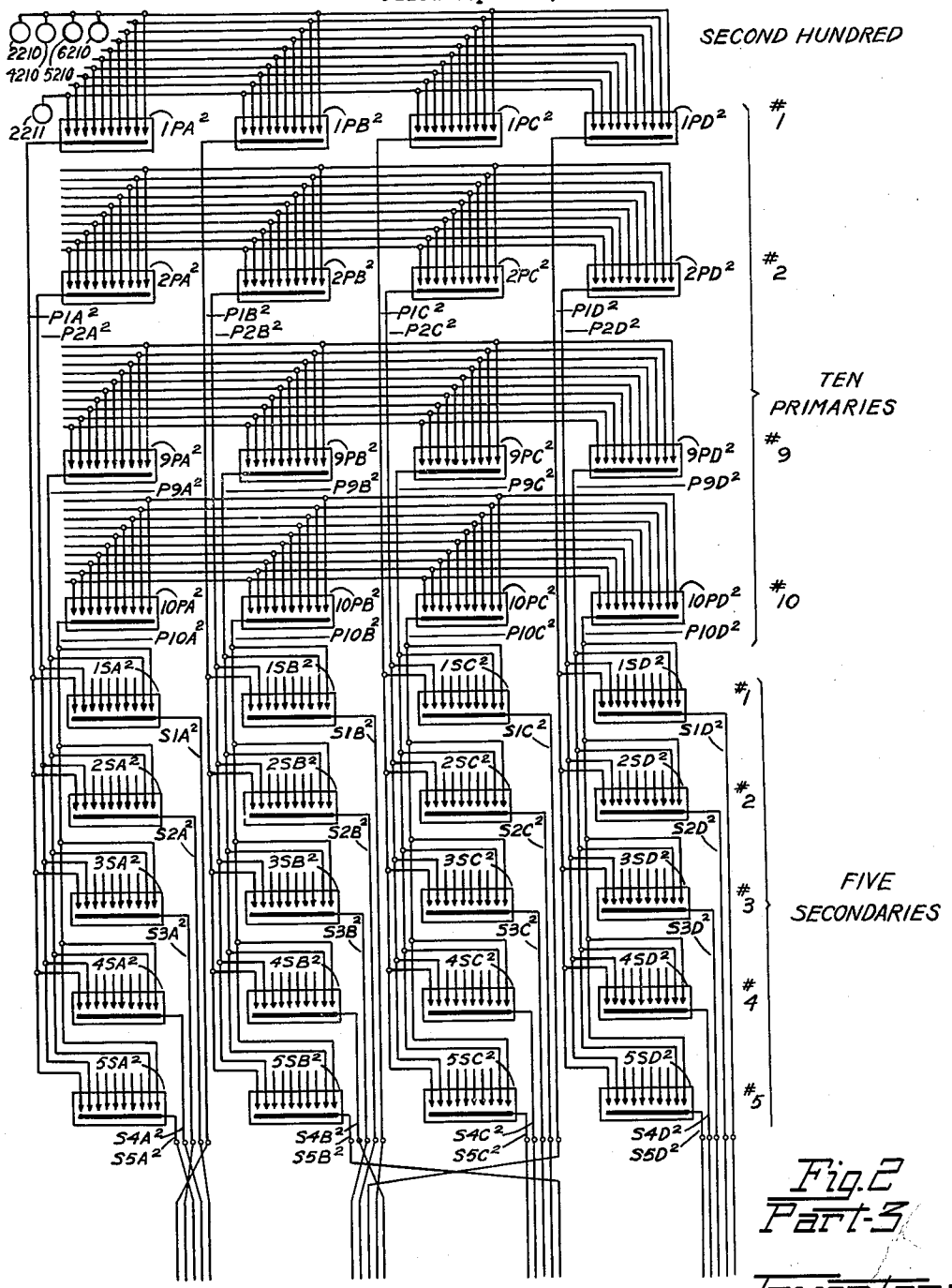

Fig. 2 Part-3

Inventor:
George R. Eaton
By C. P. Soper
Atty.

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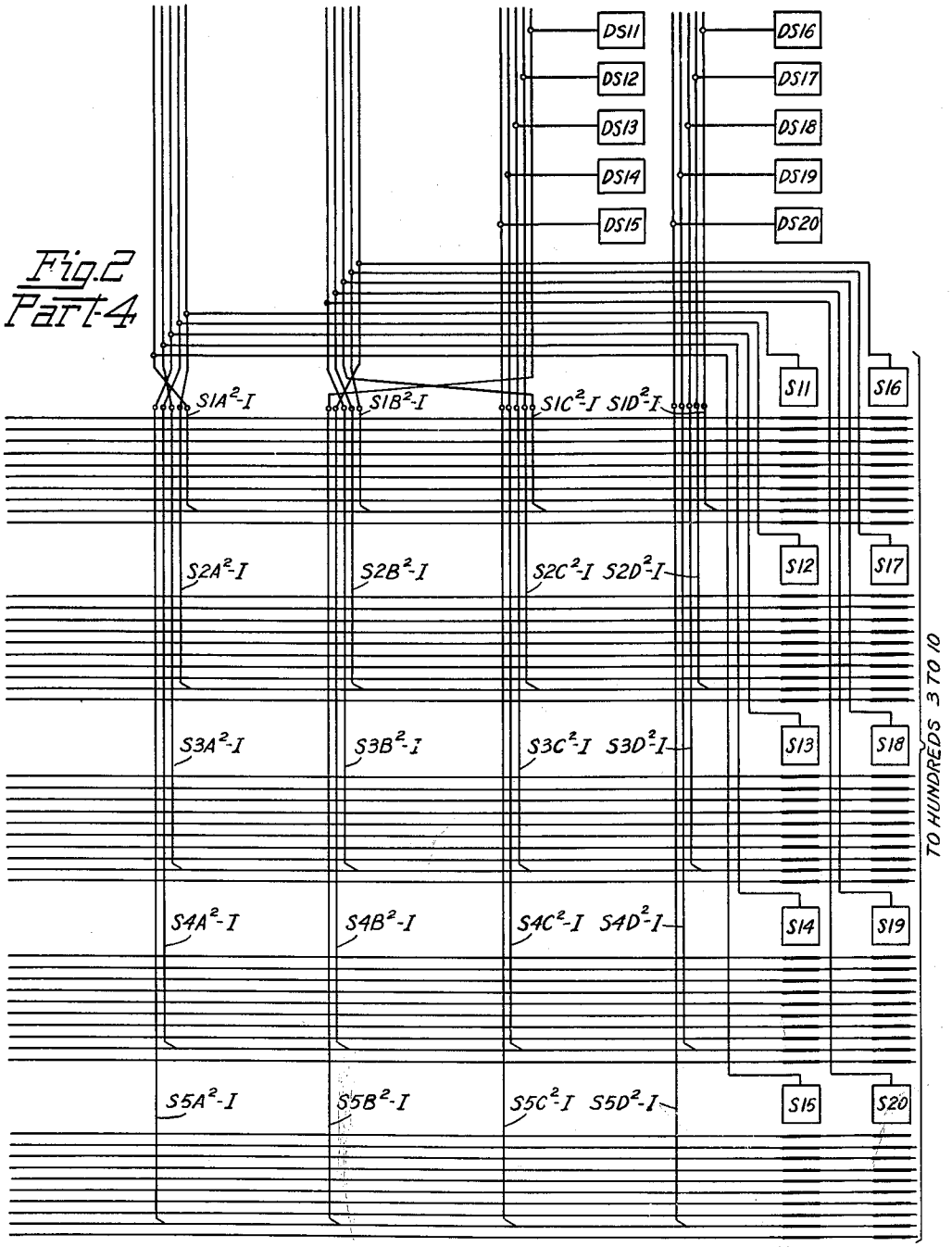

Fig. 2 Part 4

Inventor:
George R. Eaton
By C. C. Soper
Atty.

AUTOMATIC TELEPHONE SYSTEM

Filed Sept. 24, 1941 31 Sheets-Sheet 6

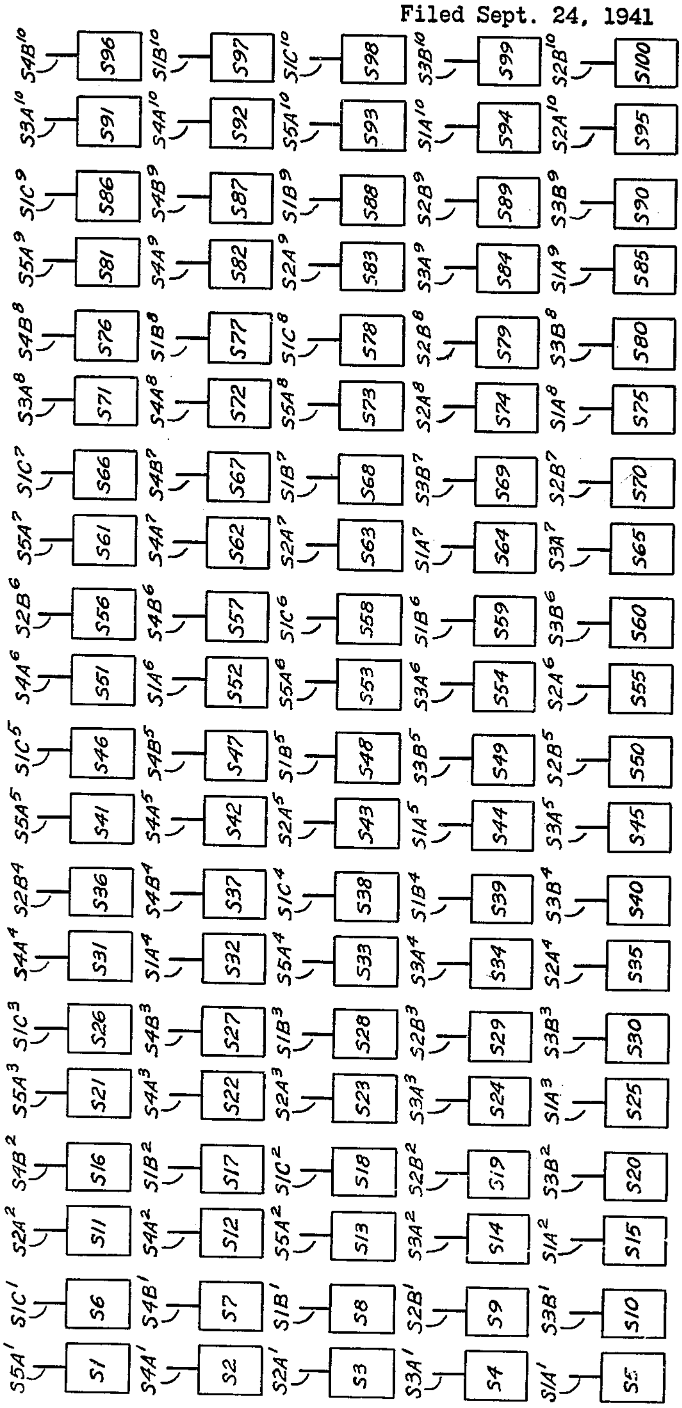

Fig. 3.

INCOMING TRAFFIC

SEC. # 1 – 6.1
SEC. # 2 – 17.5
SEC. # 3 – 21.0
SEC. # 4 – 26.2
SEC. # 5 – 26.2

Fig. 5.

OUTGOING TRAFFIC

1SA – 29
2SA – 12
3SA – 5
4SA – 2
5SA – 1/2

1SB – 29
2SB – 12
3SB – 5
4SB – 2

1SC – 1/2

Fig. 4.

Inventor:
George R. Eaton
By C. P. Sofer
Atty.

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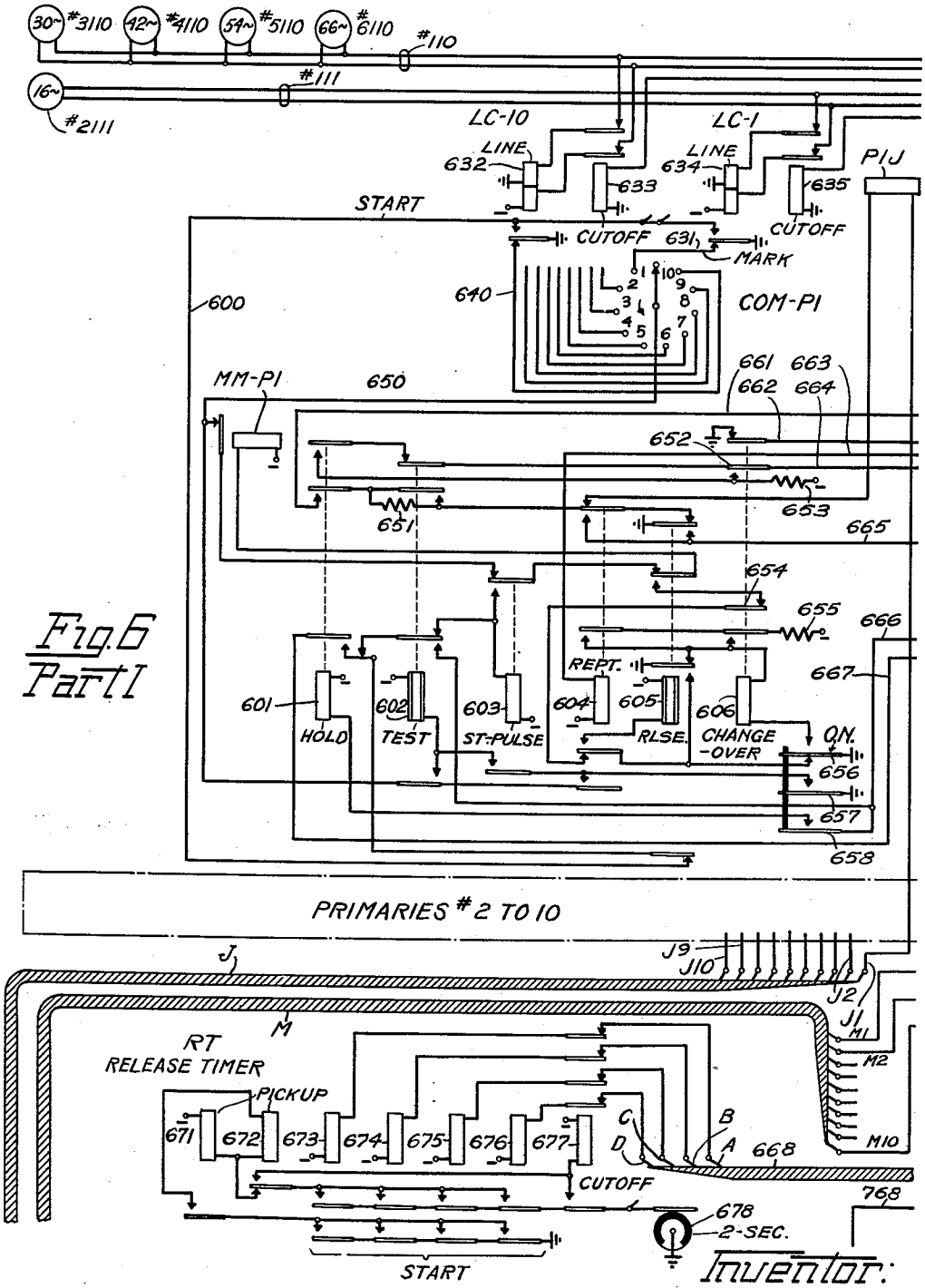

Fig. 6 Part I

Inventor:
George R. Eaton
By C. C. Shaw
Atty.

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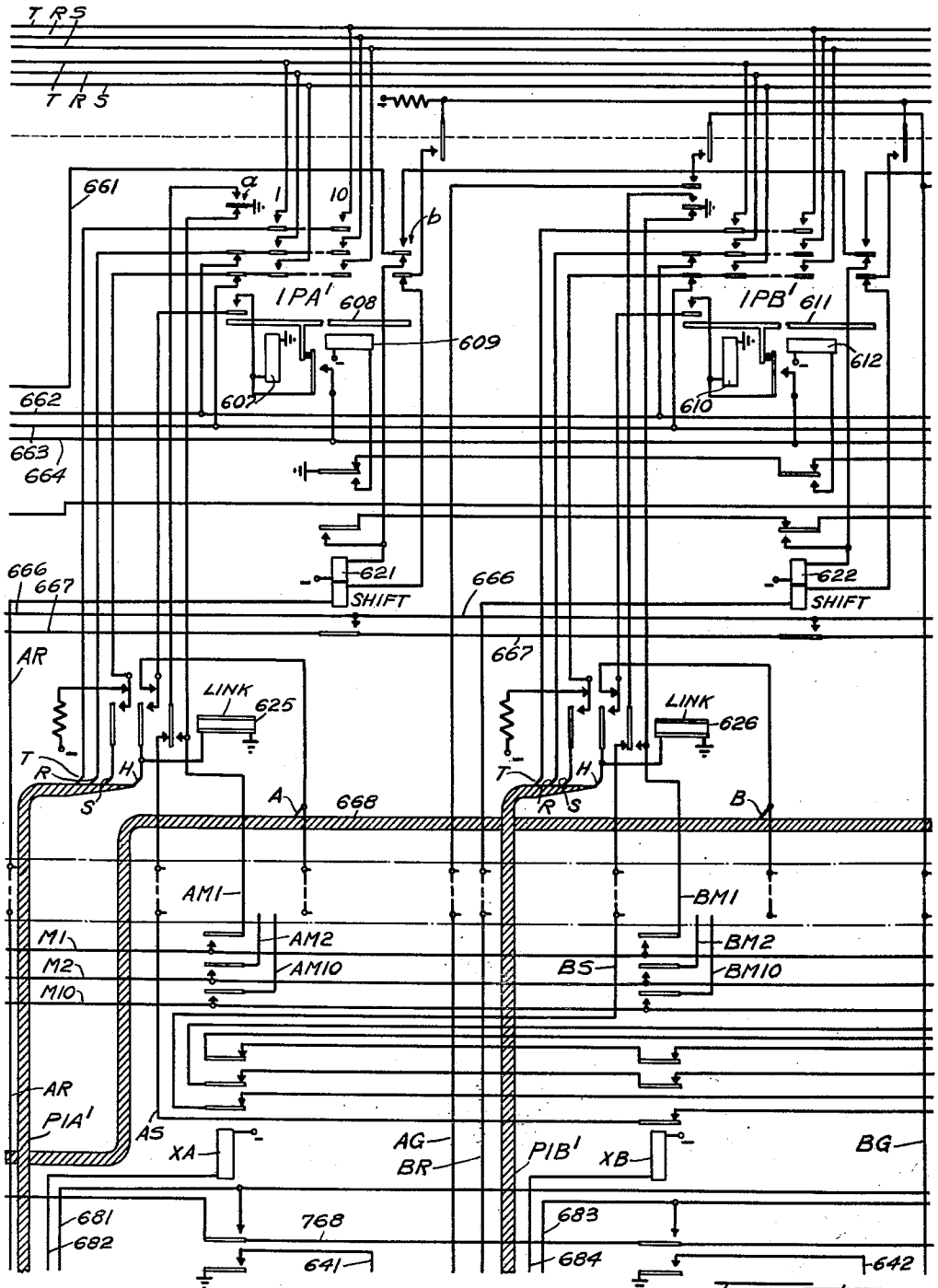

Fig. 6
Part 2

Inventor:
George R. Eaton
By C. C. Shaw
Atty.

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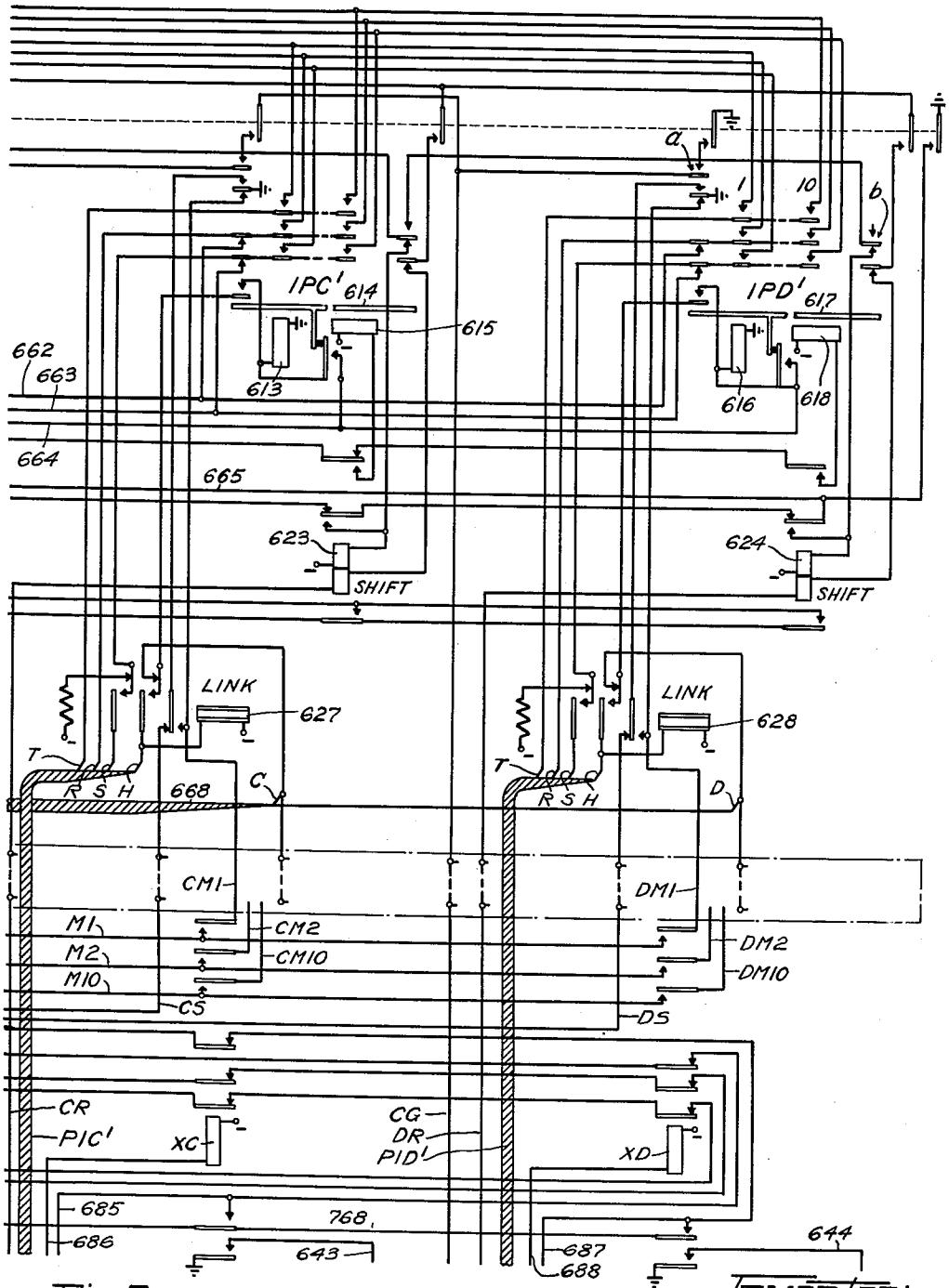

Fig. 6
Part 3

Inventor:
George R. Eaton
By C. S. Hoyer
Atty.

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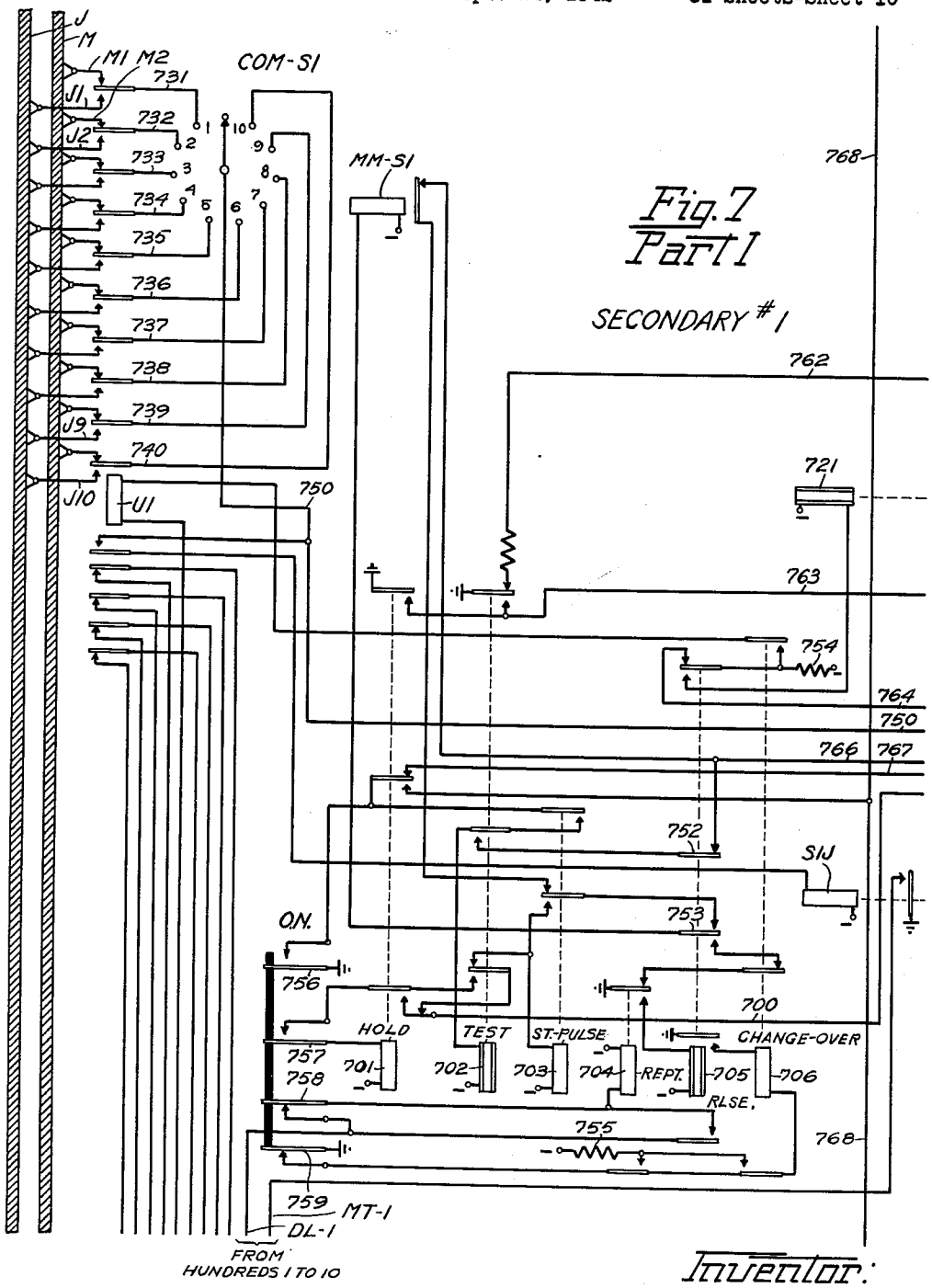

Fig. 7 Part 1

SECONDARY # 1

Inventor:
George R. Eaton
By C. A. Sofen
Atty.

June 20, 1944. G. R. EATON 2,351,808

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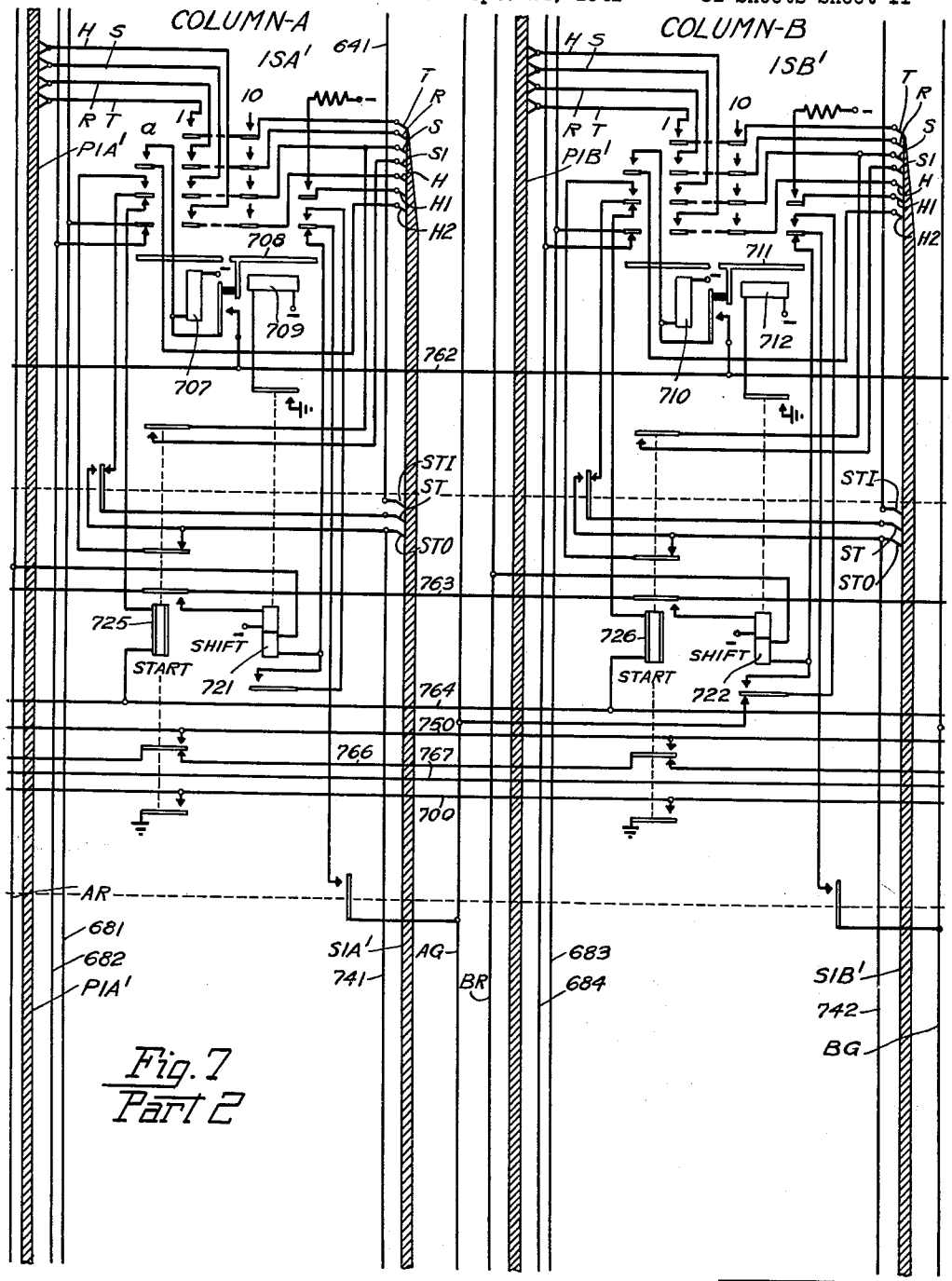

Fig. 7
Part 2

Inventor:
George R. Eaton
By S. C. Sofia
Atty.

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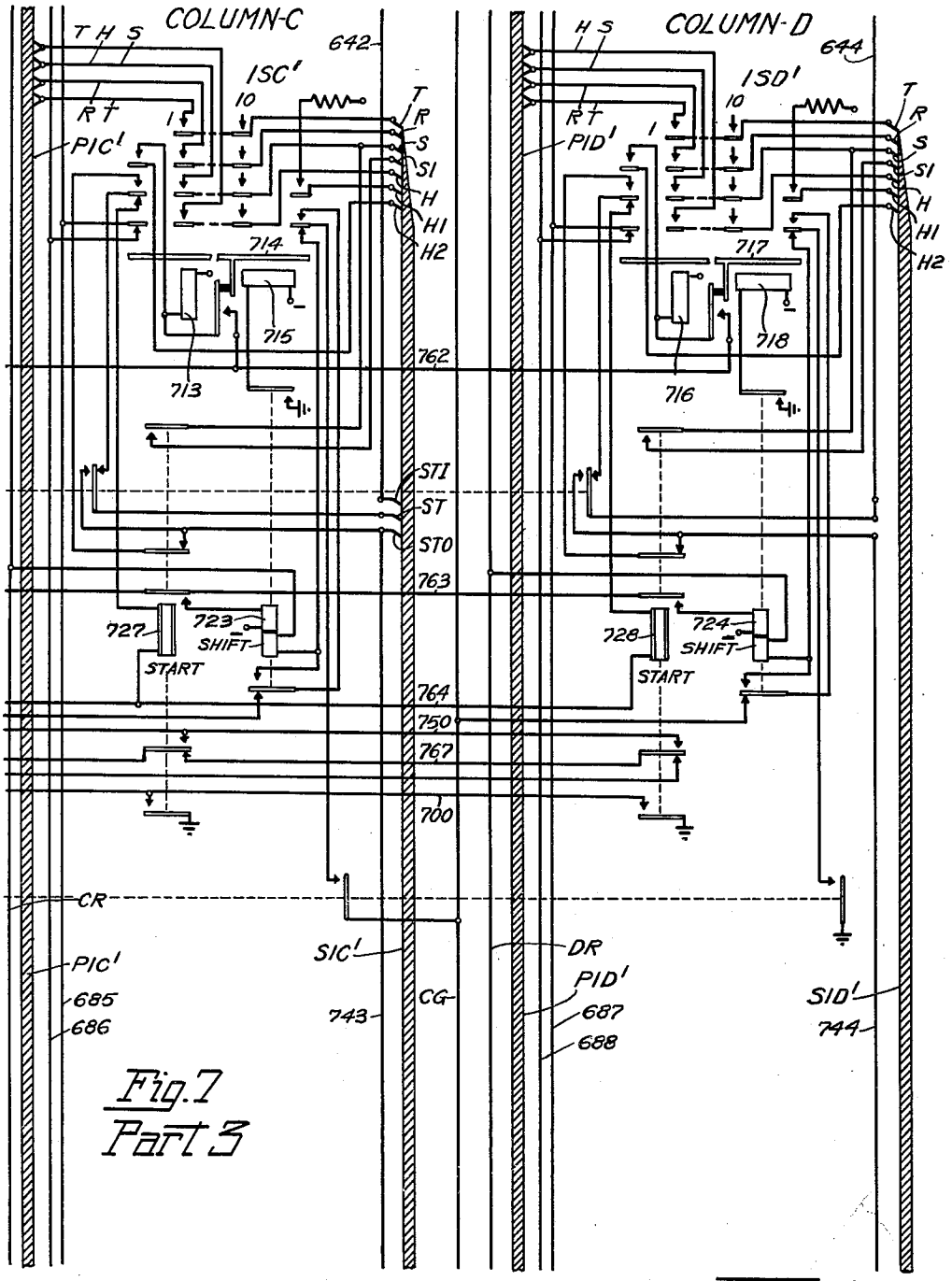

Fig. 7
Part 3

Inventor:
George R. Eaton
By C. C. Soper
Atty.

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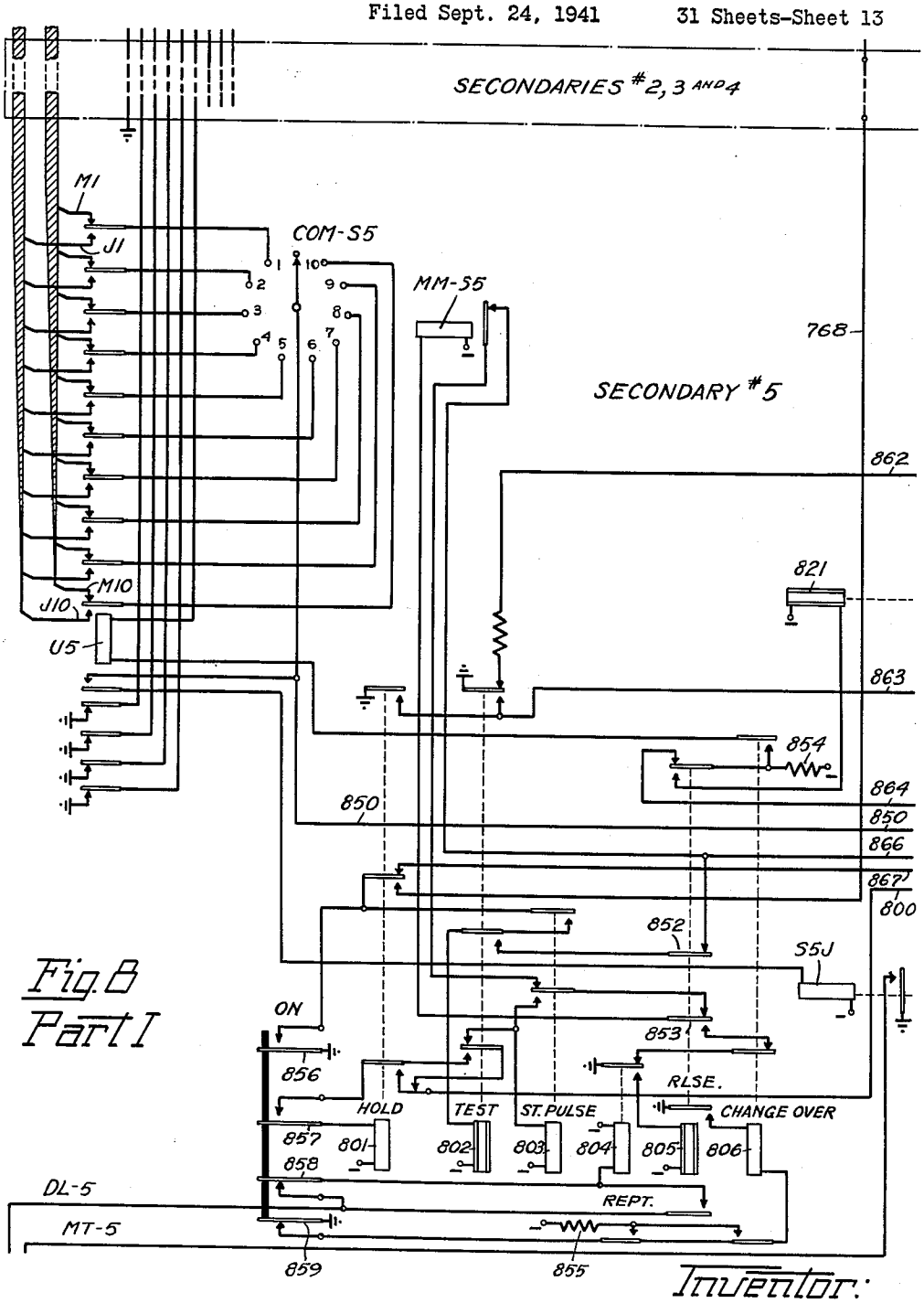

Fig. 8 Part I

Inventor:
George R. Eaton
By C. P. Soper
Atty.

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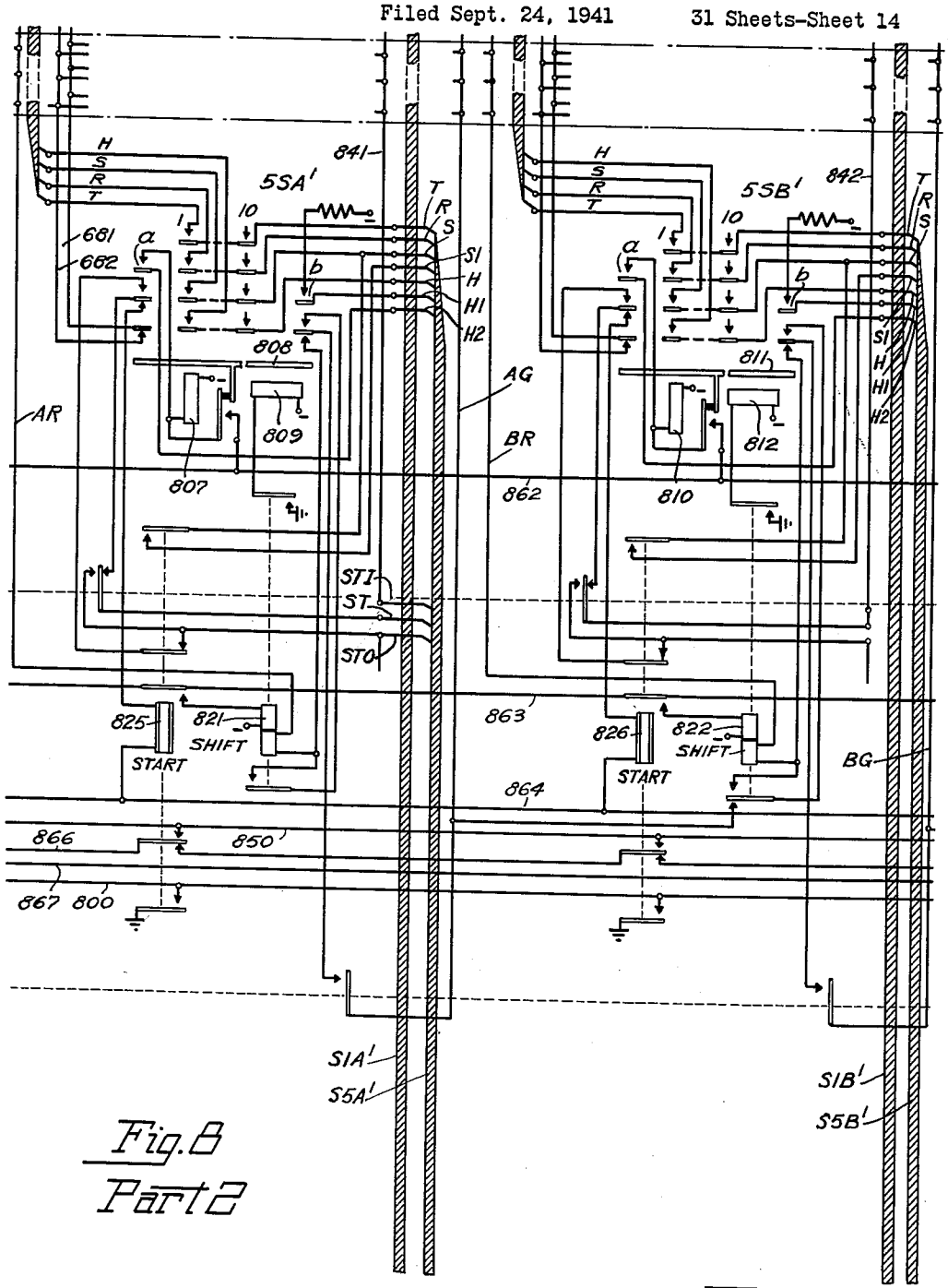

Fig. 8
Part 2

Inventor:
George R. Eaton
By C. C. Soper
Atty.

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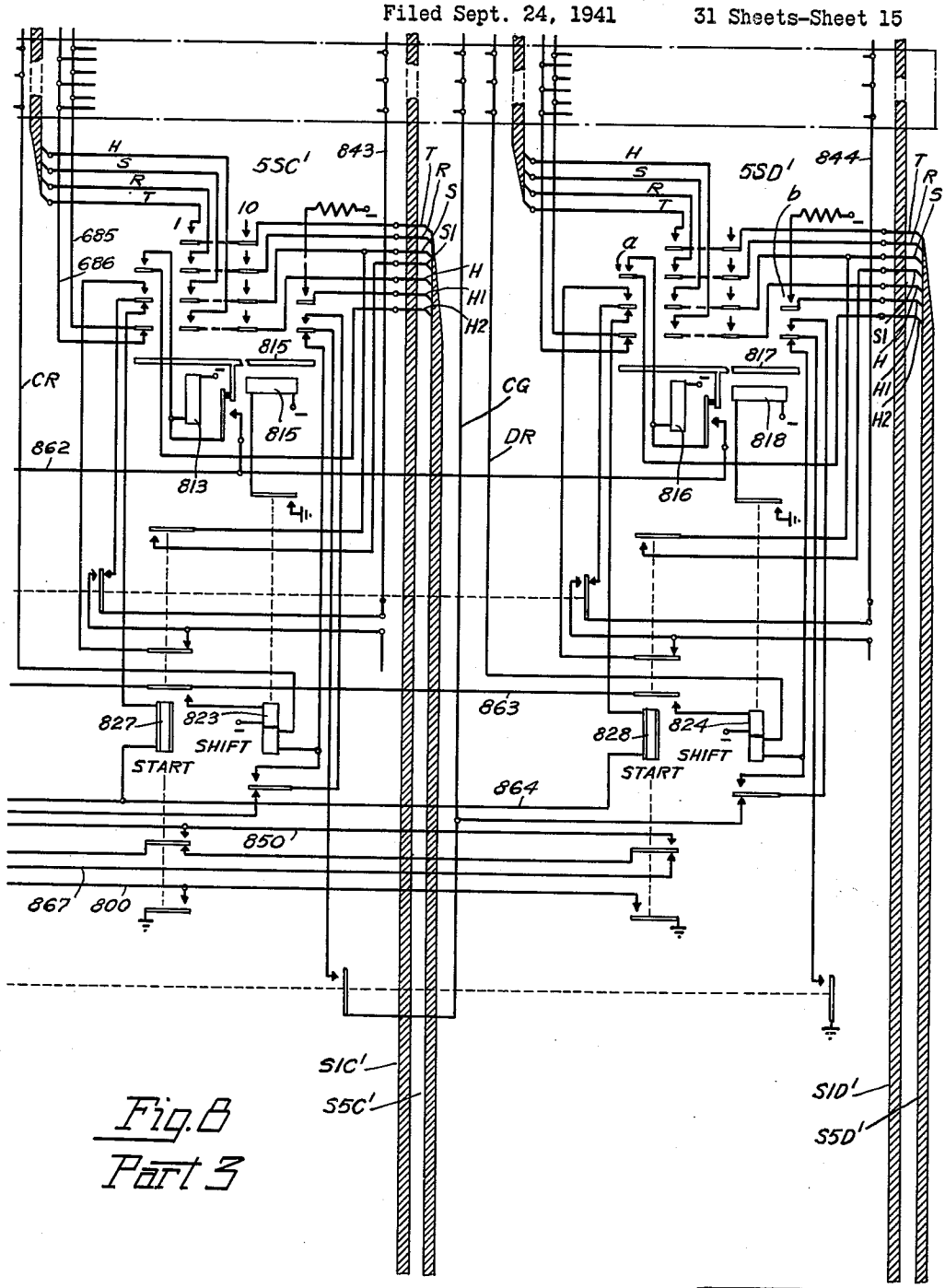

Fig. 8
Part 3

Inventor:
George R. Eaton
By C. R. Soper
Atty.

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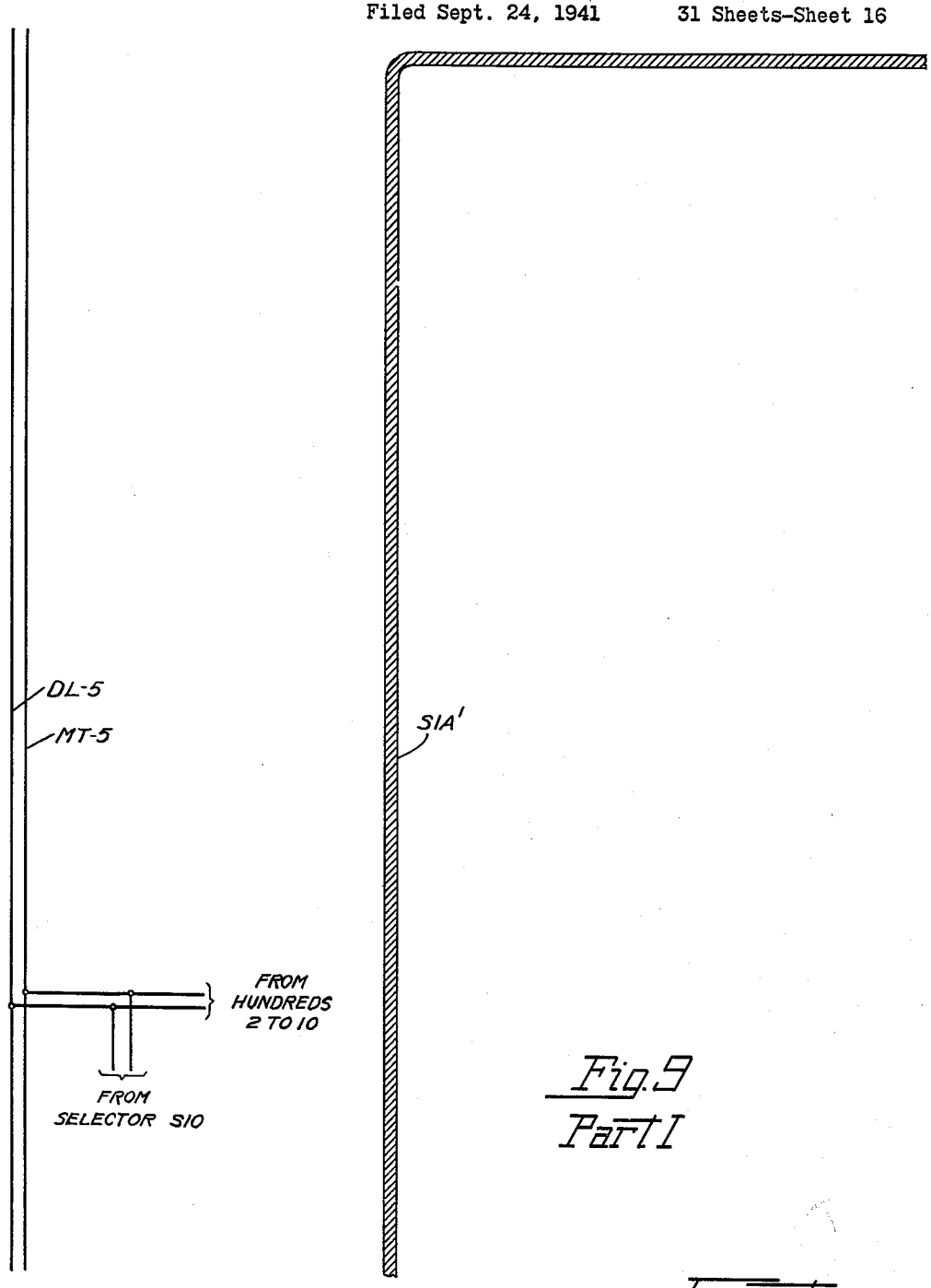

Fig. 9
Part I

Inventor:
George R. Eaton
By C. R. Sykes
Atty.

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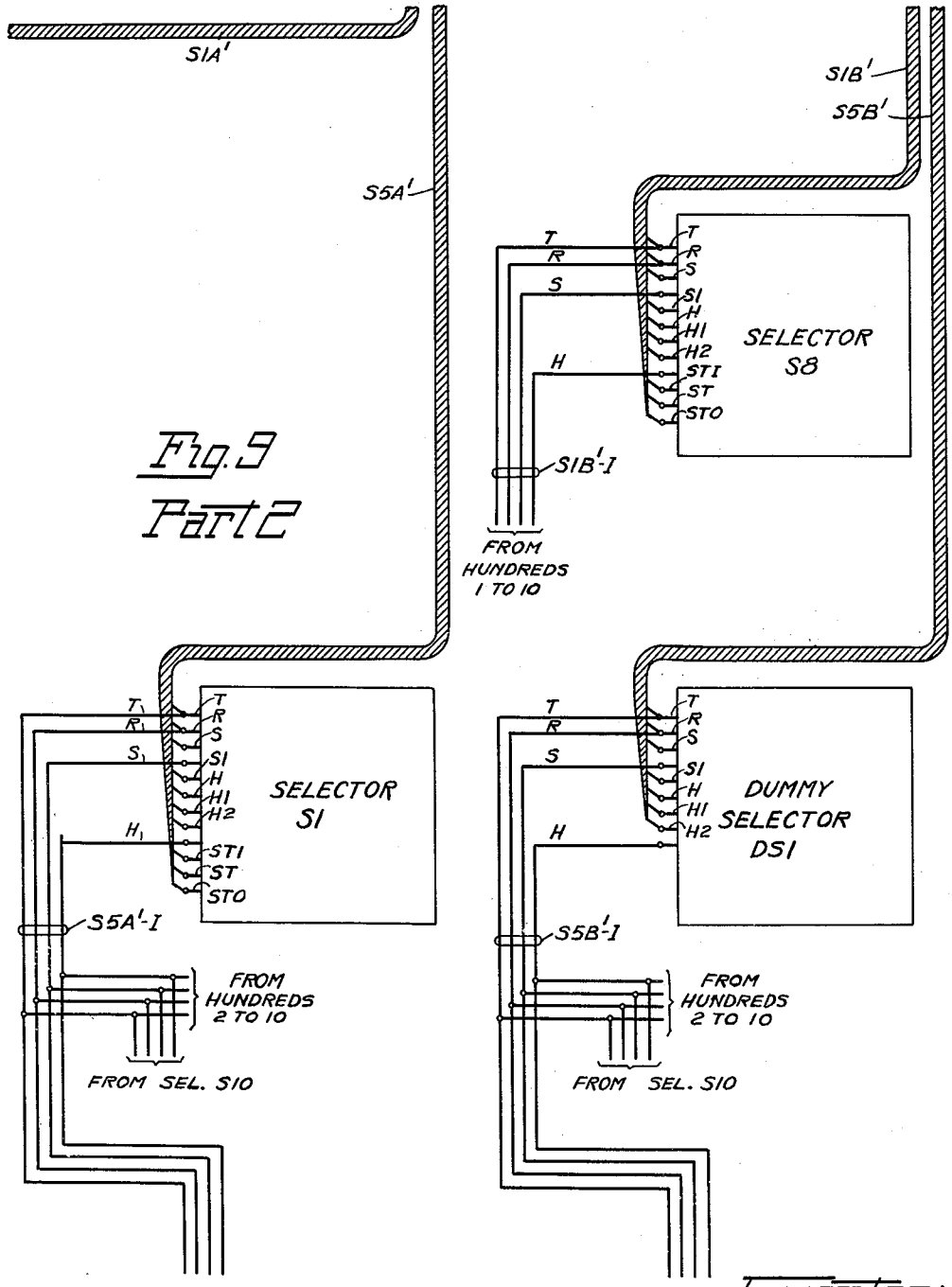

Fig. 9 Part 2

Inventor:
George R. Eaton
By C. C. Sopher
Atty.

June 20, 1944. G. R. EATON 2,351,808

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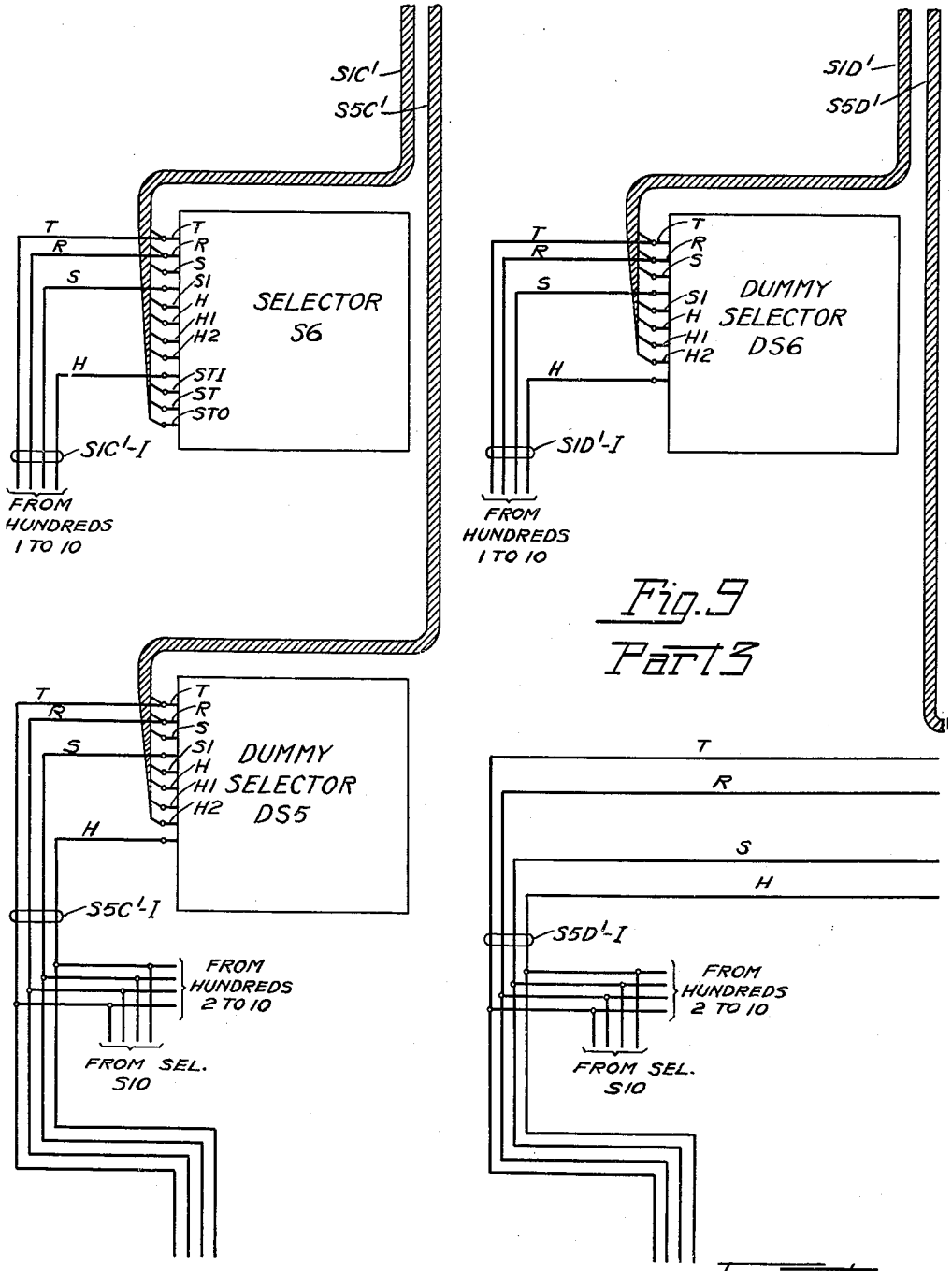

Fig. 9
Part 3

Inventor:
George R. Eaton
By C. C. Soper
Atty.

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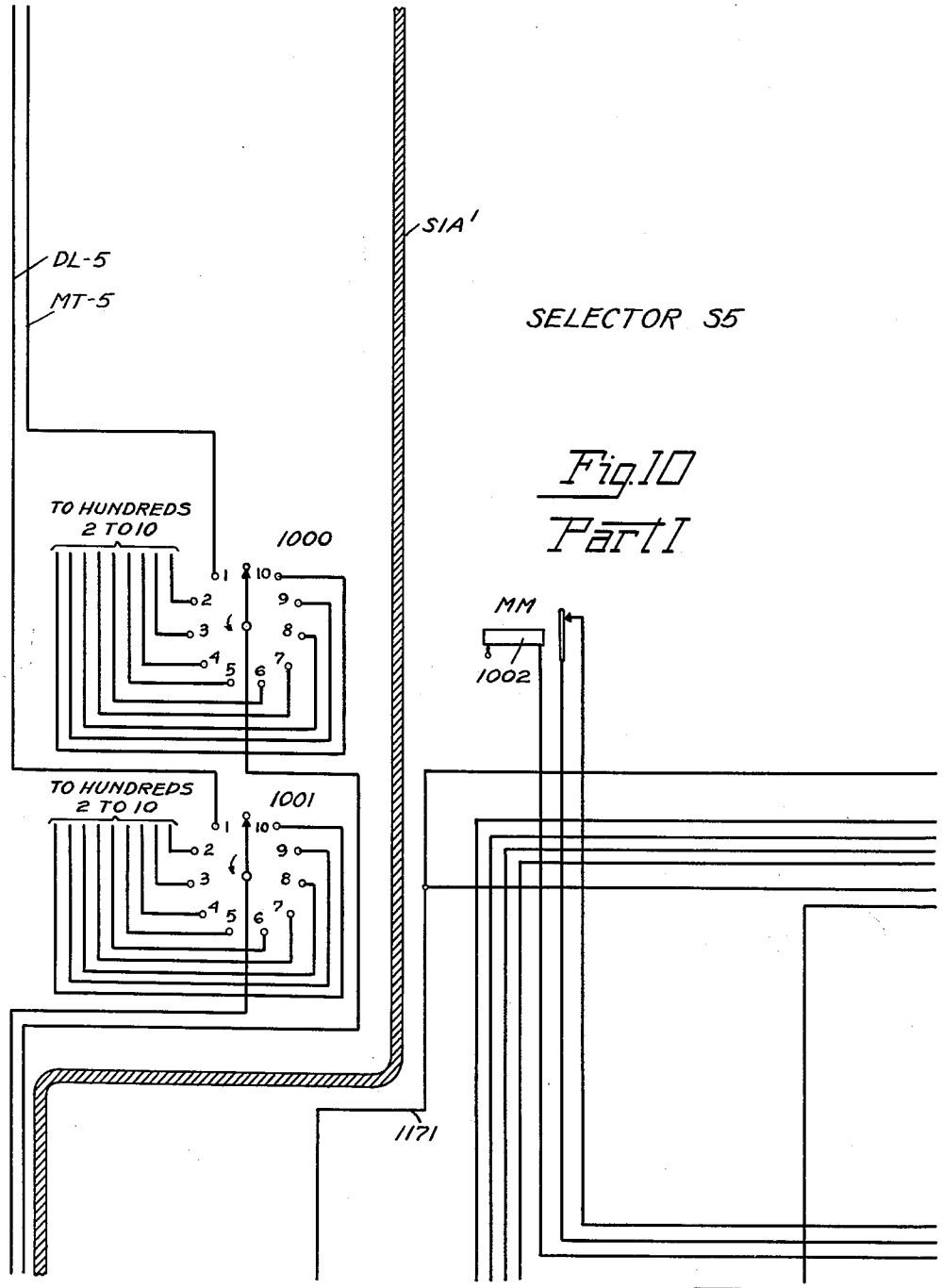

Fig. 10 Part I

Inventor:
George R. Eaton
By C. P. S. Jr.
Atty.

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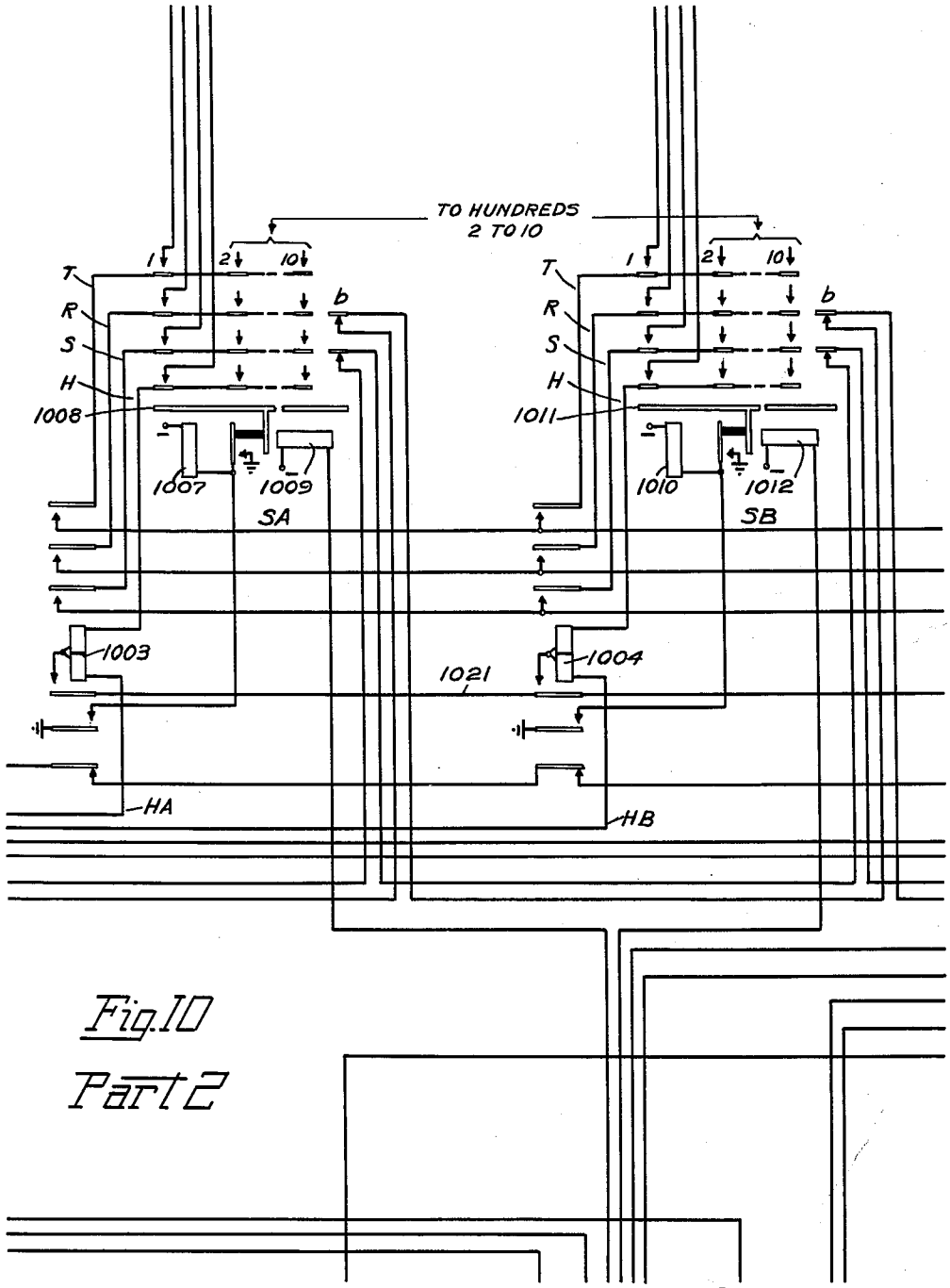

Fig. 10
Part 2

Inventor:
George R. Eaton
By C. P. Sofge
Atty.

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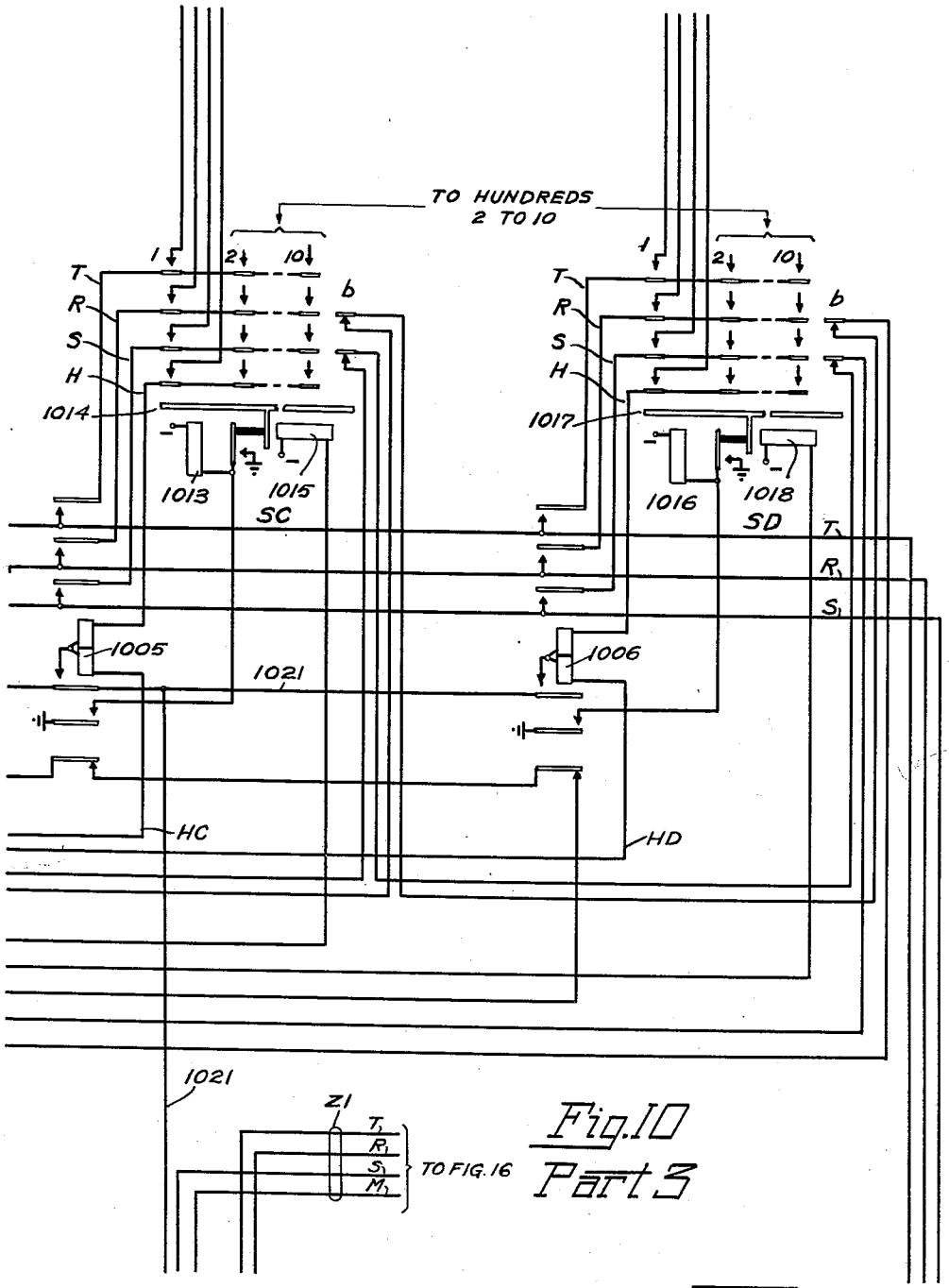

Fig. 10
Part 3

Inventor:
George R. Eaton
By C. R. Sofer
Atty.

June 20, 1944. G. R. EATON 2,351,808

AUTOMATIC TELEPHONE SYSTEM

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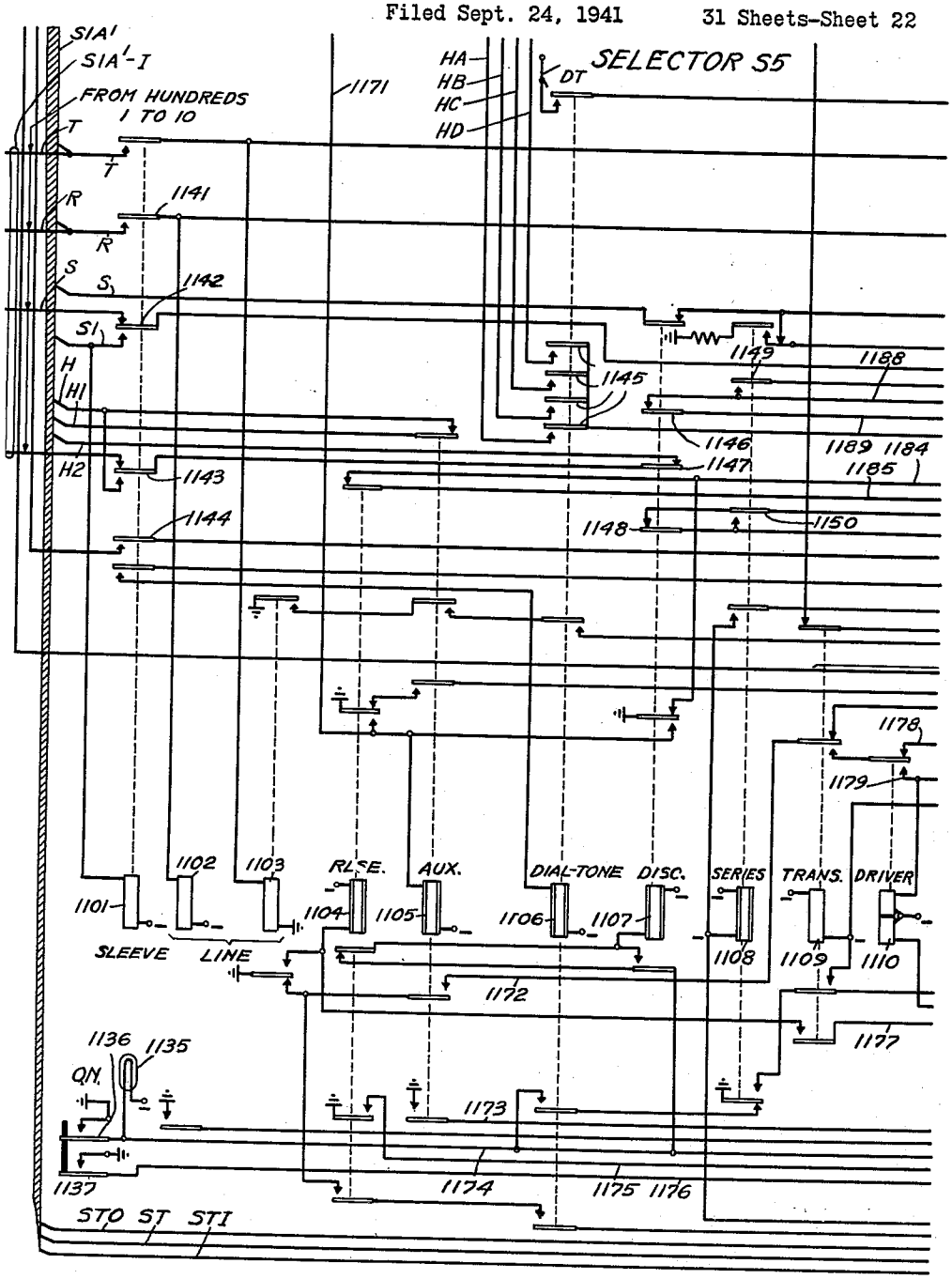

Fig. 11
Part 1

Inventor:
George R. Eaton
By C. R. Soper
Atty.

June 20, 1944. G. R. EATON 2,351,808

AUTOMATIC TELEPHONE SYSTEM

Filed Sept. 24, 1941 31 Sheets-Sheet 23

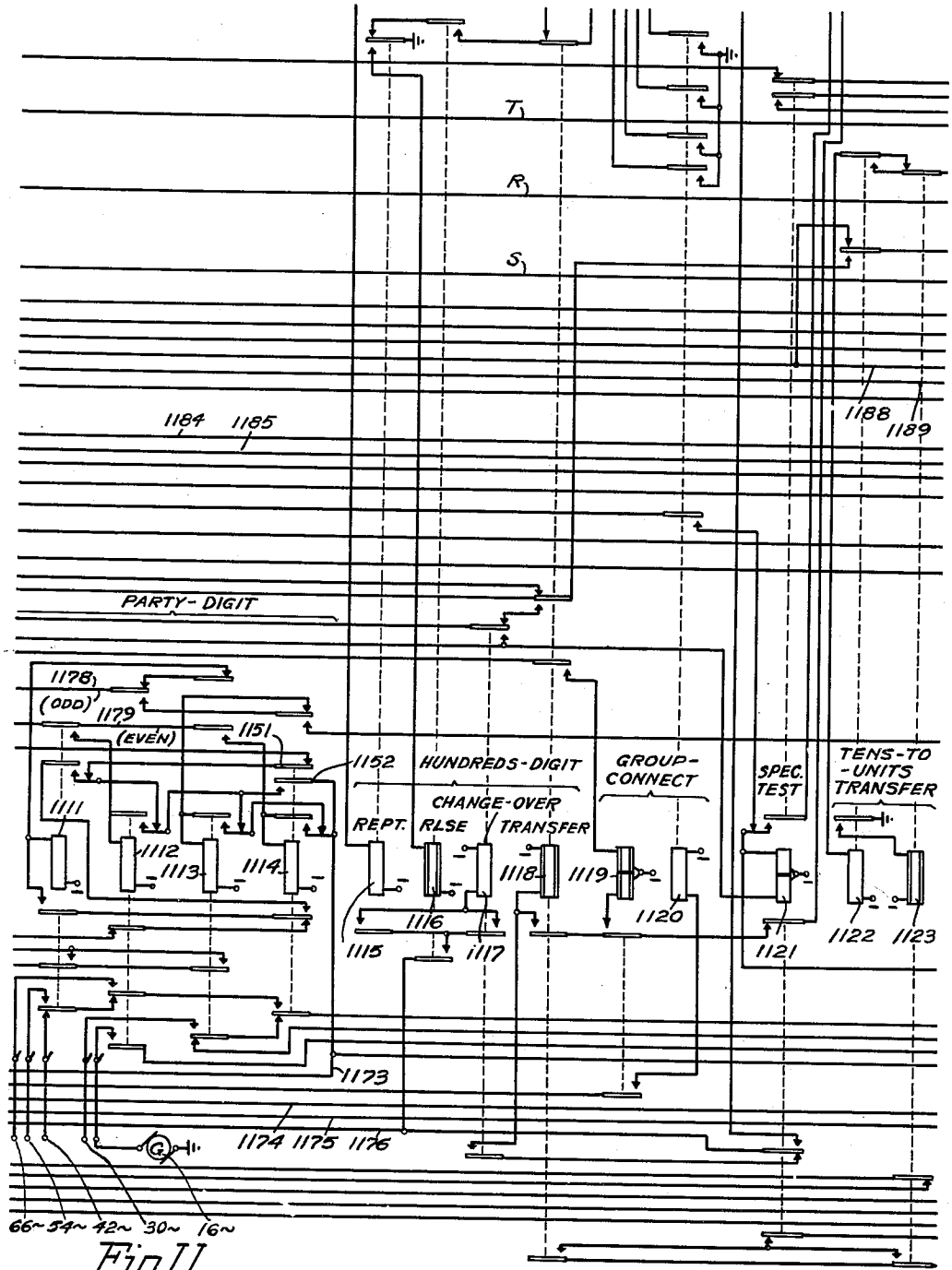

Fig. 11

Part 2

Inventor:
George R. Eaton
By C. P. Sober
Atty.

June 20, 1944. G. R. EATON 2,351,808

AUTOMATIC TELEPHONE SYSTEM

Filed Sept. 24, 1941 31 Sheets-Sheet 24

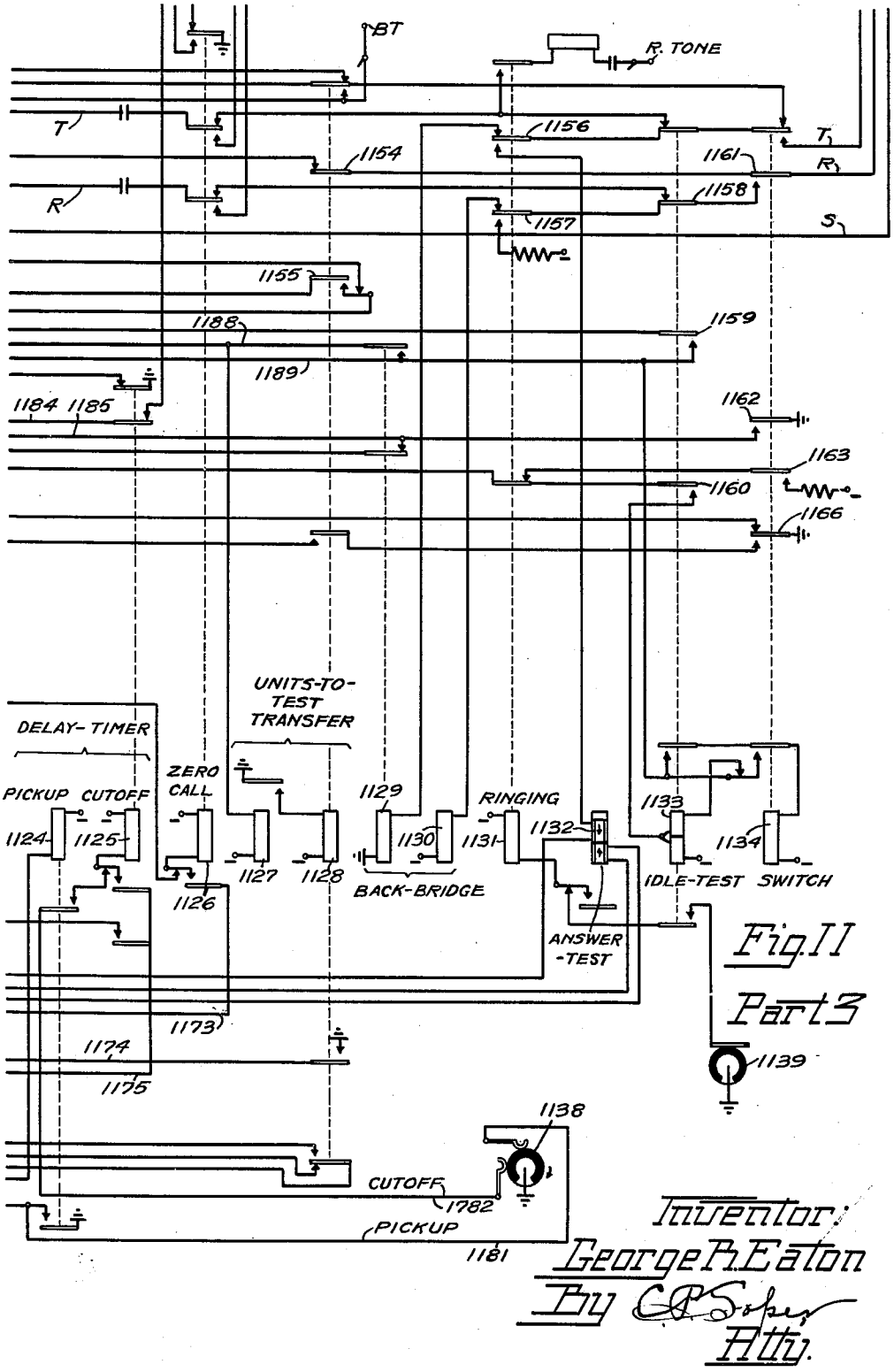

Fig. 11 Part 3

Inventor:
George R. Eaton
By C. P. Soper
Atty.

June 20, 1944. G. R. EATON 2,351,808

AUTOMATIC TELEPHONE SYSTEM

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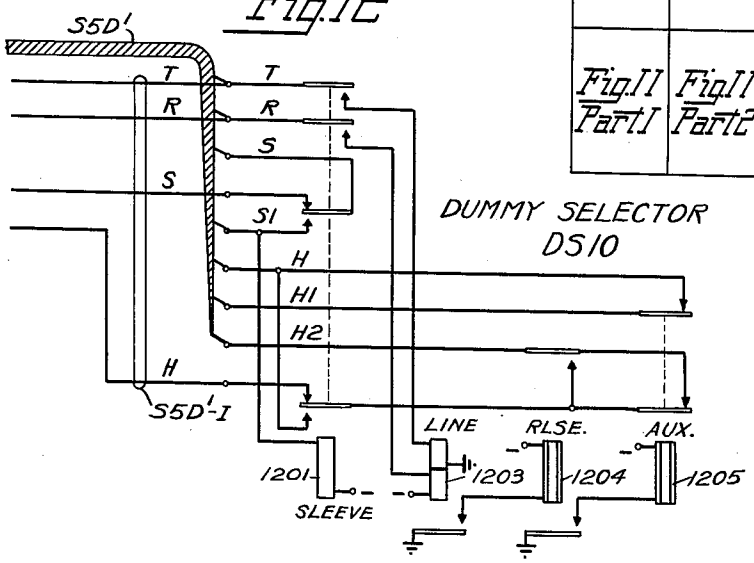
Fig.2 Part1	Fig.2 Part3
Fig.2 Part2	Fig.2 Part4

Fig.13

Fig.6 Part1	Fig.6 Part2	Fig.6 Part3	
Fig.7 Part1	Fig.7 Part2	Fig.7 Part3	
Fig.8 Part1	Fig.8 Part2	Fig.8 Part3	
Fig.9 Part1	Fig.9 Part2	Fig.9 Part3	Fig.12
Fig.10 Part1	Fig.10 Part2	Fig.10 Part3	
Fig.11 Part1	Fig.11 Part2	Fig.11 Part3	

Fig.14

Fig.12



Inventor:
George H. Eaton
By C. C. Soper
Atty.

June 20, 1944. G. R. EATON 2,351,808

AUTOMATIC TELEPHONE SYSTEM

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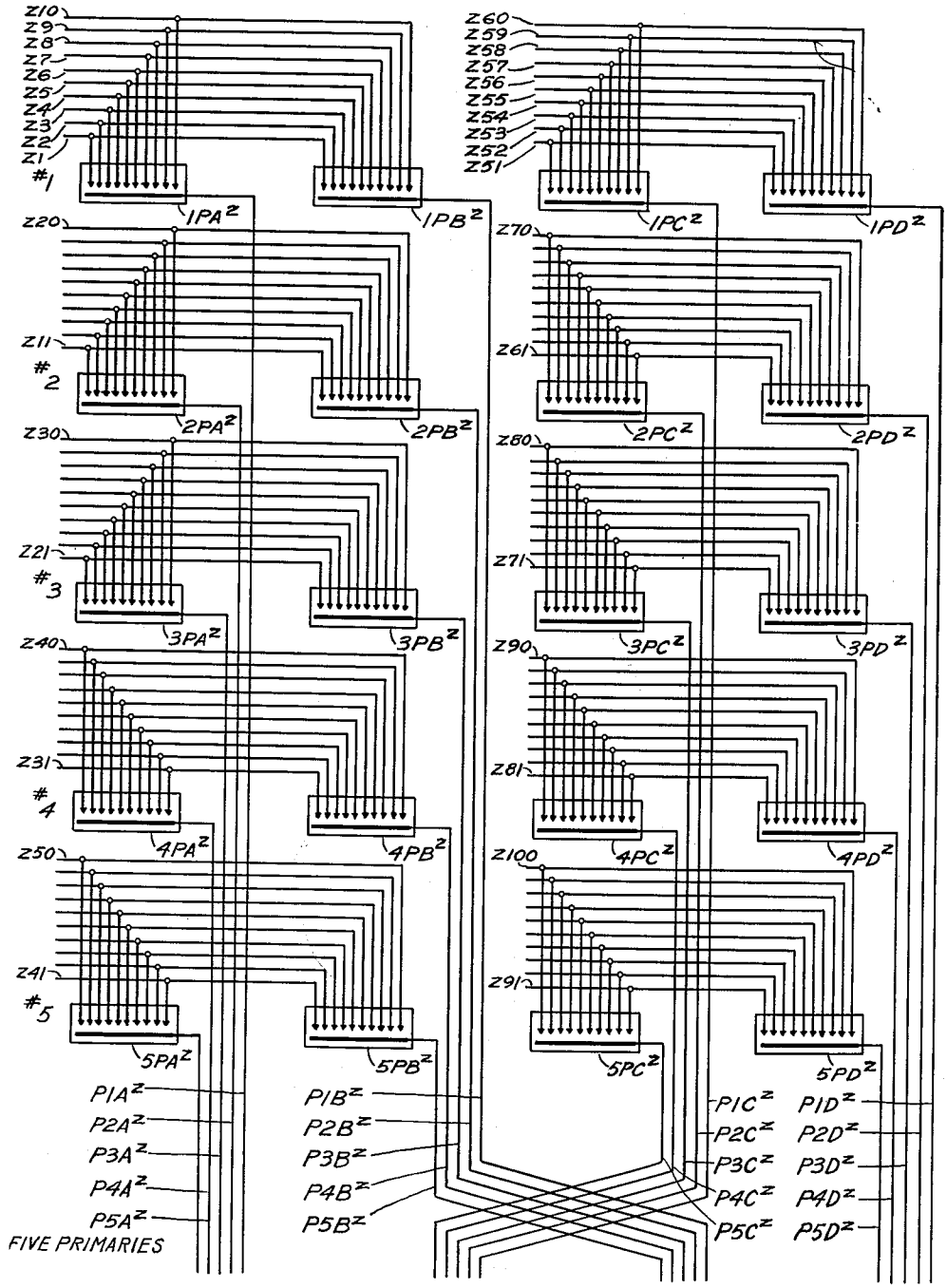

Fig. 15 Part I

Inventor:
George R. Eaton
By C.A.S. Jr.
Atty.

June 20, 1944. G. R. EATON 2,351,808

AUTOMATIC TELEPHONE SYSTEM

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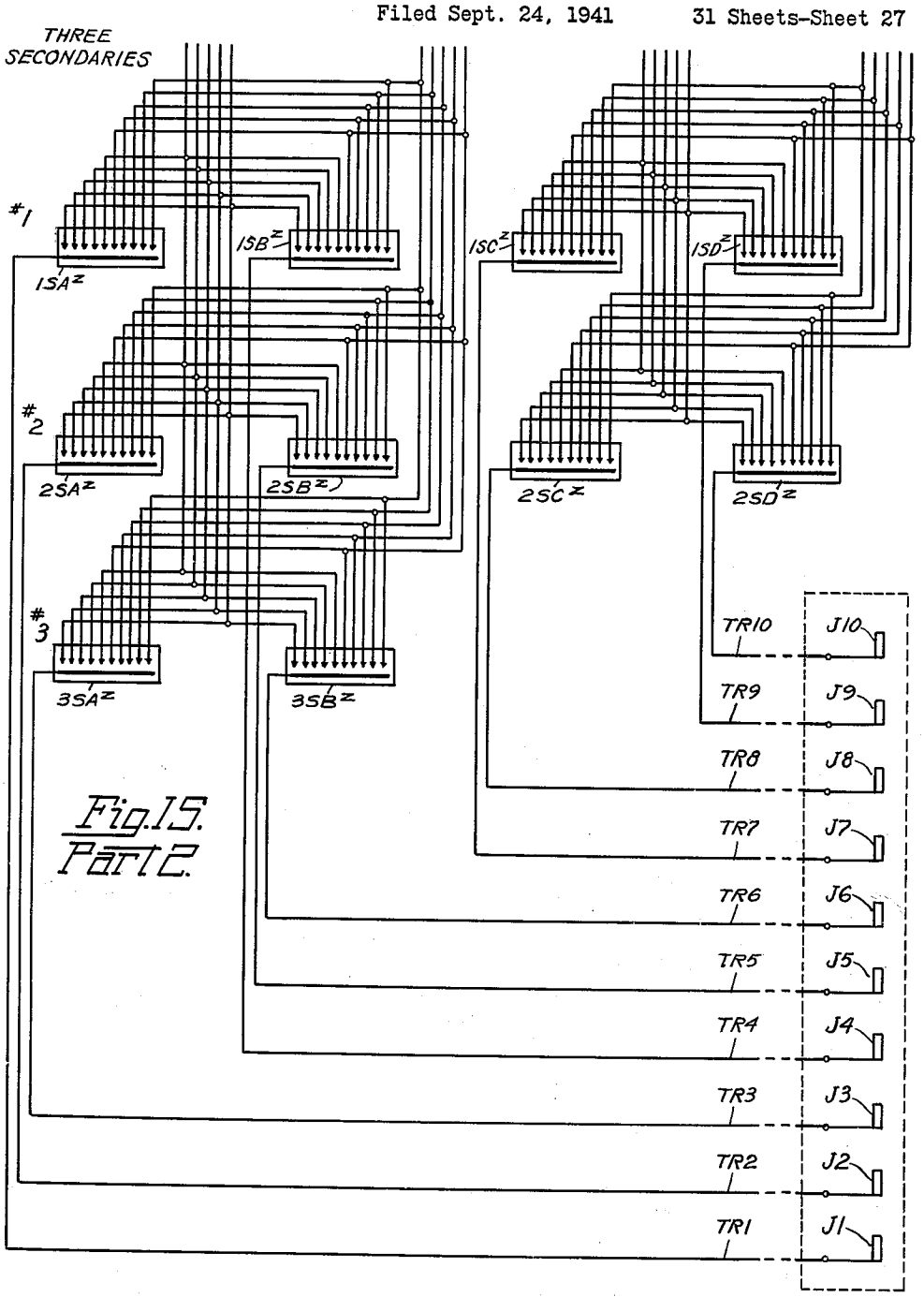


Fig. 15. Part 2.

Inventor:
George R. Eaton
By C. A. Sober
Atty.

June 20, 1944. G. R. EATON 2,351,808

AUTOMATIC TELEPHONE SYSTEM

Filed Sept. 24, 1941 31 Sheets-Sheet 28

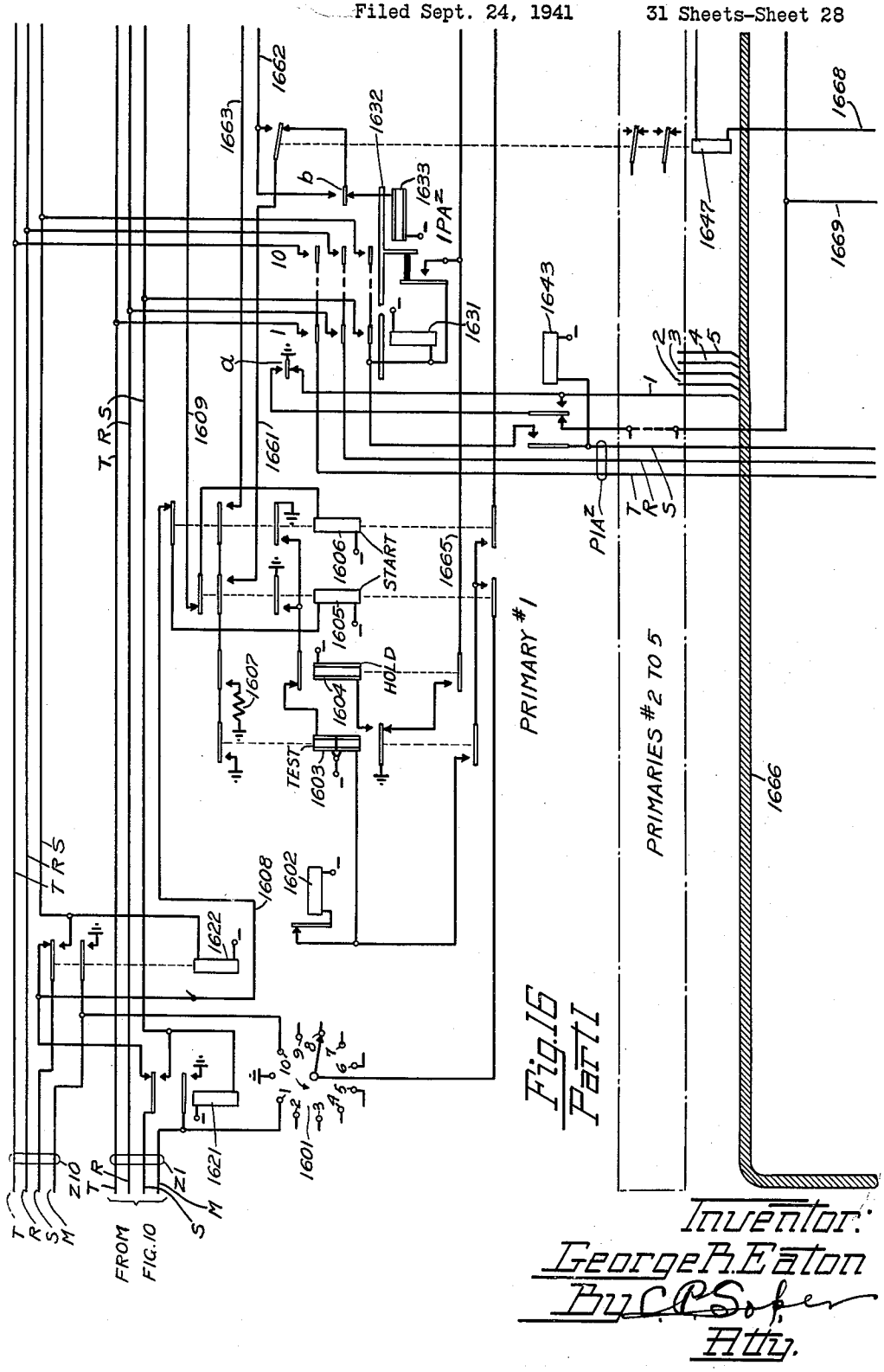


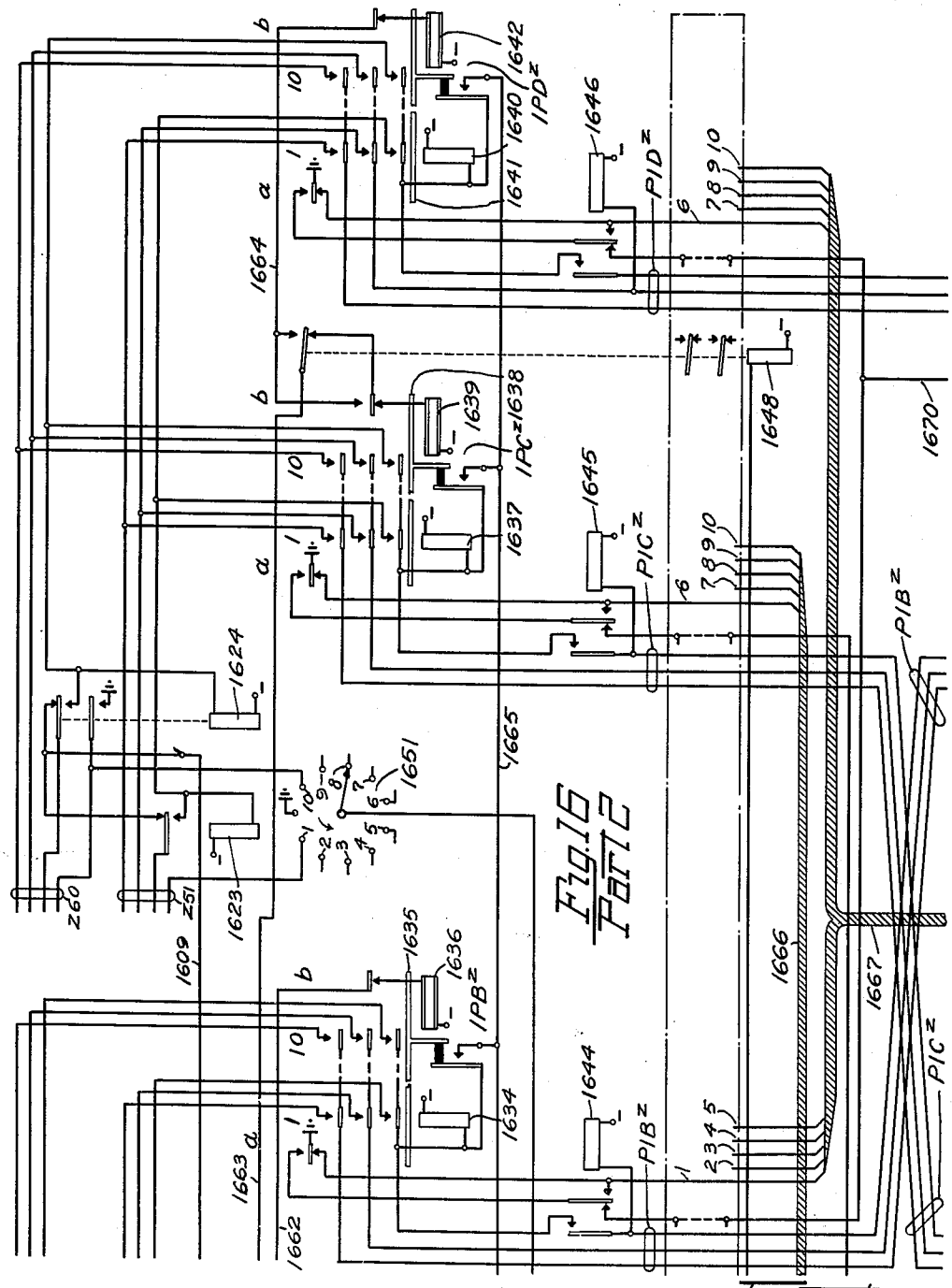
Fig. 16 Part I

Inventor:
George R. Eaton
By C. C. Soper
Atty.

June 20, 1944. G. R. EATON 2,351,808

AUTOMATIC TELEPHONE SYSTEM

Filed Sept. 24, 1941 31 Sheets-Sheet 29



Inventor:
George R. Eaton
By C. C. Soper
Atty

June 20, 1944. G. R. EATON 2,351,808

AUTOMATIC TELEPHONE SYSTEM

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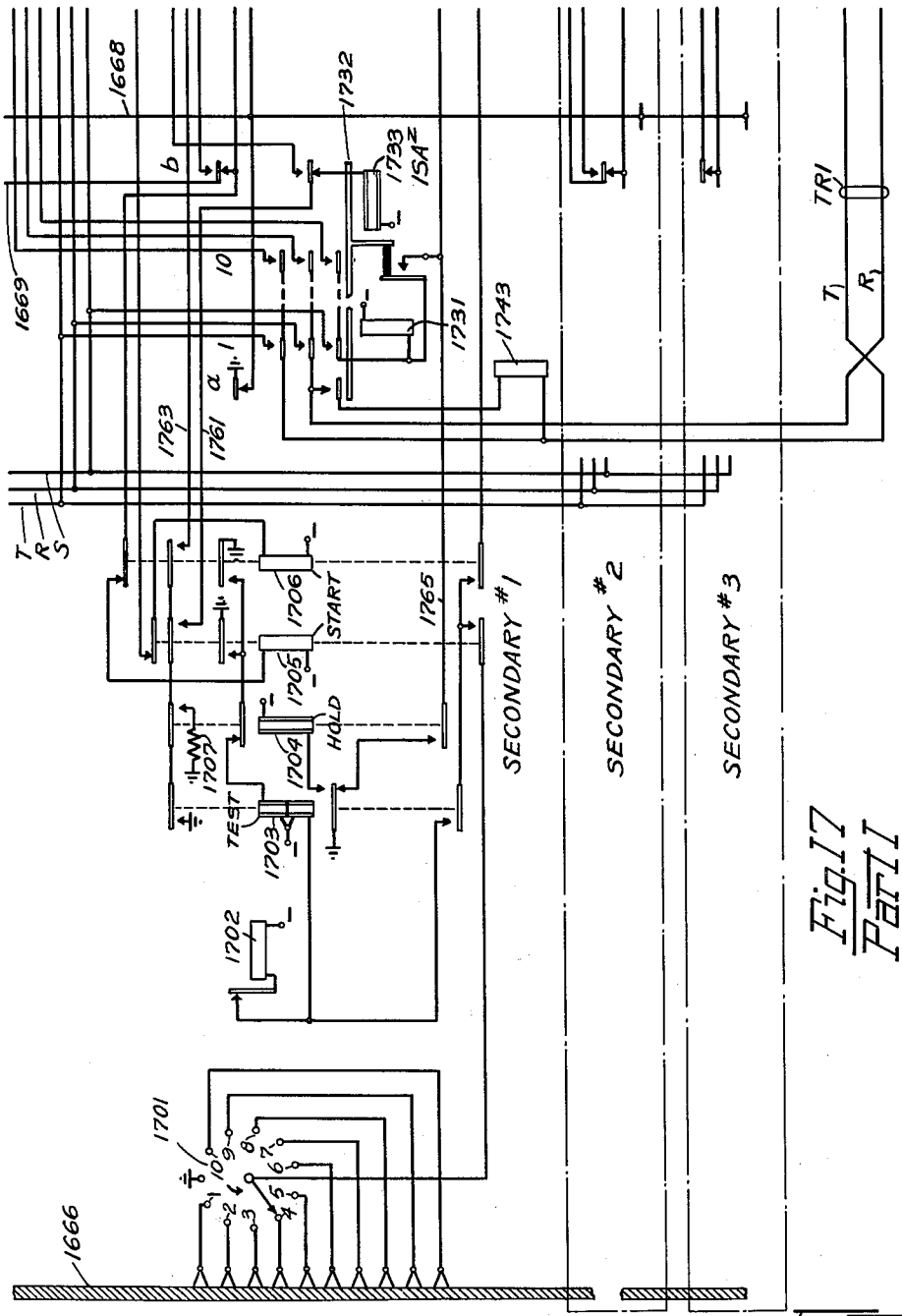

Fig. 17 Part I

Inventor:
George R. Eaton
By C. C. Soper
Atty.

June 20, 1944. G. R. EATON 2,351,808

AUTOMATIC TELEPHONE SYSTEM

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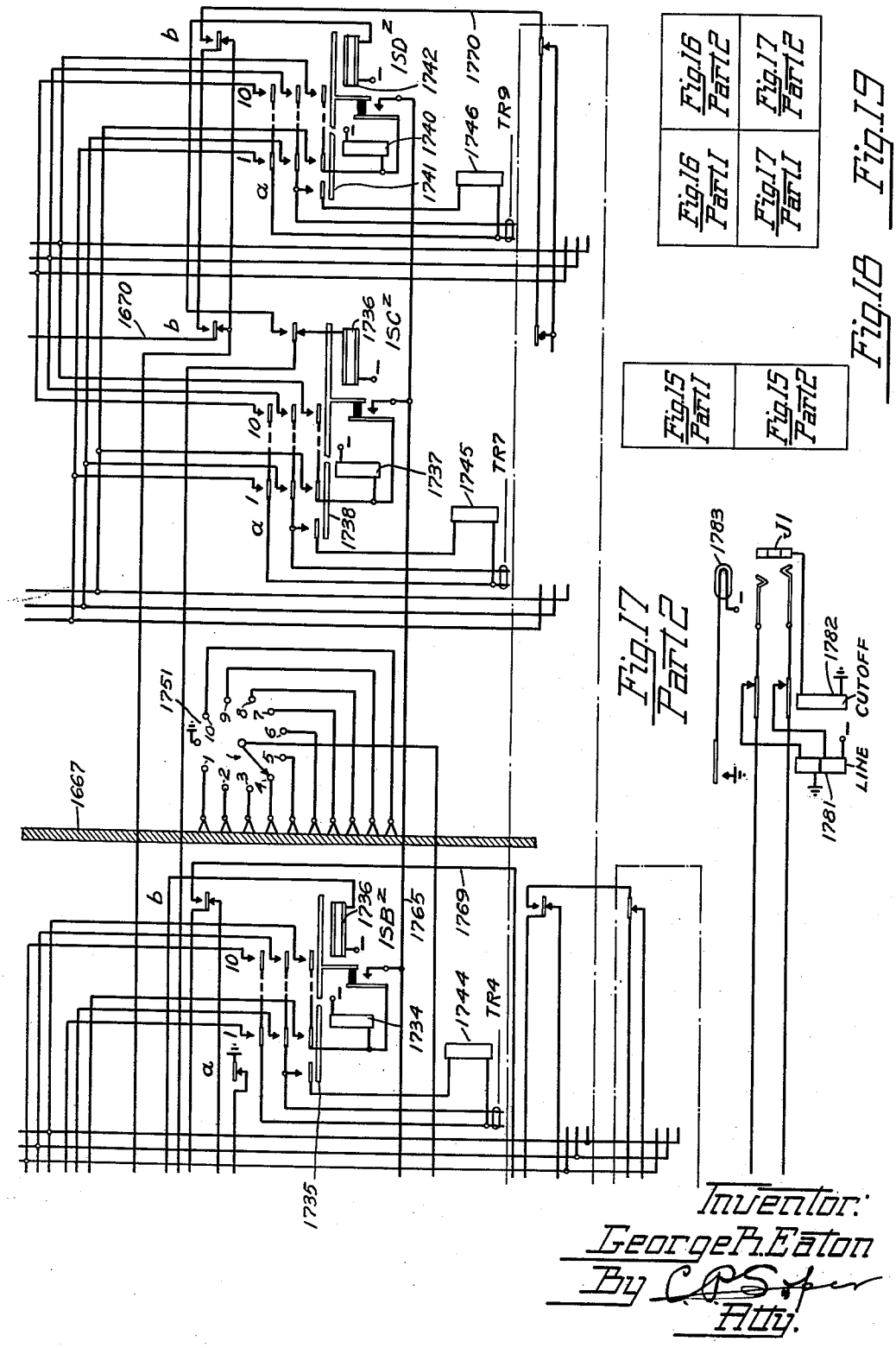

Fig.16 Part 1 | Fig.16 Part 2 | Fig.17 Part 1 | Fig.17 Part 2

Fig.15 Part 1 | Fig.15 Part 2

Fig.18

Fig.19

Fig.17 Part 2

Inventor:
George R. Eaton
By C. A. Snow
Atty.

Patented June 20, 1944 2,351,808

UNITED STATES PATENT OFFICE

2,351,808

AUTOMATIC TELEPHONE SYSTEM

George R. Eaton, Oak Park, Ill., assignor to Kellogg Switchboard and Supply Company, Chicago, Ill., a corporation of Illinois

Application September 24, 1941, Serial No. 412,103

18 Claims. (Cl. 179—17)

This invention relates to an improvement in automatic telephone systems, such as are used to establish connections between the lines of calling and called telephone subscribers, although the apparatus and system obviously may be used to extend connections for other purposes.

The object of this invention is the provision of a system of this type which is compact, durable, reliable in operation, and economical to manufacture.

General Description

The present invention is an expansion of the invention disclosed in applicant's application Serial No. 229,266, filed September 9, 1938, and uses the same type of switching device as therein disclosed. This switching device comprises a control mechanism and shaft common to four switching units, each unit comprising ten sets of contacts.

In the disclosed use of the switching device the shaft may be rotated into any one of ten selecting positions, and any switching unit of the device may be allotted or selected and thus placed under the control of the common mechanism and shaft. In the selected unit, the contact set corresponding to the setting of the shaft is actuated. The common mechanism thus selectively actuates any one of ten contact sets in any one of the four units. The units may be selected successively, and a contact set may be actuated in each, a total of four actuated contact sets at any one time.

In the prior application, the four units of contact sets are linked together in pairs, to provide a ten-line telephone system with two conversational paths. Two of said units act to seize calling lines, the other two being adapted to extend connections to the called or wanted lines.

In the system of the prior application, the calls originate and terminate in contact sets of one or another of the units of the same switching device. An important feature of the present system is that the connection is extended serially through units of a plurality of switching devices. By this expedient, the mechanism and general mode of operation disclosed in the above-mentioned application may be used in establishing connections between subscribers of large exchanges. While the present disclosure is that of a 1,000-line system, in which a connection is extended directively through the units of three switching devices, the idea here present may be used in smaller systems or extended to include larger systems, in which the connections are extended directively through the units of less than or more than three switching devices.

An important feature of the present invention is that any idle unit of a switching device having access to subscriber lines may function either as a line finder to seize a calling line, or as a connector to extend a connection to a wanted or called line. While, in the prior invention, the two units at the left in the drawing are always used as calling-line-finding apparatus, and the two at the right are employed only for extending connections to wanted lines, in the present disclosure, any one of the four units of a switching device may be employed to find and seize a calling line, and any one of the four units may be used to extend a connection to any called line accessible thereto.

A feature of the disclosure herein is that devices termed selectors herein, following their seizure by finder action, respond to the hundreds digit dialed to extend connection to the desired hundreds group, and repeat the tens and units digit impulses to the responding devices in the called hundreds group. These selectors contain the circuit equipment for testing the called line and for giving a busy signal to the calling line when the line called is busy, for controlling the application of ringing current to idle called lines, both individual and party lines, and for subsequently controlling the clearing out of the established connection; and they also contain equipment for enabling reverting calls to be made by directory number from any party-line substation to any other substation on the same line.

A feature of the invention is that a party-digit recording device, which conveniently takes the form of a series of counting relays, is provided in each selector to respond to a preliminary or party digit, preceding the hundreds digit of the called number. The party-digit device determines the character of application of ringing current to the called line, according to whether the called line is an individual line or a party line, and according to which substation on a party line is called.

A special feature of the arrangement is that the party-digit device is arranged to absorb preliminary impulses, a preliminary impulse being a single momentary interruption of the control circuit preceding dialing, such as is often produced inadvertently at the hookswitch, during or following the removal of the receiver at the calling substation.

A further feature of the invention is that the party-digit device, when set in accordance with

a predetermined digit designation (such as the initial digit 0) places the associated circuits in condition for extending a connection to the switchboard of the so-called "zero" operator. From the selectors, the connections are extended to the switchboard of the zero operator through primary and secondary finder action of additional switching devices of the type disclosed in applicant's prior application hereinbefore referred to.

A consequence of the arrangements just discussed is that a system having a nominal capacity of 1,000 lines has the same actual capacity, for all the special services (including preliminary-impulse absorption, ringing-current selection, and zero-operator calls) are taken care of by the dialing of the digit preceding the three digits necessary to designate any desired one of the one thousand lines of the system. Without such a numbering and equipment arrangement, practical considerations reduce the actual capacity of the nominal 1,000-line automatic-telephone system with uniform numbers to 800 lines or less, because the prevalence of preliminary impulses ordinarily makes the digit 1 unassignable as the first digit of a number, and the initial digit 0 is required by usage to be set aside for the extending of calls to the zero operator.

The foregoing and other objects and features of the invention will become more apparent as the description progresses.

The drawings

The accompanying drawings, comprising Figs. 1 to 19, show a sufficient amount of the circuits and apparatus involved in an automatic telephone system embodying the features of the invention to enable the invention to be understood.

Fig. 1 illustrates a portion of the interconnections between the ten 100-line groups of the 1,000-line system;

Fig. 2 (comprising four parts) illustrates in more detail the interlinkage within the first and second hundreds groups of Fig. 1 and the connections between these hundreds groups and the remaining eight groups;

Fig. 3 shows, for each of the selectors in all the hundreds groups, which secondary link extends traffic thereto by finder action in order that the traffic be distributed substantially as desired amongst the secondary switching devices in the several hundreds groups;

Fig. 4 is a table showing, for any hundreds group, substantially the percentage of outgoing or finder-action peak traffic handled by each of the secondary units thereof which extend calls to the selectors;

Fig. 5 is a table showing substantially the average distribution, in percentage, of incoming calls received by the secondary devices of any hundreds group during peak load, when the outgoing traffic distribution is as given in Fig. 4 and the secondary link assignment is as given in Fig. 3;

Fig. 6, parts 1 to 3, shows the circuits of the primary devices in the first hundred, shown schematically in the upper portion of Fig. 2, part 1;

Fig. 7, parts 1 to 3, shows the circuit arrangement of the secondary device #1 of Fig. 2, part 1;

Fig. 8, parts 1 to 3, indicates the second, third, and fourth secondaries of Fig. 2, part 1, and shows the circuit details of secondary #5;

Fig. 9, parts 1 to 3, shows to what equipment certain of the links extending from the units of secondaries #1 and #5 extend, together with the incoming branches over which such secondary units are taken for use for connector action;

Fig. 10, parts 1 to 3, shows the circuit arrangement of the switching device assigned to selector $S5^1$ of Fig. 2, part 2;

Fig. 11, parts 1 to 3, shows the circuit arrangement of the control relays of the said selector $S5^1$;

Fig. 12 shows the circuit arrangement of the dummy selector $DS10^1$ of Fig. 2, part 2;

Fig. 13 shows the way parts 1 to 4 of Fig. 2 are intended to be assembled;

Fig. 14 shows the way the sheets on which Figs. 6 to 12 are drawn are intended to be assembled;

Fig. 15, parts 1 and 2, shows the interlinkage, through primary and secondary finder devices, between the "zero"-digit terminals of the selectors and the switchboard of the zero operator;

Figs. 16 and 17, parts 1 and 2, show the circuit arrangements of the primary and secondary devices indicated in Fig. 15;

Fig. 18 shows the way parts 1 and 2 of Fig. 15 are intended to be assembled; and

Fig. 19 shows the way the sheets on which Figs. 16 and 17 are drawn are intended to be assembled.

The switching mechanism

The mechanical construction of the switching devices employed herein may be each substantially as illustrated in Figs. 1 to 12 of applicant's previously mentioned application for Automatic telephone apparatus and circuits, Serial No. 229,266, filed September 10, 1938.

The switching device as disclosed in the prior application includes a cam-carrying control shaft which is illustrated therein as extending horizontally in front of four groups, or units, of contact sets, each such unit including ten selectively operable contact sets. Any one of the four units, or groups, of contacts sets may be mechanically selected for operation by the energization of what is termed a shift magnet, a separate shift magnet being provided for each of the four units of the switching device. When the shift magnet of any unit is operated, that unit is selected for operation by the movement to the right of the shift plate shown at 10 therein, and any desired one of the ten sets of selectively operable contacts therein may be selected for operation by a rotation of the previously mentioned common shaft into the desired one of ten selective positions.

Each unit of a switching device is provided with an operating magnet, and the operating magnet is operated in the selected unit after the associated shift magnet has been operated to select the unit and the common shaft has been rotated to the desired selective position. Upon the operation of the said operating magnet the selected contact set of the selected unit is shifted, the remaining contact sets of the selected unit remaining unaffected thereby, as well as all of the contact sets of the other units. The unit of the switching device is then said to be in operated condition, remaining in operated condition as long as the said operating magnet is held operated, which is conveniently done over one of the conductors of the link connected to the unit of the device.

Following the stated operation of the operating magnet, the shift magnet of the unit may be restored to terminate the temporary association between that unit and the common operating shaft, following which the operating shaft may

be associated with any one of the other units of the device. For example, referring to Fig. 6, the four units of primary device #1 of the first hundreds group are 1PA1 to 1PD1. The unit 1PA1, for example, includes ten sets of selectively operable contacts, of which only contact sets 1 and 10 are shown. 609 is the shift magnet; 607 is the operating magnet; and 608 is the shift plate which is shifted upon operation of shift magnet 609 to effect mechanical selection of the unit 1PA1 for operation.

In addition to the ten sets of selective contacts, any unit of a switching device may have one or more sets of non-selective contacts, operated on each operation of the associated operating magnet. For example, the device 1PA1 of Fig. 6, part 2, has a set or stackup of contacts indicated at *a* and another set or stackup of contacts indicated at *b*, sets *a* and *b* being both actuated upon each operation of operating magnet 607, along with whichever one of the ten selective sets of contacts is actuated.

In the prior application, a motor magnet M is provided to step the shaft around to the desired selective position, and to return it to home (or normal) position. The motor magnet for the device of Fig. 6 is shown at MM—P1.

As above indicated the common shaft has a home position in addition to the ten selective positions, making eleven positions in all. A set of off-normal contacts is provided to control certain circuit operations, including the returning of the shaft to its normal or home position between operations thereof. These off-normal contacts shift as soon as the shaft is moved from its normal position and remain shifted until the normal position is again reached, by further rotation of the shaft in the same direction. One such set of off-normal contacts is shown at 656 to 658 in Fig. 6, part 1.

For control purposes, the common shaft is provided with a group of contact sets shown at 37, Fig. 3, in the said prior application, one such set of contacts for each of the ten off-normal or selective positions of the shaft. These contact sets, termed a commutator, are actuated successively as the shaft rotates from one selective position to another. For convenience of illustration, the commutator of any device has been illustrated in the circuit drawings herein as a traveling brush cooperating with fixed contacts arranged around the circumference of a circle. The commutator of primary device #1 of the first hundreds group is shown at COM—P1, Fig. 6, part 1.

Hereinafter, a switching device of the type above discussed, including the common shaft with its commutator, motor magnet, off-normal contacts, control relays, and the four units to which the preceding equipment is common will be generally referred to as a "primary" or a "secondary," depending upon the position occupied by the device within the system, while any one of the units of such device may be referred to as a "primary unit" or as a "secondary unit," as the case may be.

The system

Referring now to Figs. 1 and 2, the system will be described generally.

In Fig. 1 each of the ten rectangles numbered #1 to #10 represents a separate 100-line group of the 1,000-line system, each such group serving a maximum of one hundred subscriber lines, any one of which lines may be assigned to serve as an individual line or as a party line, as desired. As is indicated by the lines extending below the rectangles representing the hundreds groups in Fig. 1, each hundreds group is provided with a number of outgoing links and with a number of incoming links. At the 100-line group #1, for example, one of the outgoing links is the one extending to the rectangle indicative of the selector S5, being one of the ten selectors assigned to handle traffic originated in the first hundreds group. The selectors S5, S15, and so forth, to S95, illustrated in Fig. 1, are in each case one of the ten selectors assigned to carry traffic outgoing from the associated hundreds group.

The rectangles indicative of the selectors shown in Fig. 1 may each be taken as representing the control relays of the selector, such as the relays 1101 to 1134 of the selector S5 shown in Fig. 11, while the ten heavy horizontal lines located below each such rectangle may be taken in each case to indicate the contact groups of the associated switching mechanism through which the connection is extended according to the hundreds digit dialed, such switching mechanism for the selector S5 being shown in Fig. 10 and including the units SA to SD. Each of these units has ten selective-position contact sets, corresponding respectively to the digits 1 to 0. The lowermost heavy horizontal line shown in Fig. 1 below the rectangle indicating the selector S5 is intended to indicate the #1 selective-position contact sets of each of the four units SA to SD of Fig. 10. Similarly, the second one of the said horizontal lines (counting up) indicates the four contact sets of the second selective positions of the units SA to SD, Fig. 10. The third to tenth ones of the horizontal lines under selector S5 similarly indicate in each case the four contact sets (one in each of the units SA of SD of Fig. 10) closed when the corresponding digit designation is dialed into the selector mechanism.

The fainter horizontal lines interconnecting the heavy horizontal lines indicative of the contact groups of the selectors S5, S15, and so forth, to S95 are meant to indicate that the contact sets of these selectors are multipled together, contact by contact, as is the usual practice in automatic telephone systems employing selectors. For example, the four contact sets indicated by the lowermost heavy horizontal line below the selector S5 in Fig. 1 are multipled respectively to the four contact sets indicated by the lowermost short horizontal lines shown below the rectangle indicating the selector S15 associated with the second hundreds, and so forth, for selectors of all of the ten hundreds. The remaining contact groups 2 to 10 of the selectors are similarly multipled together, contact by contact.

It is to be observed that a link incoming to the 100-line group #1 is shown coming from the first or digit-1 group of contacts of all the selectors shown in Fig. 1. This link it will be understood is one of the four similar links reached through the #1 group of contact sets of the indicated selectors and those connected in multiple therewith. It will be observed further that the second hundreds group is reached from the second contact group of all the selectors shown in Fig. 1, the third hundreds group from the third contact group, and so forth, to the tenth hundreds group, which is reached from the tenth contact group of all the selectors shown in Fig. 1.

The foregoing described multipling arrangement is similar to that employed generally in

group selection in automatic telephone systems, except that ordinarily a selector has ten or more contact sets in a group reached responsive to the dialing of the digit, instead of only four contact sets in a group as herein illustrated. As will be hereinafter explained more fully, as many links as desired incoming to a hundreds group may be provided by arranging separate groups of selectors, each group with its own contact multiple, providing four link paths into each hundreds group for each selector multiple. As is illustrated in Fig. 2, parts 2 and 4, five separately multipled groups of selectors are provided, giving five separate selector multiples, each of which provides four link paths into each hundreds group, making a total of twenty link paths incoming to each hundreds group. This number, of course, may be increased or decreased as desired, according to the traffic requirements.

Referring now particularly to Fig. 2, parts 1 and 2 indicate the switching equipment and interlinkage thereof for the first hundreds group, while parts 3 and 4 indicate the switching equipment and interlinkage thereof for the second hundreds group. The selectors S5 and S15 of Fig. 1 are shown in the lowermost portions of parts 2 and 4 respectively of Fig. 2.

Considering now the arrangement local to the first hundreds group, shown in Fig. 2, part 1, the one hundred lines of the first hundred are divided into ten small groups, of ten lines each, each such small group bearing a separate tens digit designation. A separate primary switching device is assigned to each of the 10-line small groups, there being ten such primary devices. Primary #1 is shown along the top of the drawing with its four units 1PA^1, 1PB^1, 1PC^1, and 1PD^1. The ten subscriber lines #111 to #110 served by the #1 primary are shown multipled into the respective contacts of the units 1PA^1 to 1PD^1 of the primary. Any unit of a primary can operate in what is called primary finder action to extend connection from any calling one of the ten lines served thereby, and can also operate in what is called connector action to extend connection to any called one of the ten lines served thereby.

Primary #2 of the first hundred is shown immediately below primary #1 thereof, with its units 2PA^1, 2PB^1, 2PC^1, and 2PD^1, but the ten lines (#121 to #120) served thereby are not shown for the lack of drawing space, but it will be understood, of course, that these lines are multipled into the selective-position contacts of primary #2 in the same way that the lines served by primary #1 are multipled into the selective-position contacts of the units thereof.

Primaries #3 to #8, serving tens groups 3 to 8, have been omitted for the lack of drawing space, but it will be understood that they are associated with their respective ten-line groups as shown in connection with primary #1. Primaries #9 and #10 are indicated in the same way as primary #2.

In order to provide for the extension of connections, from and to the units of the ten primaries, five secondaries, #1, #2, #3, #4, and #5, are shown, each with its four units. Secondary #1, for example, has units 1SA^1, 1SB^1, 1SC^1, and 1SD^1, while secondary #5, for example, has units 5SA1, 5SB^1, 5SC^1, and 5SD^1. Each unit of any one of the five secondaries has access to one of the units of each of the ten primaries. For example, unit 1SA^1 of secondary #1 has access, through its first and second selective position contacts (by way of primary links P1A^1 and P2A^1) to the units 1PA^1 and 2PA^1, and it has access, through its ninth and tenth contact sets (through links P9A^1 and P10A^1) to the units 9PA^1 and 10PA^1 of primaries #9 and #10. It will be understood, of course, that the third to eighth selective position contact sets of unit 1SA^1 have access to the A units of the third to eighth primaries (not shown).

It is to be noted that the selective-position contact sets of the A units of secondaries #2, #3, #4, and #5 are connected respectively in multiple with the selective-position contact sets of the unit 1SA of secondary #1, whereby the A units of all five secondaries have access to the A units of the ten primaries. The A units of the ten primaries and of the five secondaries, because of their column-like arrangement in the drawings, are referred to hereinafter as column A; the B units as column B; the C units as column C; and the D units of the primaries and secondaries may be referred to as column D. As illustrated, the interlinkage between primary units and secondary units and the multipling between contacts of the secondary units is the same in columns B, C, and D as before described for column A.

As will appear more fully hereinafter, the order of preference for finder action is through columns A to D, from left to right, while the order of preference from connector action is through columns D to A, from right to left.

From the standpoint of secondary finder action, the order of preference in the secondary units of any column is from secondary #1 to secondary #5.

It is to be observed that there are, all told, forty primary units, four for each of the ten primaries. This provides for each of four lines out of any 10-line group to have a connection thereto, either as a calling line or as a called line. Experience has shown that this number of connections suffices for the average 10-line group including some party lines and the remainder individual lines. It will be observed further that there are twenty secondary units, four for each of the five secondaries, thus providing for a total of twenty connections, incoming and outgoing, for the entire 100-line group. Experience has shown that twenty connections to the lines of an average 100-line group are sufficient to handle the peak traffic expected. It will be understood, of course, that a greater or lesser number of columns than four can be provided when the 10-line groups can be well served by a lesser number of units than four each, or require a greater number of units than four each. Additionally, the number of secondary devices may be less than five or more than five as desired, providing a greater or lesser number of simultaneously available talking channels for the 100-line group, depending upon the particular requirements in any given installation.

The calls from and to the units of the secondaries are carried over secondary links, five such links for each column. The links for the column-A secondary units 1SA^1 to 5SA^1 are designated S1A^1 to S5A^1, respectively. Similarly, the links S1B^1 to S5B^1 are assigned to the column-B secondary units; the links S1C^1 to S5C^1 are provided for the column-C secondary units; and the links S1D^1 to S5D^1 are provided for the column-D secondary units.

It has been found sufficient to equip the ten secondary links most often used for finder action with selectors, the remaining ten secondary links

being provided only with dummy selectors, each dummy selector being only a group of control relays for the clearing out of such connections as may be infrequently extended thereto.

Because of the order of preference for finder action hereinbefore explained, from column A to column D in the primary units, and from secondary #1 to secondary #5 in the secondary units, it has been found that the peak load calling condition is best served by connecting five selectors to the column-A secondary units, four additional selectors to the column-B secondary units of secondaries #1 to #4 and a further selector to the column-C unit of secondary #1.

The ten secondary links assigned for the forwarding of finder-action connections extend respectively to the selectors S1 to S10 shown in Fig. 2, part 2, as illustrated, while the ten secondary links which but rarely receive finder-action calls extended respectively to the dummy selectors DS1 to DS10.

The selectors S1 to S10 are arranged in five groups from the standpoint of selector action, one selector group for each of the five secondaries in any called hundreds group. Each of the five selector groups has its own separate multiple containing four links for each hundred group. For example, selectors S1 and S6 of the first hundreds group (along with selectors S11 and S16, Fig. 2, part 4, of the second hundreds group, and a pair of selectors in each of hundreds groups 3 to 10) extend connections through the associated selector multiple to the units of secondary #1 in called hundreds group; selectors S2 and S7 of the first hundreds group are in the second selector group, and extend connections to the units of secondary #2 of the several hundreds groups; selectors S3 and S8, in the third selector group, extend calls to the units of secondary #3 of the several hundreds groups; selectors S4 and S9, in the fourth selector group, extend calls to the units of the #4 secondary of the several hundreds groups; and selectors S5 and S10 are in the fifth selector group, and they extend calls to secondary #5 of the several hundreds groups.

Considering, for example, the fifth selector multiple, to which selectors S5 and S10 of the first hundreds are connected (along with selectors S15 and S20 of the second hundreds, and two selectors of each of the other hundreds), the lowermost indicated contact group of each of these selectors (the digit-1 portion of the multiple) serves four paths, leading respectively to the units 5SA^1 to 5SD^1 of secondary #5 of the first hundred. Similarly, the digit-2 group of contacts of the fifth selector multiple supplies incoming traffic to the second hundreds group over the incoming branches S5A^2—I to S5D^2—I of the secondary links S5A^2 to S5D^2, and so on for the remaining hundreds groups, as shown in Fig. 1.

The arrangement of the primary and secondary units and their interlinkage in the second hundreds group is illustrated in Figs. 2 and 3 and is similar to the hereinbefore described arrangement in the first hundreds group, illustrated in Fig. 2, part 2. It is to be observed that the reference characters applied respectively to the primary and secondary devices and links in Fig. 2, part 1, in each case have the exponent "1" applied thereto, indicating that the concerned parts relate to the first hundreds group. The corresponding reference characters local to the second hundreds group each has the exponent "2" applied thereto for purposes of identification.

As previously mentioned, the order of preference for finder action is from column A toward column D in the units of the primaries and from secondary #1 to secondary #5 in the units of the secondaries. As a result, the finder-action calls handled by the secondary units diminish in frequency from column A toward column D, and from secondary #1 toward secondary #5. The observed distribution, under peak load conditions, of finder-action calls amongst the ten primary units linked to selectors in any hundreds group is shown in the table comprising Fig. 4. This table shows:

That under peak load conditions, the column-A and column-B units (such as 1SA^1, 1SB^1) of secondary #1 of any hundreds group each receives about twenty-nine percent of the total finder-action calls originated in the hundreds group;

That the column-A and column-B units of secondary #2 of any hundreds each receives about twelve percent of the total finder-action calls originated in the hundreds group;

That the column-A and column-B units of the third secondary receive about five percent each;

That the column-A and column-B units of secondary #4 receive about two percent each;

That the column-A unit of secondary #5 receives about one-half a percent; and

That the column-C unit of secondary #1 receives about one-half a percent of the total finder-action calls originated within a hundreds group during a peak load condition.

From the foregoing it will be observed that care must be taken in assigning the secondary links to the selector pairs connected to the five selector multiples shown in Fig. 2 in order that the traffic supplied to these multiples shall be in accordance with the connector-action capacities of the secondaries in the several hundreds to which these multiples lead. For example, the uppermost selector multiple (the one joining together the contacts of the illustrated selectors S1, S6, S11, and S16) leads, according to the digit dialed, to the four units of secondary #1 in the several hundreds groups. It is clear that the units of secondary #1 cannot handle as high a percentage of incoming or connector-action calls as can the units of secondary #5, for example, because of the high concentration of finder-action calls in units A and B of secondary #1. The observed and calculated distribution of the traffic incoming to a hundreds group is as given in Fig. 5, in which it is shown:

That six to seven percent of the calls incoming to a hundreds group should be directed to the units of secondary #1 of that group;

That from seventeen to eighteen percent should be directed to the units of secondary #2;

That about twenty-one percent should be directed to the units of secondary #3;

That from twenty-six to twenty-seven percent should be directed to the units of secondary #4; and

That twenty-six to twenty-seven percent should be directed to the units of secondary #5.

In order to achieve this result, the secondary links which supply finder-action calls to the selectors are variously connected to the selectors of the five selector groups in the different hundreds groups, as is shown for the first and sec-

ond hundreds in Fig. 2 and as is shown for all hundreds in Fig. 3. Supplying the percentage traffic figures in Fig. 4 to the secondary-link distribution as shown in Fig. 3, the average incoming traffic to the secondaries of any hundreds group is as given in Fig. 5.

The circuit drawings

The circuit drawings shown in Figs. 6 to 11 will now be explained generally. Referring first to Fig. 2, primary #1 of the first hundreds group is shown along the upper portion of parts 1 to 3 thereof; a broken-line rectangle indicative of primaries #2 to #10 of the first hundreds is shown immediately below primary #1; and certain timer and relay equipment common to all the primaries of the first hundreds group is shown along the bottom portion of parts 1 to 3 of Fig. 6.

Primary #1 includes the units 1PA[1] to 1PD[1], together with the common control shaft (not shown) which controls the commutator COM—P1 and the four units last named. Unit 1PA[1], for example, includes shift plate 608, which is shifted to the right by magnet 609 to select the unit for operation. The unit also includes ten sets of selectively operable contacts, of which only sets 1 and 10 are shown. Additionally, the unit includes operating magnet 607 which upon operation actuates the one of the ten selective contact sets which correspond to the position currently assumed by the common shaft above referred to. The unit 1PA[1] also has an *a* set or stackup of contacts shown to the left and a *b* set or stackup of contacts shown to the right. Unlike the selective-position contact sets, the *a* and *b* stackups are operated whenever operating magnet 607 energizes, as they are not controlled according to the position of the common operating shaft. The off-normal contacts shown at 656 to 658 are illustrated in the position they occupy when the shaft is in its normal position, shifting whenever the shaft leaves its normal position and remaining shifted until normal position is again reached.

The motor magnet for driving the operating shaft and commutator COM—P1 step-by-step is shown at MM—P1.

The hold, test, and start-pulse relays 601 to 603 are the common relays which control the operation of primary #1 during finder action of any of the four units thereof, while the repeating, release, and change-over relays 604 to 606 are the common relays which control the operation of the primary during connector action through any one of the four units.

Shift relays 621 to 624 are associated respectively with the four units of the primary, coming into play both in finder action and in connector action to cause selection of one of the units for operation by operating the associated shift magnet, such as 609.

Relay P1J of primary #1 is arranged to be operated preliminary to connector action within the primary to control matching circuits to be hereinafter described, through which an idle unit of the primary is matched with an idle unit of the secondary through which the connector-action call is arriving at the primary. Relay P1J is operated over conductor J1 of the cable J when any one of the secondaries in the same hundred is set onto primary #1.

The links P1A[1] to P1D[1] extend respectively from the units 1PA[1] to 1PD[1]. It is over these links that finder-action connections are extended from the units of the primary, and connector-action connections are extended to the units of the primary. The link relays 625 to 628 associated respectively with the links P1A[1] to P1D[1] control holding circuits to be hereinafter described, as well as the starting and marking operations for secondary finder action.

Each of the primaries #2 to #10, indicated by the broken-line rectangle in Fig. 6, may be similar to primary #1.

The relays XA to XD are common to the ten primaries, each being associated as illustrated with a separate one of the four columns of primary units. The principal function of the X relays is to connect the common marking conductors M1 to M10 exclusively to the ten marking conductors of a single column, operation following primary finder action.

The release-timer relays RT are controlled by the interrupter 678 to release any primary unit which has not been found by secondary finder action within a short while after primary finder action has occurred.

As previously stated, Fig. 7 shows the circuits of secondary #1. The secondary circuits are generally similar to the primary circuits. The four units of secondary #1 are shown at 1SA[1] to 1SD[1]; the commutator is shown at COM—S1, and the motor magnet is shown at MM—S1; and the shift relays, corresponding respectively to the shift relays 621 to 624, are shown at 721 to 724. The individual start relays 725 to 728 are associated respectively with the four units of the secondary, their function being to control the starting of secondary finder action.

The hold, test, and start-pulse relays 701 to 703 function to control finder action of any one of the units of the secondary, while the repeating, release, and change-over relays 704 to 706 operate to control connector action. Start-transfer relay 721 is arranged to be operated by release relay 705 to transfer the start conductors 641 to 644, incoming respectively to the units of the secondary, to the next succeeding secondary to by-pass the units of the secondary for finder action during connector action.

The broken-line rectangle shown extending across the top of Fig. 8, parts 1 to 3, is representative of secondaries #2, #3, and #4, each of which may be similar to secondary #1 of Fig. 7. The circuits of secondary #5 are shown in full in Fig. 8, from which it can be seen that the parts thereof correspond respectively to the parts of secondary #1, Fig. 7.

It will be observed that secondary link S1A[1] extends from unit 1SA[1] of secondary #1, Fig. 7, across Figs. 8 to 10 to the relay equipment of selector S5, Figs. 10 and 11. Fig. 9 shows the selectors S8, S6, and the dummy selector DS6, to which the secondary links S1B[1] to S1D[1] respectively extend.

It will be observed that secondary link S5D[1] extends from unit 5SD[1] of secondary #5, Fig. 8, across Fig. 9 to the dummy selector DS10, Fig. 12. Fig. 9 shows the selector S1 and the dummy selectors DS1 and DS5 to which secondary links S5A[1] to S5C[1] of secondary #5 extend. Fig. 9 shows also the incoming branches S5A[1]—I to S5D[1]—I of the links S5A[1] to S5D[1], incoming from the #1 selective-position contacts of the units SA to SD respectively of the selector S5, Fig. 10.

Fig. 9 shows also that these same links are incoming from selector S10, Fig. 2 part 2, of the same hundreds, as well as from hundreds 2 to 10.

Fig. 9 shows also the incoming branches S1B1—I to S1D1—I incoming from the selectors of hundreds 1 to 10, while the incoming branch S1A1—I incoming from the selectors of hundreds 1 to 10, is shown in Fig. 11.

As previously stated, Fig. 10 shows the switching mechanism of the selector S5, the control relays of which are shown in Fig. 11. The selector S5 includes the two commutators 1000 and 1001, carried on the common shaft (not shown) stepped by the motor magnet 1002. This common shaft controls switching units SA to SD, each of which has ten selectively operable contact sets of which only sets 1, 2, and 10 are shown. Each set of contacts leads to a separate hunders group as hereinbefore pointed out, while the four units SA to SD give the selector four choices into each hundreds group. Fig. 10 shows also the seizing relays 1003 to 1006, associated respectively with the units SA to SD. Also shown in Fig. 10 is the selector end of the zero link Z1, which is rendered active in the selector S5 responsive to the dialing of the digit 0.

Fig. 11 shows the off-normal lamp 1135, off-normal contacts 1136 and 1137 of the mechanism shown in Fig. 10, interrupters 1138 and 1139, and control relays 1101 to 1134. The principal functions of the control relays is as follows:

Relay 1101 is the sleeve relay, operated initially over conductor S1 of the link S1A1 upon the completion of finder action by the unit 1SA1, Fig. 7, to close conductors of the link S1A1 through to the other control relays;

Relays 1102 and 1103 are line relays connected respectively to the ring and tip talking conductors;

Relays 1104 and 1105 are the release relay and the auxiliary release relay;

Relay 1106 is the dial-tone relay, operated upon seizure of the selector to transmit a dial-tone signal to the calling line;

Relay 1107 is the disconnect relay, coming into operation when the selector is to be cleared out following the use thereof;

Relay 1108 is the so-called series relay, in that it operates at the beginning of a series of impulses and, being slow-restoring, does not restore until the end thereof;

Relays 1109 to 1114 are the party-digit relays, including transfer relay 1109, the common driver relay 1110, and the reflexed counting relays 1111 to 1114 which control the frequency of ringing current to be applied, the operation of zero relay 1126, and absorb preliminary impulses;

Relays 1115 to 1118 are the hundreds-digit relays which control the operation of the mechanism of Fig. 10 according to the number of impulses in the hundreds digit, the second digit dialed, relays 1115 and 1116 being the repeating and release relays while relays 1117 and 1118 are the change-over and transfer relays;

Relays 1119 and 1120 are the group-connect relays which cause the units SA to SD of Fig. 10 to make preliminary connection with the group (four links) of incoming links selected by the dialing of the hundreds digit;

Relay 1121 is a special test relay subject to operation at any one of several points during the setting up of a connection;

Relays 1122 and 1123 are the tens-to-units transfer relays, which operate at the end of the tens digit to condition the circuits for the units digit;

Relay 1124 is a pick-up relay and relay 1125 is a cutoff relay constituting a delay-timer pair, controlled from interrupter 1138 to cause any circuits seized through the selector to be freed in the event of an abnormal delay during the dialing of a called number;

Relay 1126 is what has been termed the zero-call relay, which operates responsive to the dialing of the digit 0 to cause connection to be extended to the zero operator's switchboard;

Relays 1127 and 1128 are the units-to-test transfer relays, operating to change over the circuit connections following the dialing of the units digit to line-testing condition;

Relay 1129 and retard coil 1130 constitute the so-called back-bridge of the selector; and

Relays 1131 to 1134 are the ringing relay, the answer-test relay, the idle-test relay which operates only when the called line is idle, and the switching relay which finally completes connection to an idle called line.

Detailed Description

The invention having been described generally, a detailed description of the operation of the disclosed automatic telephone system will now be given. For this purpose a description will first be given of the operations involved when a call is made from individual line 111, Figs. 2 and 6, to partly line 110, also shown in Figs. 2 and 6.

A call from line #111 to line #110

Let it be assumed now that the subscriber at the individual-line substation #2111 on individual line #111 desires to converse with the subscriber at substation #6110, for example, on party line #110. Accordingly, the subscriber at substation 2111 removes his receiver (not shown) and then, when he hears a dial-tone signal, proceeds to operate the dial of his calling device (not shown) in accordance with the digits in the desired number.

When the receiver is removed at the calling substation #2111, the associated line is thereby bridged in the usual manner, closing a circuit thereover and, through contacts of cutoff relay 635, for line relay 634. Line relay 634 thereupon operates to remove ground potential from the marking conductor 631, individual to the calling line, and to place ground potential on start conductor 600, common to the ten lines served by primary #1. Responsive to this operation, primary #1 is caused to set itself in the #1 position marked by the removal of ground potential from conductor 631, and an idle one of the units 1PA1 to 1PD1 is caused to make connection with the calling line.

Initiating primary finder action

The placing of ground potential on start conductor 600 by line relay 634 closes a circuit, through the lower contacts of release relay 605, and through contacts of relays 601 and 602, for start-pulse relay 603. Relay 603 thereupon operates. It extends the ground potential applied to its winding, through its own contacts and those of relay 605, to the motor magnet MM—P1, whereupon the motor magnet operates to advance the mechanism from the normal position thereof toward the #1 selective position. In the embodiment of the mechanism disclosed in applicant's prior application hereinbefore referred to, the arrangement is such that the mechanism advances one-half step upon energization of the motor magnet and is advanced the re-

maining one-half step upon deenergization of the motor magnet.

When the mechanism leaves its normal position, the off-normal contact springs **656** to **658** shift. At contact **657** a circuit is closed, through the lower contacts of the energized start-pulse relay **603** for test relay **602**. Relay **602** thereupon operates and at its lower contacts connects its winding to the brush of the commutator. At its inner upper armature, test relay **602** opens the initial circuit of start-pulse relay **603** and of motor magnet MM—P1, whereupon start-pulse relay **603** restores, and the motor magnet restores to advance the mechanism the remaining one-half step to the first selective position. At its lower contacts start-pulse relay **603** opens the initial circuit of slow-restoring test relay **602**, leaving this relay connected to the brush of the commutator, while at its upper contacts it completes the hunting circuit of the motor magnet.

Selecting primary unit 1PA¹ for operation

With test relay **602** operated and off-normal contacts **658** closed, a circuit is closed from ground on start conductor **600**, through contacts of relays **605** and **601**, through the inner upper contacts of the operated test relay **602**, and off-normal contacts **658**, for hold relay **601**. Relay **601** thereupon operates and places ground on the selection-control conductor **661** at its middle contacts. This application of ground potential is over a circuit path including the upper contacts of relay **605**, and the middle upper contacts of the operated test relay **602**. Assuming that the unit 1PA¹ is idle, the ground potential on conductor **661** is extended through the upper contact group in set *b* thereof to the upper winding of shift relay **621**. Shift relay **621** thereupon operates. Upon so doing, it closes a circuit at its upper armature for shift magnet **609**. Shift magnet **609** now operates and prepares a circuit for operating magnet **607**, at the same time actuating the shift plate **608**, thus mechanically and electrically selecting the unit 1PA for operation. At its lower contacts, relay **621** joins conductors **666** and **667** together, thereby preparing a locking circuit for hold relay **601**.

As a further result of its described operation, hold relay **601** opens its initial circuit at the contacts controlled by its inner lower armature, at the same time closing a locking circuit for itself as follows: from ground on start conductor **600**, through contacts of relay **605**, the front contact of inner armature of relay **601** and the said armature, conductor **667**, lower contacts of the operated shift relay **621**, conductor **666**, and off-normal contact **658**, to the winding of hold relay **601**.

Finding the calling line

When the calling line is some line other than the one reached through the first selective position, as in the present case, ground potential is encountered by the brush of the commutator when it is advanced one step as described. This ground potential completes a self-locking circuit for test relay **602**, through the lower contacts thereof, and it completes a hunting circuit for magnet MM—P1, through the interrupter contacts thereof and contacts of relays **603** and **605**. Test relay **602** remains locked to the commutator, and magnet MM—P1 is thereupon operated in a buzzer-like manner through the action of its self-interrupting contacts to advance the mechanism until the brush of the commutator arrives upon the contact which has become ungrounded, by the removal of ground potential from the mark conductor thereof similar to conductors **631** to **640**. Test relay **602** is a slow-restoring relay, as indicated by the additional vertical lines drawn within the rectangle indicating the winding and core structure thereof, to enable it to remain operated while the brush of the commutator is passing from one contact to the next.

In the present example, the calling line is #111, and occupies the first selective position, in which case the action of the switching mechanism ceases as soon as the first step is reached, and slow-restoring relay **602** restores a moment later.

Seizing the calling line

When test relay **602** restores, it includes resistor **651** in the circuit of the upper winding of the shift relay **621**, thereby reducing the current through the shift relay below the operating value, but still leaving it above the holding value. The purpose of this provision will be explained subsequently.

At its upper contacts, relay **602** closes an operating circuit for the selected idle unit 1PA¹, as follows: from battery, through resistor **653**, contacts of operated relay **601** and of restored relay **602**, conductor **664**, contacts of the operated shift magnet **609**, and thence to ground through the winding of operating magnet **607** of the unit 1PA¹. Magnet **607** thereupon operates, shifting the contacts of the associated *a* and *b* stackups, and closing the selective-position contact set corresponding to the present position of the mechanism of the primary. In the assumed example, the contacts associated with the calling line #111 are the ones closed.

The closing of the tip, ring, and sleeve contacts associated with the calling line constitutes seizure of the calling line. The tip and ring conductors of the calling line are now connected respectively to the tip and ring conductors T and R of the link P1A¹, while the sleeve conductor S of the calling line #111 is extended, through contacts of the link relay **625**, to battery through the associated resistor, thereby marking the calling line busy in the multiple extending to devices 1PB¹ to 1PD¹, and closing a circuit for cutoff relay **635** of the calling line. Cutoff relay **635** thereupon operates to disconnect line relay **634**. Line relay **634** thereupon restores to again place ground potential on marking conductor **631**. At the same time, ground potential is removed at that point from the common start conductor **600**, whereby the start conductor is ungrounded unless a call has been initiated over another one of the ten lines of primary #1 in the meantime.

As a further result of the shifting of the contacts of the *a* stackup of unit 1PA¹, the lower contact pair thereof closes a temporary locking circuit for operating magnet **607**, as follows: from ground through the winding of magnet **607**, the associated contacts in the *a* stackup, normally closed contacts controlled by the middle armature of link relay **625**, conductor A in cable **668**, contacts of cutoff relay **667** of the release timer RT, and thence to battery through the winding of start relay **673**. Relay **673** operates, and magnet **607** remains locked over the above-traced circuit. The operation of start relay **673** is ordinarily without effect upon the connection being established, for a new locking circuit is ordinarily substituted for the one above traced before the release timer has had time to complete its operation.

Clearing out primary #1

When the *b* stackup of the device 1PA¹ is shifted as described, selection-control conductor 661 is disconnected from the winding of shift relay 621 and is extended to the shift relay of the next idle unit of the primary, shift relay 622 of unit 1PB¹, for example. This latter shift relay, however, is not operated at this time because the current-limiting resistor 651 has been placed in circuit by the described restoration of test relay 602. Selection and operation at this time of the next unit is thereby prevented. Shift relay 621 restores when conductor 661 is disconnected therefrom as above stated. Upon so doing, it opens the circuit of shift magnet 609, whereupon magnet 609 restores to permit shift plate 608 to restore and thus terminate the mechanical selection of the unit. The restoration of magnet 609 also opens the initial circuit of operating magnet 607, but magnet 607 is now maintained operated in its previously traced locking circuit.

Shift relay 621 at its lower contacts disconnects conductor 667 from conductor 666 thereby opening the locking circuit of hold relay 601. Hold relay 601 is thereby restored, if it has not already restored responsive to removal of ground from start conductor 600. The operation which now takes place depends upon whether or not another line has called in the meantime to place the ground at an additional point on start conductor 600. If start conductor 600 is grounded at this time, relays 603, 602, and 601 reoperate as hereinbefore described, causing the next idle unit to be selected and operated to find the newly calling line. On the other hand, if start conductor 600 is not grounded at this time, the regrounding of mark conductor 631 closes a homing circuit, through the brush of the commutator COM—P1, the self-interrupter contacts of motor magnet MM—P1, and contacts of relays 603 and 605, for the magnet MM—P1. The magnet MM—P1 is operated in a buzzer-like manner over this circuit to advance the primary over its remaining positions until the home or eleventh position is again reached, whereupon the operation ceases and off-normal contacts 656 to 658 are again opened.

Initiating secondary finder action

When the uppermost contacts of stackup *a* of unit 1PA¹ are shifted by the above-described operation of magnet 607, the marking conductor AM1, individual to the unit 1PA¹ is ungrounded, and ground potential is extended, through contacts of link relay 625, to start conductor AS, common to the ten column-A primary units. Assuming that this occurs when all four of the mutually exclusive relays XA to XD are in restored condition, and one or more of the column-A secondary units (Figs. 7 and 8) is idle, the grounding of conductor AS closes a circuit for relay XA, through contacts of relays XB to XD, over conductor 681, contacts of stackup *a* of any idle column-A secondary unit, conductor 682, and through the winding of relay XA, to battery. Relay XA thereupon operates and places ground potential, at its lower contacts, on the column-A secondary start conductor 641; prepares a locking circuit for itself over conductor 768, common to the five secondaries; opens a point in the circuit of each of the relays XB to XD to prevent operation of any one of them for the time being; and it connects the ten individual mark conductors AM1 to AM10 of the column-A primary unit respectively to mark conductors M1 to M10, common to the five secondary devices. Relay XA has ten contact pairs for this purpose, only three of which are shown. The other seven mark-control contact pairs of relay XA are omitted to conserve drawing space, the same being true for the similar contacts of relays XB to XD.

Let it be assumed that unit 1SA¹ of secondary #1 is idle at the time the column-A secondary start conductor 641 is grounded, and that the associated selector S5 (Figs. 10 and 11) is not being held over a called line. In this case the placing of ground potential on start conductor 641 results in the closure of a circuit for start relay 725, over start-in conductor STI of link S1A¹ (shown in the form of a cable for convenience), lower armature and back contact of relay 1128, Fig. 11, start conductor ST of link S1A¹, an armature and back contact of relay 721, (Fig. 7), normally closed contacts of stackup *a* of unit 1SA¹, the winding of start relay 725 of unit 1SA¹, conductor 764, upper contacts of release relay 705 of secondary #1 and resistor 754, to battery.

Start relay 725 operates over the above circuit. Upon so doing, it prepares a circuit for the upper winding of shift relay 721 over conductor 763; at its middle upper contacts it opens a point in the circuit path over which the start conductor 641 is to be subsequently extended to conductor 741; at its inner lower contacts it opens a point in the homing circuit of the motor magnet MM—S1 and prepares a test circuit for relay 702; and at its lower contacts it places ground potential on start conductor 700 of secondary #1, thereby closing a circuit, through contacts of hold relay 701, and contacts of test relay 702, for start-pulse relay 703. Start-pulse relay 703 thereupon delivers an impulse, through its inner armature, and through contacts 753, to motor magnet MM—S1, causing the secondary to advance from its normal position toward its first selective position. Off-normal contacts 756 to 759 are thereby closed. The closure of off-normal contact 756 results in the operation of test relay 702, through the upper contact of start-pulse relay 703. At its middle upper contacts, test relay 702 prepares a locking circuit for itself to the brush of the commutator COM—S1, through contacts 752, and over conductor 766, contacts of the operated start relay 725, and conductor 750.

Selecting secondary unit 1SA¹ for operation

At its upper armature, test relay 702 disconnects ground potential from conductor 762 so as to avoid a premature operation of the operating magnet in the secondary unit to be selected for operation, at the same time placing ground potential on selection-control conductor 763, thereby closing a circuit, through contacts of start relay 725, for the upper winding of shift relay 721. Shift relay 721 thereupon operates and closes a circuit at its upper contacts for shift magnet 709. Magnet 709 operates to move shift plate 708 to the right to mechanically select the unit 1SA¹ for operation, at the same time preparing a circuit for magnet 707, electrically selecting the unit for operation.

Test relay 702 also opens the circuit of the operated start-pulse relay 703 and of motor magnet MM—S1 at its inner upper armature, at the same time closing a circuit, through off-normal contacts 757 for hold relay 701. Relay 701 thereupon operates to lock itself to the grounded secondary start conductor 700, opening its initial

circuit. At its middle upper armature, hold relay 701 opens a further point in the homing circuit of motor magnet MM—S1, and applies ground potential (from off-normal contacts 756) to locking conductor 768, thereby closing a locking circuit for the operated relay XA, through the inner lower contacts thereof and over conductors 681 and 682 in series, to maintain relay XA operated independent of the continued grounded condition of the column—A start conductor AS.

Finding the calling primary link P1A1

Upon the described open-circuiting of start-pulse relay 703 and motor magnet MM—S1 by test relay 702, motor magnet MM—S1 restores and advances the mechanism to the #1 selective position. Start-pulse relay 703 restores and connects motor magnet MM—S1 to the brush of the commutator COM—S1 over a circuit path including armature 753 and its back contact, inner tipper armature of start-pulse relay 703 and its back contact, the interrupter contacts of motor magnet MM—S7, conductor 766, inner lower armature of the operated unit—A start relay 725, and conductor 750. The motor magnet MM—S1 is thus enabled to operate in a buzzer-like manner to advance the mechanism step-by-step, as long as ground potential is encountered successively on conductors 731 to 740, and until an ungrounded contact is reached in the position of the secondary corresponding to the calling primary device. Test relay 702 remains operated as long as ground potential is encountered by the brush of the commutator COM—S1, for it is connected to the said brush through its own middle upper contacts, contacts 752, and thence to the brush of the commutator over conductors 766 and 750, by way of contacts of relay 725.

In the present assumed example, the call originated in the 10-line group served by primary #1, to find which secondary #1 must be set in its first selective position. As a result, when the first selective position is reached by the mechanism the brush of the commutator COM—S1 encounters the contact connected to the ungrounded conductor 731. Conductor 731 is ungrounded at this time because it is connected, through contacts of relay U1, to conductor M1 of cable M, which is now connected, through contacts of the operated relay XA (Fig. 6) to the marking conductor AM1, which has been temporarily ungrounded by the previously described operation of the *a* stackup contacts of unit 1PA1. Accordingly, the stepping operation ceases when the first selective position of the secondary is reached, and slow-restoring test relay 702 restores shortly thereafter to cause the calling primary link to be seized.

Seizing the calling primary link P1A1

Upon restoring, relay 702 disconnects itself from the brush of the commutator COM—S1 at its middle contacts, while at its upper contacts it applies ground potential to conductor 762, thereby closing a circuit, through contacts of the operated shift magnet 709, for operating magnet 707 of the selected unit 1SA. Magnet 707 thereupon operates to close through the tip, ring, sleeve, and hold conductors T, R, S, and H of the link P1A1 to the corresponding conductors of the secondary link S1A1, the mechanism having been stopped in its first selective position, as described. At the same time, the contacts in stackups *a* and *b* of unit 1SA1 are shifted. The upper contacts of stackup *a* of the unit prepare a holding circuit for magnet 707 over conductor H2 of link S1A1, which circuit is subsequently completed in the relay equipment, Fig. 11, of the selector S5. The lower contacts of stackup *a* of the unit disconnect group conductors 681 and 682 at one point.

At the uppermost contact set of stackup *b* of unit 1SA1, battery potential, through the associated resistor, is applied to conductor H of the found primary link P1A1, by way of the following circuit path: from battery through the resistor associated with the *b* stackup of link 1SA1, uppermost contact pair of the said *b* stackup, conductor H1 of link S1A1, contacts of relay 1105 of selector S5, hold conductor H of link S1A1, and through the operated hold contacts of selective stackup 1 of the unit 1SA1, to the hold conductor H of the link P1A1. This application of battery potential operates link relay 625, connected between ground and the said conductor H of the link P1A1. Upon operating relay 625 extends the sleeve and hold conductors S and H of the link P1A1 to the contacts of unit 1PA1, at the same time disconnecting the primary side of the sleeve conductor of the link from battery through the illustrated resistor, and disconnecting the primary side of the hold conductor of the link from ground over conductor A of cable 668. The holding circuit of operating magnet 607 of the device 1PA1 is now from battery over the circuit path previously traced to conductor H of link P1A1, and thence to ground through the middle contacts of relay 625, contacts of device 1PA, and magnet 607. Magnet 607 is thus held operated in multiple with link relay 625. Battery supply for maintaining the sleeve conductor S of the calling line marked as busy, and for maintaining cutoff relay 635 operated, is now from battery by way of sleeve relay 1101, branch sleeve conductor S1 of link S1A1, upper contacts of start relay 725, sleeve contacts of unit 1SA1, sleeve conductor S of link P1A1, outer contacts of the operated link relay 625, and thence through contacts of unit 1PA1 to the sleeve conductor S of the calling line. Sleeve relay 1101 thereupon operates in series with the cutoff relay of the calling line. Upon so doing it establishes a new circuit for itself and the cutoff relay of the calling line over the sleeve conductor S of the secondary link S1A1 independent of branch conductor S1 and contacts of start relay 725, which new circuit path is from battery by way of the winding of sleeve relay 1101, operated armature 1142, contacts controlled by armature 1155, upper contacts of disconnect relay 1107, sleeve conductor S of the secondary link S1A1, and thence to ground, through the contacts of units 1SA1 and 1PA1, and the winding of cutoff relay 635. The operation of sleeve relay 1101 also completes a locking circuit for operating magnet 707, as follows: from battery, through the winding of magnet 707, the associated *a*-stackup contacts, conductor H2 of link S1A1, contacts 1147 of disconnect relay 1107, armature 1143 and its front contact, hold conductor H of the link S1A1, and thence through contacts of the unit 1SA1, over conductor H of the primary link P1A, to ground through the windings of link relay 625 and operating magnet 607, in parallel. This locking circuit is closed while the initial circuit for magnet 707 over conductor 762 is still closed. The illustrated resistor in series with conductor 762 at the contacts of relay 702 prevents direct ground potential, which would otherwise be on conductor 762, from short-

circuiting and restoring link relay 625 and magnet 607.

Freeing the common marking conductors M1 to M10

As a further result of the previously described operation of link relay 625, the ground potential applied through the inner armature thereof to start conductor AS by the upper *a*-stackup contacts of the device 1PA1 is thereupon removed from the column-A conductor AS and is replaced on the marking conductor AM1 to mark the unit 1PA1 as non-calling in the commutators of the secondary devices.

Assuming that no other column-A primary unit has reached calling condition in the meantime, the described removal of ground potential from start conductor AS opens the initial start circuit of relay XA, but leaving this relay operated in its described locking circuit over locking conductor 768, common to all secondaries. Then, when conductor 768 becomes ungrounded in secondary #1, as it shortly does, relay XA restores and opens a further point in its previously established locking circuit at its inner lower armature; removes ground potential from the column-A secondary-start conductor 641 at its lower contacts; closes a point in the circuit of each of the relays XB to XD; and disconnects the column-A marking conductors AM1 to AM10 from the common marking conductors M1 to M10 of cable M, thereby freeing the common marking conductors for further use in any of the columns A to D.

Clearing out secondary #1

A moment after the described operation of magnet 707 to cause unit 1SA1 to seize the primary link P1A1, start relay 725 restores responsive to being disconnected at the associated *a* stackup of contacts. Upon so doing, it disconnects the upper winding of shift relay 721 from the grounded conductor 763, whereupon shift relay 721 restores and deenergizes shift magnet 709. Shift magnet 709 thereupon restores to permit the shift plate 708 to restore, and thereby terminating the mechanical selection of the unit 1SA1. The contacts of magnet 709 open the initial circuit of operating magnet 707, leaving this magnet operated over the locking circuit above traced therefor, in series with the operating magnet 607 of the calling primary device. At its upper contacts, start relay 725 disconnects the associated end of branch sleeve conductor S1 from sleeve conductor S of the link S1A1, thereby opening the initial circuit of sleeve relay 1101, leaving the sleeve relay operated over the previously traced locking circuit therefor which includes conductor S of link S1A1, to ground through cutoff relay of the calling line. Start relay 725 also removes ground potential from start conductor 700, thereby opening the locking circuit of hold relay 701, whereupon relay 701 immediately restores. Upon restoring, relay 701 removes ground potential from locking conductor 768 to permit the above described immediate restoration of the previously locked column-A relay XA (Fig. 6) to unground start conductor 641.

A further result of the described restoration of the slow-acting start relay 725 is that it completes the extension of the incoming start conductor 641, through the contacts of unit 1SA1 to the column-A start conductor 741 leading to the succeeding column-A secondary units. This extension, however, is made by relay 725 just at the moment when the locking circuit of hold relay 701 is opened as described by relay 725, which is followed immediately by the described restoration of relay XA when no other column-A primary calls are waiting, with the result that no succeeding secondary is started into finder action unless another column-A primary call is waiting.

The restoration of start relay 725 completes a homing circuit for motor magnet MM—S1, as follows: from ground through off-normal contacts 756, middle upper armature and back contact of the restored relay 701, conductor 767, contacts of start relays 728 to 725, conductor 766, interrupter contacts of the motor magnet, contacts of relays 703 and 705, and thence to battery through the winding of the motor magnet MM—S1. The motor magnet thereupon operates in a buzzer-like manner to advance the mechanism until it reaches its eleventh or normal position, whereupon the off-normal contacts 756 to 759 are restored to their illustrated normal condition, off-normal contacts 756 opening the homing circuit.

Preparing selector S5 for operation

As a further result of its previously described operation in series with the cutoff relay of the calling line, sleeve relay 1101 of the selector S5 connects the tip and ring conductors T and R of the link S1A1 at its upper armature and armature 1141 to the finder-action end of the talking conductors of the selector. When this occurs line relays 1102 and 1103 energize in series over the calling line. Line relay 1102 prepares a circuit for relay 1120, but this circuit remains open for the time being. Line relay 1103 operates the associated slow-restoring release relay 1104. Relay 1104 thereupon operates auxiliary release relay 1105 at its inner upper armature. Auxiliary release relay 1105 prepares an impulse circuit over conductor 1172 at its inner contacts, while at its lower contacts it applies ground potential to locking conductor 1173, thereby closing a circuit for transfer relay 1109 of the hundreds-digit group, through contacts of relays 1114 to 1111, contacts 1151, to battery through the winding of relay 1109. Transfer relay 1109 thereupon operates and at its inner upper armature, extends impulse conductor 1172 through the upper contacts of driver relay 1110 to the odd impulse conductor 1178, preparatory to operating the reflexed counting relays 1111 to 1114 to record the first digit in the desired number.

As a further result of its described operation, sleeve relay 1101, closes a circuit at its inner contacts for dial-tone relay 1106 through contacts of switching relay 1134. Dial-tone relay 1106 thereupon operates and applies ground potential to conductor 1174, thereby lighting the signal lamp 1135 as a visible signal to an attendant that the selector S5 has been seized. At its upper contacts, dial-tone relay 1106 connects the common dial-tone signal lead DT, through contacts of relays 1121, 1128, and 1134, to the tip talking conductor T of the selector whereby a dial-tone signal is transmitted back through the operated secondary and primary units to the calling line to inform the calling subscriber that he may now begin to dial the digits in the desired number.

Dialing the party digit 6

When the first digit (the party digit 6) is dialed, by manipulating the dial of the usual calling device (not shown) at the calling substation in ac-

cordance with the digit 6, the control bridge across the conductors of the calling line is momentarily interrupted six times to produce a train of six "dial" impulses. As a result, line relays 1102 and 1103 are restored six times momentarily. The restorations of line relay 1102 are without any particular effect at this time. Each time line relay 1103 restores, it opens the circuit of release relay 1104, but relay 1104 remains operated throughout the series of restorations, being slow-restoring as indicated.

Each time it restores, line relay 1103 transmits an impulse at its lower contacts, through the lower contacts of relays 1104 and 1106, and the inner lower contacts of relay 1123, to the winding of series relay 1108. Series relay 1108 operates responsive to the first impulse in the series, and being slow-restoring as indicated, remains operated throughout the series of impulses. At its lower armature, series relay 1108 completes a locking circuit for transfer relay 1109, through the inner lower contacts of the latter relay, for holding relay 1109 operated until the end of the series of impulses.

As a further result of the series of restorations of line relay 1103 a series of impulses is transmitted over conductor 1172, and through contacts of transfer relay 1109, to operate the counting relays 1111 to 1114 successively, driver relay 1110 alternately operating and restoring as will be described. The first impulse transmitted over conductor 1172 proceeds through the upper armature and front contact of transfer relay 1109, through the upper armature and back contact of driver relay 1110, to the odd-impulse conductor 1178, and thence through contacts of relays 1112 and 1113 to the first counting relay 1111. Relay 1111 operates responsive to this impulse. At its middle lower contacts, it prepares a circuit for the lower winding of driver relay 1110; at its inner lower contacts it closes a locking circuit for itself, through the lower contacts of relays 1114 and 1112, to ground at the lower contacts of series relay 1108; it prepares an operating circuit for the second counting relay 1112 over the even-impulse conductor 1179; and at the normally closed contacts controlled by its inner upper armature it opens the initial circuit of transfer relay 1109, rendering relay 1109 dependent upon its described locking circuit closed at its lower contacts through contacts of series relay 1108.

When line relay 1103 reoperates following the first momentary restoration, it reestablishes the circuit of release relay 1104, thereby applying ground potential through contacts of transfer relay 1109 to conductor 1177, completing a circuit, through contacts of counting relay 1111 for the lower winding of driver relay 1110. Driver relay 1110 thereupon operates and transfers impulse conductor 1172 from odd-impulse conductor 1178 to the even-impulse conductor 1179. As a result, upon the second momentary restoration of line relay 1103, while the circuit of the lower winding of driver relay 1110 is opened at the front contacts of the line relay, a locking circuit for the upper winding of driver relay 1110 is closed from even-impulse conductor 1179, to which impulse conductor 1172 has now been shifted by relay 1110. The second counting relay 1112 is now operated over even conductor 1179, through contacts of counting relay 1111. Upon operating, relay 1112 closes a locking circuit for itself at its inner upper contacts to the grounded locking conductor 1173, through contacts of relays 1113 and 1114, at the same time opening a further point in the initial circuit of transfer relay 1109.

At its upper armature, relay 1112 disconnects the odd-impulse conductor 1178 from the winding of relay 1111 and transfers it, through contacts of relay 1114, to the winding of the third counting relay 1113.

At its inner lower contacts, relay 1112 open-circuits and restores the first counting relay 1111 by opening the locking circuit thereof. Upon restoring, relay 1111, at its middle lower armature, disconnects the lower winding of driver relay 1110. As a result, when the second impulse over conductor 1172 is terminated, resulting in the ungrounding of the even impulse conductor 1179, the consequent deenergization of the upper winding of driver relay 1110 permits the relay to restore, transferring impulse conductor 1172 back to the odd-impulse conductor 1178.

When the third impulse is delivered over conductor 1172, it is transmitted over odd conductor 1178, through the upper armature and front contact of the operated relay 1112, and through the upper contacts of relay 1114, to the winding of the third counting relay 1113. Relay 1113 thereupon operates and closes a locking circuit at its inner upper armature, at the same time opening a further point in the initial circuit of transfer relay 1109, unlocking and restoring relay 1112; it connects the even-impulse conductor 1179 to the winding of relay 1114 at its middle upper contacts; while at its upper contacts it disconnects the first counting relay 1111 to prevent premature reoperation thereof.

At the inner lower contacts of relay 1113, the circuit of the lower winding of driver relay 1110 is again prepared. As a result, driver relay 1110 operates for the second time when relay 1103 reoperates at the end of the third impulse. Upon operating at this time, relay 1110 transfers the impulse conductor 1172 back from the odd-impulse conductor 1178 to the even-impulse conductor 1179. Upon the fourth momentary restoration of line relay 1103, the impulse transmitted over conductor 1172 passes through the contacts of the operated driver relay 1110 to energize the upper winding of the driver relay to hold the relay locked throughout the impulse, and it passes further, over conductor 1179 through contacts of the operated relay 1113, to the winding of the fourth counting relay 1114. Relay 1114 is thereby operated. At its inner armature, relay 1114 locks itself directly to the grounded conductor 1173, open-circuiting and restoring the third counting relay 1113; and at its inner lower armature and armature 1152 it prepares a new locking circuit for relay 1111.

Upon its above-noted restoration responsive to the operation of relay 1114, relay 1113 prepares a circuit at its upper contacts for the reoperation of relay 1111, while at its inner lower contacts it disconnects the lower winding of driver relay 1110 from in parallel with the winding of release relay 1104. As a result, upon the termination of the fourth impulse, and the consequent ungrounding of the even conductor 1179, driver relay 1110 again restores and transfers the impulse conductor 1172 from even-impulse conductor 1179 back to odd-impulse conductor 1178.

Upon the fifth momentary restoration of line relay 1103, the fifth impulse transmitted over conductor 1172 passes through the upper contacts of the restored driver relay 1110 to the odd-impulse conductor 1178, and thence by way of the

upper contacts of relays 1113 and 1112, to the winding of impulse relay 1111. Upon reoperating, relay 1111 completes a locking circuit from its winding to the grounded conductor 1173, through its inner lower contacts and those of the operated relay 1114, inner upper contacts of relay 1111, contacts controlled by the inner armature of the restored relay 1112, and contacts 1152.

When line relay 1103 reoperates at the end of the fifth momentary restoration, the lower winding of driver relay 1110 is operated in parallel with the winding of release relay 1114, through the lower contacts of transfer relay 1109 and the middle lower contacts of counting relay 1111. As a result when the sixth, and final, momentary restoration of line relay 1103 occurs, the sixth impulse transmitted over conductor 1172 passes through the upper armature and front contact of relay 1110 to the even conductor 1179, and thence to battery through the upper winding of driver relay 1110. At the same time, counting relay 1112 is reoperated through the upper contacts of relay 1111. Upon reoperating, relay 1112 locks itself to conductor 1173 through contacts 1152, at the same time open-circuiting and restoring relay 1111.

As described, relay 1112 has responded to the sixth and final impulse in the dialed party digit 6. Of the counting relays 1111 to 1114, relays 1112 and 1114 are locked operated as described, while relays 1111 and 1113 are in restored condition.

When relay 1103 reoperates at the end of the sixth and last momentary restoration in the dialed party digit, the resulting removal of ground potential from impulse conductor 1172 and consequently from even conductor 1179 permits driver relay 1110 to restore. A moment later, slow-acting series relay 1108, which has remained operated throughout the described series of impulses, restores. At its lower armature, it opens the locking circuit of transfer relay 1109. The initial energizing circuit of transfer relay 1109 is now held open at the normally closed contacts controlled by the inner upper armature of relay 1112, and at contacts 1151. As a result, transfer relay 1109 now restores and does not again operate until the selector has been cleared out.

As a result of counting relays 1112 and 1114 of the operated digit group having been energized and locked as described, a ringing circuit is prepared from the illustrated 66-cycle common ringing lead, preparatory to applying 66-cycle ringing current to the called party line.

As a further result of the described restoration of transfer relay 1109, repeating relay 1115 of the hundreds-digit group is operated over the following circuit; from ground through the inner upper contacts of line relay 1103, through contacts of relays 1105 and 1106, the inner upper armature of hundreds-digit transfer relay 1118 and its back contact, contacts of party-digit transfer relay 1109, the upper contacts in the *b* stackups of units SA to SD, Fig. 10, and the winding of repeating relay 1115 to battery. Repeating relay 1115 of the hundreds-digit group operates over the above-traced circuit. When it does so, it closes a circuit at its upper armature for the associated release relay 1116. Release relay 1116 thereupon operates and prepares a circuit at its upper contacts for motor magnet 1002 of the switching mechanism of the selector, while, at its lower contacts, relay 1116 prepares a circuit for the associated change-over relay 1117, which relay is arranged to be operated at the end of the series of impulses constituting the hundreds digit.

Dialing the hundreds digit 1

When the hundreds digit of the called number is dialed, line relays 1102 and 1103 are restored momentarily a number of times corresponding to the value of the digit. Each time relay 1103 restores, at its upper contacts, it opens the above-traced circuit of the hundreds-digit repeating relay 1115. As a result, repeating relay 1115 is likewise restored momentarily a number of times corresponding to the value of the hundreds digit. Each time it restores, at its lower contacts, relay 1115 opens a point in the circuit of change-over relay 1117 so as to prevent a premature operation of relay 1117 during the receipt of the hundreds digit, following the closure of off-normal contacts 1137 responsive to the first impulse. At its upper contacts, relay 1115 closes a circuit, each time it restores, through contacts of the operated slow-restoring release relay 1116, and contacts of transfer relay 1118, for the winding of motor magnet 1002. Motor magnet 1002 is thereby energized momentarily a number of times corresponding to the value of the digit. Upon each momentary energization and following deenergization of magnet 1002, the shaft (not shown) of the selector mechanism is advanced one step from its normal position toward the desired position corresponding to the hundreds digit, correspondingly advancing the brushes of the commutators 1000 and 1001.

In the present assumed example, the hundreds digit dialed is the digit 1, constituting but a single impulse. As a result, the shaft of the mechanism, together with the brushes of the commutators, is advanced to the first selective position, corresponding to the hundreds digit 1.

When relay 1115 comes to rest in an operated position, at the end of the digit, change-over relay 1117, which has a winding of sufficient inductance that the relay is not operatively energized by the momentary reoperations of relay 1115 during the receipt of a series of digit impulses, energizes through off-normal contacts 1137, over conductor 1136, and through contacts of the operated relays 1116 and 1115. Upon operating, relay 1117 shunts the lower contacts of relay 1115 so as not to be prematurely restored by relay 1115.

Testing the common dial lead

As indicated in Fig. 9, and shown more fully in Fig. 2, the selector S5 is only one of a number of selectors (twenty in all) which have access to the units of secondary #5 in the first hundreds group for connector action. Even though the common mechanism of the secondary is used only for about a second or less for completing an incoming or connector-action call, there is nevertheless a possibility that the common equipment is in use by another selector at the moment when the previously described dialing of the hundreds digit 1 is completed. The directive control over the common mechanism is exercised over what is termed a dial lead. The dial lead over which secondary #5 of the first hundreds (Fig. 8) is operated, from the selectors in all hundreds groups is the dial lead DL—5, there being one such dial lead for each secondary in each hundreds.

The brush of commutator 1001 is now setting upon the dial lead DL—5, and the first operation to be carried on through this brush is the testing of the dial lead DL—5 to determine whether or

not this lead is in use, and consequently whether or not secondary #5 is in use. If the dial lead DL—5 is in use by another selector, ground potential is maintained thereon over the dialing circuit. The connecting-up and testing of the dial lead at the end of the dialing of the hundreds digit occurs as follows:

Upon the described operation of change-over relay 1117, at its upper armature, relay 1117 completes a circuit path from the dial lead DL—5 to the lower winding of special-test relay 1121, at the same time closing a circuit for transfer relay 1118, through contacts of special-test relay 1121. The operation which follows depends upon whether the common dial lead of the called secondary device is busy or idle.

The dial lead is busy

Let it be assumed first that the common dial lead DL—5 of the called secondary device is busy, in which event there is a ground potential thereon as hereinbefore pointed out. Special-test relay 1121 is thereby operated in the following circuit: from ground on dial lead DL—5, through the first-position contact of commutator 1001, the brush of the said commutator, upper armature and front contact of change-over relay 1117, and the lower winding of relay 1121, to battery. Relay 1121 is preferably adjusted so that it operates more quickly than transfer relay 1118, connected up at the lower contacts of relay 1117. Upon operating, relay 1121 open-circuits relay 1118 at its middle lower armature and back contacts; disconnects locking ground potential at its inner lower contacts from the inner lower armature of relays 1118 and 1119; closes a locking circuit for its upper winding, through the lowermost contacts of relays 1000 to 1003, to ground on conductor 1171, grounded at contacts of the operated relays 1104 and 1107; at its upper contacts it disconnects the dial-tone lead DT to terminate the application of a dial-tone signal to the calling line; and at its middle upper contacts it connects the busy-tone lead BT to the tip talking conductor so as to return a busy-tone signal to the calling line to inform the calling subscriber of the busy condition.

With relay 1118 prevented from operating, the dial lead DL—5 is not seized, and the control circuit remains established through repeating relay 1115.

At the front contact of the middle lower armature of relay 1121, the ground potential, from conductor 1176 and off-normal contacts 1137, is extended through the interrupter contacts of the motor magnet MM, and thence through the upper contacts of transfer relay 1118 to motor magnet 1002, whereupon the motor magnet operates in a buzzer-like manner in its self-interrupting circuit to advance the mechanism until the normal position thereof is reached, whereupon off-normal contacts 1137 open the homing circuit. Relay 1117 thereupon restores.

Upon hearing the busy-tone signal applied as above explained from the busy-tone lead BT, the calling subscriber is expected to replace his receiver to cause the partially established connection to clear out in a manner substantially as explained hereinafter.

The dial lead is idle

Assume now that, when the hundreds digit 1 is dialed as hereinbefore described, the dial lead DL—5 is idle, as is nearly always the case. Under this condition, special-test relay 1121 is not operated, for there is then no ground potential on the seized dial lead DL—5. In this event, the described operation of change-over relay 1117 is followed by the operation of transfer relay 1118 from ground, through off-normal contacts 1137, conductor 1176, and contacts of relays 1121 and 1117.

Upon operating, transfer relay 1118 locks itself, at its inner lower contacts, through the lower contacts of relay 1121, and thence through the lower contacts of the *b* stackups of units SD to SA, to ground on conductor 1171; at its inner upper armature it prepares an operating circuit for relay 1119; at its upper contacts it disconnects motor magnet 1002 to prevent further operation thereof; and at its inner upper armature it disconnects the impulse repeating contacts of line relay 1103 from repeating relay 1115 and prepares to transfer them to the dial lead DL—5. When this occurs relays 1115, 1116, and 1117 restore successively.

Upon the restoration of relay 1117, ground potential is applied to the dial lead DL—5 over the following circuit path: from ground at the upper contacts of line relay 1103, through contacts of the operated relays 1105 and 1106, middle upper armature and front contact of relay 1118, contacts of the restored change-over relay 1117, the brush of commutator 1001, and thence through the first selective-position contact of this commutator, to the dial lead DL—5. By this ground potential, the dial lead DL—5 is marked busy to the other selectors having access thereto.

Preparing secondary #5 for connector operation

In the called secondary #5 of the first hundreds group, Fig. 8, the described placing of ground potential on the incoming dial lead DL—5 immediately operates repeating relay 804, through off-normal contacts 858, if the secondary mechanism is in normal position, which is ordinarily the case. On the other hand, if the secondary is away from its normal position, the circuit of repeating relay 804 remains open at off-normal contacts 858 until the normal position of the device is again reached, as it will be shortly.

Upon operating, repeating relay 804 prepares a circuit at its lower contacts for change-over relay 806, and at its upper contacts it closes a circuit for release relay 805. Release relay 805 thereupon operates. At its lower armature release relay 805 connects repeating relay 804 to the dial lead DL—5 independent of off-normal contacts 858; it completes a circuit at its inner upper contacts for change-over relay 806, through the lower contacts of repeating relay 804 and resistor 855, but relay 806 is not operated at this time, for it is short-circuited by ground potential through off-normal contacts 859; at armature 853, relay 805 prepares a circuit for motor magnet MM—S5; at armature 852 it opens a point in the test circuit of finder-action relay 802; at its upper armature it disconnects battery potential from conductor 864 so as to restore any one of the start relays 825 to 828 which may be operated, at the same time operating transfer relay 821. Relay 821 transfers each of the incoming start conductors 841 to 844 to their respective outgoing branches, such outgoing branches being used only in the event that a sixth secondary is added. Finder action is thus prevented from interfering with the con-

nector action of the secondary now about to occur.

Dialing the tens digit 1

When the tens digit is dialed, line relays 1102 and 1103 respond with two results. One result is that relay 1119 of the group-connect pair responds at the beginning of the dialing of the tens digit, and relay 1120 responds at the end of the dialing of the tens digit to cause the contact pairs in the group of contacts selected by the hundreds digit to be closed in the devices SA to SD of Fig. 10. The other result is that the impulses constituting the dialed digit 1 are repeated over the seized dial lead DL—5 to the associated secondary #5, Fig. 8, to cause this secondary to be positioned in accordance with the tens digit to select the primary having access to the 10-line group including the called line.

Closing the selected group of contact sets

The contacts in the group of contact sets selected by the mechanism of selector S5, Figs. 10 and 11, in accordance with the hundreds digit 1 are all closed at the end of the dialing of the tens digit, by the operation of units SA to SD, Fig. 10, as follows:

The upper winding of relay 1119 of the group-connect pair of relays 1119 and 1120 is energized over the following circuit, responsive to the first momentary restoration of line relay 1103 during the tens digit: from ground through the lower armature and back contact of line relay 1103, contacts of relay 1105, conductor 1172, inner upper armature and back contact of relay 1109, inner contacts of relay 1118, and the upper winding of relay 1119, to battery. Upon operating, relay 1119 closes a self-locking circuit at its inner lower armature, to ground through the inner lower contacts of special-test relay 1121, *b*-stackup contacts of devices SD to SA, conductor 1171, and contacts of the operated relays 1104 and 1107. Relay 1119 also prepares a circuit at its lower contacts for the winding of group-connect relay 1120. Upon each subsequent reoperation of relay 1102, a circuit is closed at the contacts thereof and through contacts of relay 1119 for the winding of relay 1120. The winding of relay 1120 is sufficiently inductive that the relay does not operate during the momentary reoperations of line relay 1102 while a series of digit impulses are being transmitted.

When the line relays 1102 and 1103 come to rest in an operated condition at the end of the dialing of the tens digit, relay 1120 operates over its above-traced circuit. Upon so doing, it closes a circuit for each of the shift magnets 1009, 1012, 1015, and 1018 of the devices SA to SD. The said shift magnets, upon operating, move the shift plates 1008, 1011, 1014, and 1017 to the right to mechanically select the four units of the switching device for operation. Each of the said shift magnets also closes an operating circuit for the associated one of the operating magnets 1007, 1010, 1013, and 1016. By their operation, each of the said operating magnets closes its #1 selective-position contacts (the selector mechanism having been set in the digit-1 position responsive to the dialing of the hundreds digit 1, as previously described) and also opens the associated *b*-stackup contacts. The upper *b*-stackup contacts open additional points in the circuit of hundreds-digit repeating relay 1115, while the lower contact pairs of the *b*-stackups open the previously traced locking circuit of the lower winding of relay 1119. Relay 1119 is slow-restoring as indicated, whereby it remains operated for a moment to maintain relay 1120 operated, so as to maintain the shift and operating magnets of Fig. 10 in operated condition until the matching operation to be described has taken place, and one of the relays 1003 to 1006 has operated as a result of the matching operation to close a holding circuit for the associated one of the four operating magnets 1007 to 1016.

Repeating the tens digit to the secondary

The dialed tens digit is repeated to secondary #5 over the dial lead DL—5, as follows. Upon each momentary restoration of line relay 1103 during the tens digit, the upper contacts thereof open the circuit of repeating relay 804, over the dial lead DL—5, with the result that repeating relay 804 likewise restores momentarily a number of times corresponding to the valve of the tens digit.

Upon each restoration of relay 804, the circuit of release relay 805 is opened. Relay 805, however, being slow-acting, as indicated, remains operated throughout the series of restorations of relay 804. As a further result of each momentary restoration of relay 804, a circuit is closed for motor magnet MM—S1, through contacts of change-over relay 806, and the front contact of armature 853 and the said armature. A series of impulses is thereby delivered to motor magnet MM—S5 to cause the mechanism to be stepped from the normal position thereof into the position designated by the value of the tens digit.

As soon as the mechanism leaves the normal position, off-normal contacts 856 to 859 are shifted. The shifting of off-normal contacts 859 removes the shunting ground connection from the lower terminal of relay 806 to permit relay 806 to operate through resistor 855. Highly inductive change-over relay 806, however, is unable to operate during the transmission of the series of impulses because its circuit is closed only intermittently during such time.

In the present assumed example, the tens digit dialed is the tens digit 1. In this event, only a single impulse is delivered to motor magnet MM—S1. The mechanism therefore is brought to rest in its first selective position.

Preparing the matching circuits

When repeating relay 804 comes to rest in operated position at the end of the dialing of the tens digit, relay 806 operates through resistor 855, lower contacts of relay 804, and the inner upper contacts of release relay 805. Upon operating, relay 806, at its lower contacts, closes a locking circuit for itself independent of the lower contacts of the repeating relay 804; opens a point in the motor magnet circuit at its inner upper armature; and at its upper armature it closes a point in the circuit of the associated U of relay U5. Each of the five secondaries is provided with a U relay, of which relays U1 and U5 (Figs. 7 and 8) of the first and fifth secondaries are shown. These relays are mutually exclusive in their operation, for each of them, on operating, opens a point in the circuit of the other four. In the event that one or the other secondaries is in matching condition at this time and the U relay thereof is operated, relay U5 is unable to operate because its circuit is maintained open at the U relay of the other secondary for that short interval of time required for the matching operation to be completed with respect to the other secondary.

As soon as all of the U relays are in restored condition (or immediately if none of them are operated when change-over relay 806 operates as described), relay U5 operates in the following circuit: from battery through resistor 854, the upper contacts of relay 806, the winding of relay U5, lower contacts of relay U1, and thence to ground through contacts of the U relays associated respectively with the second, third, and fourth secondaries.

Upon operating, relay U5 opens a point in the circuit in each of the other U relays; it disconnects the selective-position contacts 1 to 10 of the commutator COM—S5 from the conductors M1 to M10 of the marking cable M and transfers them respectively to the conductors J1 to J10 of the matching-control cable J, which latter conductors extend respectively to the J relays (such as relay P1J, Fig. 6) of the ten primaries of the first hundreds group. At its inner lower contacts, relay U5 connects the associated secondary J relay S5J to the brush of the commutator COM—S5, now on its first-position contact. When this occurs, and assuming that the called primary #1, Fig. 6, is not off-normal during connector action, relays S5J and P1J operate in series over the following circuit: from battery through the winding of relay S5J, contacts of relay U5, the brush of the commutator COM—S5 in its first selective position, the upper armature and front contact of relay U5, conductor J1 in cable J, the winding of relay P1J, Fig. 6, and thence to ground through contacts of relays 604 and 605.

When relay S5J, Fig. 8, part 1, operates, it applies ground potential at the contacts thereof, Fig. 8, part 1, to the lowermost set of *b*-stackup contacts of unit 5SD[1] to prepare for a matching operation in column D; and it closes its contacts associated with the C, B, and A units, respectively, preparatory to matching in columns C, B, or A, in that order, in the event that matching cannot take place in column D. Additionally, at its inner contacts relay S5J places ground potential on the matching-test conductor MT—5 for a purpose to be explained hereinafter.

Upon the described operation of relay P1J, Fig. 6, in the called primary, battery potential is applied through the lower contacts of the *b* stackup of each idle unit of the primary, to the lower windings of the respective ones of the shift relays 621 and 624, thus preparing for a matching operation in any one of the four columns of the called primary and calling secondary. At the same time, relay P1J closes certain other contacts through which the ground buses CG, BG, and AG may be energized under conditions of matching to be hereinafter described.

Matching delayed

Assume now that the matching operation about to be described (wherein an idle unit of the operated secondary #5 is to be matched with an idle unit in the called primary #1) is delayed, such as by a busy condition of all paths through the units of the concerned secondary and primary. Under this condition, a busy signal is given to the calling subscriber indicative of the fact that the connection cannot be completed, as will now be pointed out.

It will be recalled that relay S5J, Fig. 8, upon operating as above described following the operation of change-over relay 806 and relay U5, places ground potential on the match-test lead MT—5 of secondary #5. A circuit is thereby closed, through the first selective-position contact of commutator 1000, the brush of the said commutator, contacts 1144 of sleeve relay 1101, contacts of relay 1120, normally closed contacts controlled by the inner armature of special-test relay 1121, and thence through the winding of relay 1121, to battery. Special-test relay 1121 is thereby operated. Upon operating, relay 1121 opens its initial circuit and closes a locking circuit for itself, at its inner upper armature, to ground through the lower contacts of relays 1006 to 1003, and conductor 1171. At its upper and inner upper armatures, relay 1121 disconnects the dial-tone lead DT and substitutes the busy-tone lead BT. Unless the matching operation takes place, the further progress of the partially established connection is halted, and special-test relay 1121 remains operated to maintain busy-signalling current applied to the calling line.

In the present example, it is assumed that matching takes place normally within the short interval of time allotted therefor, as will now be described.

Matching in column D

Let it be assumed now that the column-D unit of the calling secondary (unit 5SD[1] of secondary #5, Fig. 8), and of the called primary (unit 1PD[1] of primary #1, Fig. 6) are both idle when the matching circuits are prepared as hereinbefore described. Under this condition, the described operation of relays S5J and P1J in series at the end of the tens digit results in the energization of shift relay 824 of secondary unit 5SD[1], and shift relay 624 of the primary unit 1PD[1], in series, over the following circuit: from ground through the outer contacts (Fig. 8 part 3) of secondary matching-control relay S5J (Fig. 8 part 1), lower contacts of the *b* stackup of unit 5SD[1], lower winding of shift relay 824, column-D relay bus DR (common to all the column-D primaries and secondaries of the same hundreds), lower winding of shift relay 624 of the unit 1PD[1], closed contacts in the associated *b* stackup, contacts of the operated primary matching relay P1J, and thence to battery. Upon operating, shift relay 624 closes a locking circuit for its upper winding, over conductor 665, to ground through the outer contacts of the operated matching relay P1J. Assuming that the primary is at normal position, none of the shift relays 621 to 623 are operated, and relay 624 closes an operating circuit at its upper contacts for shift magnet 618, whereupon shift magnet 618 operates to mechanically and electrically select the unit 1PD[1] for operation.

In the calling secondary #5, Fig. 8, when shift relay 824 operates it prepares a locking circuit for itself at its lower armature, at the same time opening a point in the circuit path over which ground potential is extended to the column-C ground bus CG, while at its upper armature it closes an operating circuit for shift magnet 818. Shift magnet 818 thereupon operates to move the associated shift plate 817 to the right to mechanically select the unit 5SD[1] for operation. At the same time, it completes a circuit for operating magnet 816, to ground over conductor 862, through upper contacts of relay 802. Operating magnet 816 thereupon closes the #1 selective-position contacts (the mechanism having previously been set in accordance with the tens digit 1 to select primary #1), at the same time shifting the associated *a* and *b* stackups of contacts. Upon the shifting of the lower contact set in stackup *b*, the original circuit of shift relay 824 is opened and a locking circuit therefor is completed

through the lower armature of the relay and its front contact, while at the upper contact pair of the *b* stackup, battery potential, through the associated resistor is applied to the hold conductor H of the primary link P1D1 over the following circuit path: from battery through the upper contact pair in the *b* stackup of unit 5SD1, over conductor H1 of the secondary link S5D1, upper contacts of auxiliary release relay 1205 of the dummy selector DS10, Fig. 12, conductor H of the secondary link S5D1, and through operated contacts of the unit 5SD1, to the hold conductor H of the primary link P1D1. The application of battery potential to the hold lead H of the link P1D1 closes an operating circuit for link relay 628. Relay 628 thereupon operates to extend the associated hold and sleeve leads H and S through to contacts of the primary unit 1PD1.

Closure of the upper contact pair of stackup *a* of the secondary unit 5SD1 closes the following locking circuit for operating magnet 816: from battery through the winding of operating magnet 816, upper contacts of the associated *a* stackup, conductor H2 of the secondary link S5D1, contacts of relays 1205 and 1201 of the dummy selector DS10, hold conductor H of the incoming branch S5D1—I of the secondary link S5D1, the lower contact pair of the now-closed #1 selective-position contacts of the column-D unit SD of selector S5, Fig. 10, the two windings of seizing relay 1006 in series, the associated column-D hold lead HD, the upper contact pair of dial-tone relay 1106, to ground through contacts of relay 1125.

Operating magnet 816 is held operated over its above-traced locking circuit, and relay 1006 operates thereover. Upon operating, relay 1006, at its inner lower armature, closes a locking circuit for itself and for operating magnet 816 exclusive of the lower winding of the relay. This circuit extends over conductor 1021, through the middle upper contacts of relay 1125, and over conductor 1184, to ground at the back contact of the inner upper armature of disconnect relay 1107. At its middle lower armature, relay 1006 closes a holding circuit for the associated operating magnet 1016, to maintain this magnet operated after shift magnet 1018 has restored, as it shortly does. Relay 1006 also closes through the associated tip, ring, and sleeve conductors T, R, and S of the connector-action end of the selector S5; and at its lower contacts it opens the locking circuit of special-test relay 1121 so as to restore this relay to remove the busy-tone signal and replace the dial-tone signal.

Preparing the called primary for connector operation

Responsive to the described operation of seizing relay 1006, the tens-to-units transfer relay 1122 is operated over the following circuit: from battery, through the winding of relay 1122, contacts of relay 1123, contacts 1154, the ring conductor R extending from the connector-action end of the selector S5, closed contacts of relay 1006 and of the secondary device SD (#1 selective position), ring conductor R of the incoming branch S5D1—I and of the secondary link S5D1, closed contacts of the secondary device S5D, ring conductor R of the primary link P1D1, normally closed contacts in the *a* stackup of unit 1PD1, and the common ring conductor 662 of primary #1, to ground through the upper contacts of change-over relay 606. Upon operating, relay 1122 closes a locking circuit for itself at its upper contacts, while at its inner contacts it operates the slow-restoring relay 1123. At its middle armature, relay 1122 opens a point in the busy-test circuit of the selector and closes the following circuit for repeating relay 604 of the called primary #1: from ground through the upper contacts of line relay 1103, contacts of the operated relays 1105 and 1106, contacts of the operated transfer relay 1122, sleeve conductor S of the connector-action (right-hand) end of the selector, contacts of relay 1106 and of unit SD, sleeve conductor S of the incoming branch S5D1—I, contacts of sleeve relay 1206 of the dummy selector DS10, sleeve conductor S of the secondary link S5D1, contacts of the operated device 5SD1, sleeve conductor S of the primary link P1D1, contacts of the actuated link relay 628, normally closed contacts in the *a* stackup of device 1PD1, and the common sleeve conductor 663 of primary #1, to battery, through the winding of repeating relay 604. Relay 604 thereupon operates over the above-traced circuit. At its upper armature, relay 604 open-circuits and restores the matching control relays P1J and S5J, at the same time applying ground potential to conductor 665 to maintain shift relay 624 locked operated after relay P1J has restored, as it now does.

The operations which now occur depend upon whether the common mechanism of primary #1 is in normal position, or is away from normal position, pursuant to finder action.

Let it be assumed first that primary #1 is away from normal position pursuant to finder action. Under this condition, a circuit is closed at the inner upper contacts of repeating relay 604 for the winding of change-over relay 606, through the shifted off-normal contacts 656, the battery supply for relay 606 being through resistor 655. Relay 606 does not operate at this time because it is short-circuited by ground potential applied to its upper terminal by the inner upper contacts of relay 605, relay 605 being unable to operate because of the shifted condition of off-normal contacts 656. The lower contacts of repeating relay 604 apply ground potential, obtained through off-normal contacts 657, to the brush of commutator COM—P1 to cause the motor magnet MM—P1 to continue to operate until the eleventh or home position of the device is reached, at which point, the off-normal contacts 656 to 658 shift back to their illustrated normal position, and the homing circuit is opened at off-normal contacts 657.

The subsequent operations are the same as those occurring when the primary device is in normal position when energization of repeating relay 604 occurs, which condition will now be assumed.

Upon operating under the condition now assumed, at its inner lower armature, relay 604 operates release relay 605, through the off-normal contacts 656, in normal position. At its upper armature release relay 605 removes ground potential from the upper terminal of change-over relay 606, at the same time applying ground potential to the inner lower armature of repeating relay 604 independent of off-normal contacts 656; it disconnects start conductor 600 at its lower contacts; at its upper armature it disconnects motor magnet MM—P1 from the hunting and homing circuit, at the same time preparing a directive operating circuit for the motor magnet; while at its upper armature it applies ground potential more directly to conductor 665 (independent of the contacts of repeating relay 604) so as to maintain the locking circuit of the operated shift relay 624.

The circuits of primary #1 are now prepared for connector action in response to the dialing of the units digit 0 (the final digit) in the desired number.

Terminating the matching condition

The matching condition is terminated upon the restoration of matching control relays P1J and S5J, which occurs as described responsive to the opening of the upper contacts of repeating relay 604. Shift relay 824 of the primary unit 1PD1 remains locked operated over the grounded locking conductor 665, but shift relay 824 of the secondary unit 5SD1 restores. Upon restoring, relay 824 open-circuits and restores shift magnet 818 at its upper contacts. Shift magnet 818 thereupon permits shift plate 817 to restore, at the same time opening the initial circuit of operating magnet 816. Operating magnet 816 remains operated over its previously traced locking circuit including the upper contacts of the associated *a* stackup.

Clearing out the operated secondary #5

The termination of the matching condition is followed closely by the clearing out of the secondary #5, as follows.

In the selector S5, Fig. 11, following the dialing of the tens digit, slow restoring relays 1118 and and 1119 are each held operated temporarily in a locking circuit controlled by the inner lower contacts of special-test relay 1121, and by *b*-stackup contacts of units SA to SD, Fig. 10. This temporary locking circuit is broken upon the described operation of the said units SA to SD (responsive to the operation of relay 1120 at the end of the tens digit).

Slow restoring relays 1118 and 1119 fall back shortly after their locking circuit is opened as above set forth. When relay 1119 restores it open-circuits and restores group-connect relay 1120. Relay 1120 opens the initial circuits of the shift magnets 1009, 1012, 1015, and 1018 of the units SA to SD, respectively. When this occurs, the associated shift plates are permitted to restore and the initial circuits of the associated operating magnets 1007, 1010, 1013, and 1016 are opened. Operating magnets 1007, 1010, and 1013 thereupon restore but operating magnet 1016 remains operated in its described holding circuit through the middle lower contacts of the operated seizing relay 1006. The temporary association between selector S5 and the links connected to the first selective-position contacts of devices SA to SC is thereby terminated.

When slow-restoring transfer relay 1118 restores, at the front contact of its inner upper armature it removes ground potential from the dial lead DL—5 thereby freeing the dial lead. When this occurs, repeating, release, and change-over relays 804, 805, and 806 of secondary #5 restores successively. Upon the restoration of release relay 805, by-pass relay 821 is open-circuited and permitted to restore shortly thereafter to transfer the start conductors 841 to 844 back into the units 5SA1 to 5SD1 to enable finder action to occur at such of the said units as are idle.

Responsive to the opening of the upper contacts of change-over relay 806, relay U5 is open-circuited and restored, transferring the commutator conductors back from matching-control conductors J1 to J10 to marking conductors M1 to M10, respectively. The restoration of relay U5 open-circuits relays P1J and S5J at another point, and closes points in the circuits of the U relays of the other secondaries.

A homing circuit for motor magnet MM—S5 is closed at armature 853 and its back contact as follows: from ground through off-normal contacts 856, middle armature and back contact of relay 801, conductors 867, contacts of start relays 828 to 825, conductor 866, interrupter contacts of the motor magnet, contacts of relay 803, contacts 853, and through the winding of motor magnet MM—S5, to battery. Motor magnet MM—S5 operates in a buzzer-like manner in this circuit to restore the mechanism to normal position. When the normal position is reached, the homing circuit is opened at off-normal contacts 856.

Dialing the units digit 0

When the calling subscriber dials the units digit 0 in the desired number, line relays 1102 and 1103 are restored ten times momentarily. Each time line relay 1103 restores, at its upper contacts it opens the previously traced circuit (over the sleeve conductor through the devices SD and 5SD1) for repeating relay 604 of primary #1. Repeating relay 604 is accordingly restored ten times momentarily. Each time it restores, repeating relay 604 opens the circuit of release relay 605. Release relay 605, however, remains operated throughout the dialing of the digit because it is slow-restoring as indicated. With release relay 605 operated, each momentary restoration of relay 604 results in the closure of a circuit for motor magnet MM—P1 as follows: from ground, through the inner upper armature and front contact of release relay 605, inner armature and back contact of repeating relay 604, contacts 654, front contact of the middle upper armature of relay 605 and the said armature, and the winding of motor magnet MM—P1, to battery. Motor magnet MM—P1 is operated ten times over this circuit to thereby advance the mechanism step-by-step until the tenth selective position thereof is reached.

The off-normal contacts shift upon the first movement of the mechanism from its normal position. Therefore, upon each reoperation of repeating relay 604, a circuit is closed for change-over relay 606. Relay 606, however, is slow-operating, being provided with a highly inductive winding. As a result, relay 606 does not operate until the repeating relay 604 comes to rest in an operated condition at the end of the series of impulses. When this occurs, relay 606 operates through the shifted off-normal contacts 656, through the inner upper contacts of repeating relay 604, in series with resistor 655. Upon operating, relay 606 locks itself by shunting the inner upper contacts of relay 604; it opens a point in the directive circuit of motor magnet MM—P1 at contacts 654; at its upper contacts, it removes ground from the common ring conductor; and at contacts 652 it applies battery potential, obtained through resistor 653, to conductor 664, thereby closing a prepared circuit, through contacts of the actuated shift magnet 618, for operating magnet 616 of the unit 1PD1. Magnet 616 thereupon operates and closes the associated tenth selective-position contacts (the units digit 0 having been dialed), at the same time shifting the contacts of the *a* and *b* stackups thereof. The lower contact pair of the *a* stackup closes a holding circuit for operating magnet 616 through the middle contacts of the operated link relay 628, in parallel with the said link relay. Other contacts in the *a* stackup disconnect the ring con-

ductor R and the sleeve conductor S of the link P1D1 from the common ring and sleeve conductors 662 and 663, respectively.

Clearing out primary #1

When conductor 663 is disconnected as above pointed out, repeating relay 604, release relay 605, and change-over relay 606 of the primary restore successively. The previously traced homing circuit for motor magnet MM—P1 is closed at the middle upper contacts of release relay 605, with the result that the primary is restored to its normal position as previously described.

Testing the called line

The tip, ring, and sleeve conductors T, R, and S of the primary link P1D1 have now been extended respectively to the corresponding conductors of the called line #110, wherefore the next step to be performed is the testing of the called line to determine its busy or idle condition.

In the selector S5, Fig. 11, relay 1122 restores when ground potential is removed from the ring conductor at the upper contacts of relay 606. Upon restoring, relay 1122 unlocks itself from the ring conductor of the connection by opening its upper contacts, the slow-restoring relay 1123 being then in operated condition. The ring talking conductor is thus immediately cleared in the selector. Relay 1122 also open-circuits relay 1123 to permit it to restore after a slight interval. At its middle armature relay 1122 disconnects the associated sleeve conductor from the impulse-repeating circuit and transfers it to conductor 1188, between which and battery the winding of the units-to-test transfer relay 1127 is connected. When this occurs, relay 1127 (being a sensitive relay) energizes over the sleeve conductor in series with the cutoff relay 633 of the called line, whether the line is busy or idle. Upon energizing relay 1127 closes a circuit for the associated transfer relay 1128. At armature 1154, relay 1128 disconnects relay 1122 at another point from the associated ring conductor of the connection before the slow-restoring relay 1123 has had time to fall back; and at its upper armature it disconnects the dial-tone lead DT and substitutes the busy-tone lead BT so as to transmit busy signalling current back to the calling substation in the event that the line is busy, which busy signalling current, however, is interrupted by the operation of idle-test relay 1133 if the called line is idle.

The called line is busy

Let it be assumed that the called party line #110 is busy. Under this condition, battery potential (through a sleeve relay such as 1101 in the event the line is busy as a calling line, or through a switching relay such as 1134 and a relay such as 1127 in the event the line is busy as a called line) is applied to the sleeve conductor of the called line to mark the line as busy, and to operate cutoff relay 633. Under this condition, while the sensitive relay 1127 operates as described to bring about the operation of relay 1128, idle-test relay 1133 is unable to operate because of the reduced potential on the sleeve conductor of the called line. Busy-tone current from the lead BT, through the upper contacts of relay 1128, continues to be applied to the called line to inform the calling subscriber of the busy condition. The calling subscriber is expected to replace his receiver to cause the established connection to clear out in a manner to be hereinafter described.

The called line is idle

Let it be assumed now that party line #110 is idle when called. Under this condition, cutoff relay 633 energizes over the following circuit when the connection is established: from ground through the winding of relay 633, the associated sleeve conductor S, contacts of unit 1PD1, outer contacts of link relay 628, sleeve conductor S of link P1D1, contacts of unit 5SD1, sleeve conductor S of link S5D1, contacts of sleeve relay 1201 of the dummy selector DS10, sleeve conductor S of incoming branch S5D—I, sleeve contacts of the #1-selective stackup of unit SD of selector #5, sleeve contacts of relay 1006, the associated sleeve conductor S, middle armature and back contact of relay 1122, to conductor 1188, at which point the circuit branches. One branch of the circuit extends to battery through the winding of relay 1127, while the other branch extends to battery through contacts 1146, conductor 1189, contacts of relay 1134, and the two windings in series of idle-test relay 1133. Relays 1127 and 1133 both operate at this time. Relay 1128 operates responsive to the operation of relay 1127. When relay 1133 operates, it opens points in the talking path at its upper contacts and at contacts 1158, while at its inner upper contacts it connects the winding of switching relay 1134 to the sleeve conductor of the called line, in parallel with its own windings and the winding of relay 1127. Relay 1134 operates.

Upon operating, switching relay 1134, and its upper armature, disconnects the dial-tone and busy-tone signalling leads and closes a point in the tip talking conductor, while at armature 1161 it closes a point in the ring talking conductor; at armature 1162, relay 1134 applies ground potential to conductor 1185, thereby completing a locking circuit for the lower winding of idle-test relay 1133, through contacts of back-bridge relay 1129, contacts 1148, and contacts 1160; at armature 1163, relay 1134 connects the associated resistor in parallel with the lower winding of idle-test relay 1133 through contacts of ringing relay 1131 and contacts 1160; at its inner armature, relay 1134 closes a locking circuit for itself over the sleeve lead to ground through the cutoff relay of the called line, at the same time, opening the initial circuit of idle-test relay 1133, whose lower winding is now included in the above-traced locking circuit therefor including contacts 1160, 1148, contacts of relay 1129, and contacts 1162.

Switching relay 1134 also open-circuits and restores dial-tone relay 1106 at armature 1166. Dial-tone relay 1106 disconnects ground potential at contacts 1145 from the leads HA to HD, whereby the original circuit over lead HD for relay 1006 is opened, but relay 1006 remains operated over the grounded locking conductor 1021.

Ringing the called substation on the called party line #110

With the now-locked idle-test relay 1133 in operated condition, ringing relay 1131 is intermittently operated from the common ringing interrupter 1139, through contacts of answer-test relay 1132. Each time it operates, relay 1131 disconnects back-bridge relays 1129 and retard coil 1130 at armatures 1156 and 1157 and substitutes ringing current (superimposed on ground potential) on the tip conductor, and provides a return path over the ring conductor to battery through the illustrated resistor.

In Fig. 6, part 1, it is indicated that the called substation #6110 is one having a ringer responsive only to 66-cycle ringing current, the other ringers on the party line being responsive respectively to 30-, 42-, and 54-cycle ringing current.

In the party-digit device comprising relays 1109 to 1114, of which relays 1111 to 1114 are counting relays, relays 1112 and 1114 have been operated and are being held locked as a result of the described response of the party-digit device to the party-digit 6, called as the first digit of the desired number. Consequently the ringing current now applied is from the illustrated 66-cycle common lead, through the front contact of the middle lower armature of relay 1112 and the said armature, front contact and lower armature of relay 1114 and the said armature, through the upper winding of answer-test relay 1132, front contact of armature 1156 and the said armature, upper armature and front contact of relay 1134, and thence over the tip conductor T of the established connection to the tip conductor of the called line, through the usual ringing condenser and 66-cycle ringer (not shown) at the called substation #6110, back over the ring conductor of the established connection, through contacts 1161, armature 1157 and its front contact, to battery through the associated resistor.

Each time it restores following an application of ringing current, relay 1131 opens the ringing circuit and reconnects back-bridge relay 1129 and retard coil 1130.

The called subscriber answers

When the called subscriber responds, by removing his receiver, the closure of the usual direct-current bridge across the conductors of the called line results in the immediate termination of the ringing operation and the completion of the talking circuit. The exact manner in which this is done depends upon whether the called subscriber responds during an application of ringing current or during the silent period following an application of ringing current. Assuming that the called subscriber responds during an application of ringing current, answer-test relay 1132 (which is prevented from responding to the alternating ringing current by the retarding action of the indicated copper collar on the armature end of the core thereof, in addition to the indicated retarding copper sleeve around its core) responds to the flow of direct current over the called line when the receiver is removed. Upon responding, answer-test relay 1132 interrupts the circuit of ringing relay 1131. Relay 1131 thereupon restores and reconnects back-bridge relay 1129 and retard coil 1130 at armature 1156 and 1158. When this occurs relay 1129 operates over the called line to terminate the ringing condition by restoring idle-test relay 1133.

When the response occurs during the silent period, answer-test relay 1132 is not affected, relay 1129 responding directly to the removal of the receiver. In either event, relay 1129 joins conductor 1178 and 1179 at its upper contacts to enable the incoming or connector-action end of the circuit to be held from the called line in the event that the calling subscriber replaces his receiver first; and at its inner upper armature, it opens the previously traced locking circuit of idle-test relay 1133 (including contacts 1162 and 1169). Relay 1133 thereupon restores and further opens the said locking circuit at armature 1160. The talking circuit between the calling and called lines is completed at the upper contacts of relay 1133 and at contacts 1158. The calling and called subscribers may now converse as desired.

Clearing out the established connection

When the subscribers have completed their conversation, they are expected to replace their receivers to permit the established connection to be cleared out and the equipment involved therein to be restored to normal condition.

The called subscriber replaces his receiver first

Let it be assumed now that the called subscriber is the first to replace his receiver. Under this condition, back-bridge relay 1129 restores. Upon so doing, it separates conductors 1178 and 1179 at its upper contacts, thereby placing the clearing out of the connection entirely under the control of the calling substation, enabling the entire connection to be released when the calling subscriber replaces his receiver.

The calling subscriber replaces his receiver first

On the other hand, if the calling subscriber is the first to replace his receiver, only that portion of the connection established to the selector S5 by finder action is cleared out, the portion of the connection established to the called line by connector action being held in order to avoid undesirable finder action which would occur if the connector-action portion of the connection were cleared out prior to the replacing of the receiver at the called substation.

The clearing out of the finder action portion of the established connection under the condition last assumed occurs as follows: Line relays 1102 and 1103 restore responsive to the receiver being replaced at the calling substation. Upon restoring, relay 1103 opens the circuit of the associated release relay 1104, but it does not at this time operate series relay 1108, for the circuit of the latter relay has been opened at the lower contacts of dial-tone relay 1106.

Relay 1104 restores after a short interval and opens the circuit of the associated slow-restoring auxiliary release relay 1105. At its inner lower contacts, release relay 1104 closes a circuit for disconnect relay 1107 from conductor 1174, grounded at off-normal contacts 1136. Disconnect relay 1107 thereupon operates and locks itself to conductor 1174 at its lower contacts. At its inner upper armature relay 1107 closes a holding circuit for auxiliary release relay 1105. At the back contact of its inner upper armature, relay 1107 disconnects ground potential at one point from conductor 1184, thereby tending to open the locking circuit of the operated relay 1006 to release the connection between the selector and the called line, but conductor 1184 is maintained grounded at this time through contacts 1162 of switching relay 1134, over conductor 1185, and through contacts of the restored release relay 1104. At its upper contacts, disconnect relay 1107 disconnects the sleeve lead S of the link S1A[1] from the sleeve relay 1101, thereby marking the calling line as idle at the primary multiple, and restoring sleeve relay 1101 and cutoff relay 635. The restoration of relay 635 returns the circuits associated with the calling line to normal condition.

Upon the opening of contacts 1147 upon the described operation of disconnect relay 1107, the

hold conductor H of the secondary link S1A[1] is disconnected from the branch hold lead H2 thereof, thereby opening the series holding circuit of operating magnet 707 of unit 1SA[1] and operating magnet 607 of the primary unit 1PA[1]. These two operating magnets thereupon restore to clear out their respective units. By the same operation the holding circuit of link relay 625 is opened. Relay 625, being slow-restoring as indicated, restores a short interval thereafter, again preparing the associated link P1A[1] to receive a finder-action call through the device 1PA[1].

In order to restore the selector mechanism to its normal condition, a circuit is closed at the inner upper armature and back contact of release relay 1104, through contacts of the auxiliary relay 1105 for the lower winding of special-test relay 1121. Relay 1121 thereupon operates, and at its middle lower armature extends ground potential (obtained through off-normal contacts 1137, over conductor 1176), through the interrupter contacts of the motor magnet 1002, and the upper contacts of restored transfer relay 1118, to the motor magnet 1002. Motor magnet 1002 thereupon operates in a buzzer-like manner to advance the mechanism to its normal position. The brushes of the commutators 1000 and 1001, and the off-normal contacts 1136 and 1137 thereupon assume the normal position illustrated. The homing circuit of the motor magnet is opened by the off-normal contacts 1137.

Off-normal contacts 1136 remove ground potential at one point from conductor 1174, but this conductor is maintained grounded at the inner contacts of relay 1127.

The finder-action end of the established connection has been cleared out as described, but the portion of the connection established by connector action is being held, under the assumed condition by back-bridge relay 1129. Relay 1128, at its lower armature, maintains the start-in lead STI of link S1A[1] disconnected from the start lead ST thereof and transferred to the start-out lead STO.

By referring to Fig. 7, part 2, it will be observed that the lead referred to as the start-in lead STI of the link S1A[b] is an extension of the incoming column-A start conductor 641, while the start-out lead STO is the origination point of the outgoing or descending column-A secondary start lead 741. The incoming start lead of the unit 1SA[1] is thus by-passed to the outgoing start lead 741, leading to the next secondary device, whereby finder action of the unit 1SA[1] is prevented for so long a time as the connector-action end of the selector S5 is held under the control of the called line.

When the called subscribed replaces his receiver, back-bridge relay 1129 restores. Upon so doing (contacts 1146 of the operated disconnect relay 1107 being held open) it separates conductors 1188 and 1189 at its upper contacts, thereby opening the sleeve connection between the selector S5 and the called line. Relay 1127 and switching relay 1134 in the selector and cut-off relay 633 of the called line thereupon restore. The called line is now marked as idle in the primary multiple.

Clearing out the connector-action devices

With disconnect relay 1107 in operated condition, the removal of ground from conductor 1185 at contacts 1162 by the restoration of switching relay 1134 deprives conductor 1021 of ground potential, opening the holding circuit of seizing relay 1006 (over the hold conductor H of branch link S5D[1]—I, and thence over the conductor H2 of the link S5D[1]) in series with operating magnet 816 of the device 5SD[1]. At the middle lower contacts of relay 1006, the holding circuit of operating magnet 1016 is opened, whereupon this magnet restores, clearing out the selector device SD.

Upon the consequent restoration of magnet 816, secondary device 5SD[1] is cleared out.

Upon the opening of the hold contacts in the #1 selective-position stackup of the device 5SD[1], the battery potential previously applied, over conductors H1 and H (in series) of link S5D[1], to hold the conductor H of the primary link P1D[1] is removed, depriving link relay 628 and operating magnet 616 of current. Magnet 616 immediately restores, clearing out the device 1PD[1], and slow-restoring link relay 626 restores a short interval thereafter.

When relay 1127 restores responsive to the described restoration of back-bridge relay 1129, relay 1128 restores to remove ground potential from conductor 1174, extinguishing off-normal lamp 1135, and open-circuiting disconnect relay 1107. A short interval later disconnect relay 1107 restores. At its inner upper contacts it opens the holding circuit of auxiliary relay 1105, permitting the latter relay to restore a moment later.

Conductor 1173 is ungrounded by relay 1105, permitting the locked counting relays 1112 and 1114 to clear out.

The clearing out operation of the selector S5 is now complete, the switching devices involved in the previously established connection having been cleared out as described. Start-in conductor STI of link S1A[1] is transferred back from conductor STO to conductor ST, by relay 1128, to permit finder action through device 1SA[1].

Calling other party-line substations

In the description hereinbefore given the substation called was #6110, Fig. 6, being the 66-cycle substation on the called line #110. It is apparent that a complete party-line telephone number comprises the number of the called line, preceded by a digit indicating which substation on the line is being called, or indicating (more specifically) the frequency of ringing current to be applied to the called line to signal the desired substation thereon. When the 54-cycle substation #5110, for example, is called, the number 110 indicating the called party line has the party-selecting digit 5 prefixed thereto as indicated; the party digit 4 is prefixed to the line number when the 42-cycle substation of line #110 is called; and the party digit 3 is prefixed when the 30-cycle substation on the party line is being called. The same arrangement holds for any other party line of the system.

Referring again to the relay equipment of the selector S5 of Fig. 11, it will be recalled that counting relays 1111 to 1114 of the party-digit group, operated successively responsive respectively to the first four impulses of the party digit 6 during the setting up of the previously described connection; that each of the relays 1111 to 1113 restored responsive to the operation of the next succeeding counting relay; that relay 1114, having once operated remained operated; and that counting relays 1111 and 1112 reoperated successively responsive to the fifth and sixth impulses respectively in the dialed party

digit 6. It will be recalled that the 66-cycle ringing current was sent out through contacts of the operated relays 1112 and 1114, which pair of relays are in operated condition only at the end of a party digit having as many as six impulses therein.

If it be assumed that the selector S5 is being used in setting up a connection to the 54-cycle substation on a called party line, the party digit dialed is the digit 5. In this event, the first four impulses of the digit operate relays 1111 to 1114 successively relays 1111 to 1113 restoring, while the fifth and last impulse of the digit reoperates 1111. The counting relays then operated at the end of the digit are 1111 and 1114. Under this condition, when the connection is completed, and ringing relay 1131 operates as previously described, ringing current from the 54-cycle common lead passes through the front contact of the lower armature of relay 1111 and the said armature, back contact of the middle lower armature of relay 1112 and the said armature, front contact of the lower armature of relay 1114 and the said armature, and thence through upper winding of answer-test relay 1132 to the called line, through closed contacts of the relays 1131 and 1134.

When the 42-cycle substation on the party line is the one called, the party digit dialed contains only four impulses, in which case relays 1111 to 1114 are operated successively, relays 1111 to 1113 restoring. Under this condition, the ringing current is sent out to the calling line from the 42-cycle ringing lead, through contacts of the unoperated relays 1111 and 1112, contacts of the operated counting relay 1114, and thence to the called line through the upper winding of answer-test relay 1132. When the party digit 3 is dialed, counting relays 1111 to 1113 operate successively as previously described, relays 1111 and 1112 restoring. In this event, the ringing current, when transmitted, is from the 30-cycle common ringing lead, through contacts of the operated counting relay 1113, contacts of the unoperated counting relay 1114, and thence to the called line through the upper winding of answer-test relay 1132.

Calling individual-line substations

When an individual-line substation, such as substation #2111 (Fig. 6) of individual line #111, is called, the preliminary digit 2 is prefixed, as indicated, to the number of the called line. Referring again to the relay equipment of the selector S5 (Fig. 11), when the call being made through this selector is for an individual line substation, relays 1111 and 1112 operate successively responsive to the two impulses of the prefixed digit 2 of the desired number, relay 1111 restoring responsive to the operation of relay 1112, relay 1112 remaining operated. Under this condition, when the connection has been completed and the ringing operation started, ringing current is transmitted to the called line from the 16-cycle generator G, through the lower contacts of the operated counting relay 1112, the lower winding of answer-test relay 1132, contacts of the unoperated relays 1113 and 1114, the upper winding of answer-test relay 1132, and thence to the called line, through contacts of the operated relays 1131 and 1134. The windings of answer-test relay 1132 are differentially connected, as indicated. The upper winding of the relay has a suitable number of turns for controlling the operation when any frequency from 30 cycles to 66 cycles is being transmitted, but the effective number of turns is preferably reduced (by the auxiliary, differential lower winding) when 16-cycle ringing current is being transmitted, so as to avoid premature operation of the relay.

With respect to the restoration of transfer relay 1109 following the dialing of any ringing-frequency-selecting digit, it is to be observed that the initial circuit of this relay is opened at the "make-before-break" contacts of any one of the relays 1111 to 1114, whereby the control is transferred at the end of the first digit of any of the stated values.

Absorbing preliminary impulses

The party digit device of the selector S5 is arranged to absorb preliminary impulses; that is, impulses produced by inadvertent opening of the control circuit, such as at the hookswitch contacts, incident to the removal of the receiver. As previously explained, the digit 1 is preferably not assigned as the first digit of numbers, because of the prevalence of the so-called preliminary impulses.

Let it be assumed now that the selector S5 is taken for use as hereinbefore described, relays 1101 to 1106, and transfer relay 1109 operating, and that the control circuit is inadvertently opened momentarily at the calling substation to cause a single momentary restoration of line relays 1102 and 1103, such as is produced by the dialing of the digit 1. Under this condition, the momentary restoration of relay 1103 causes series relay 1108 to be operated through the lower contacts of relays 1103, 1104, 1106, and contacts of relay 1123. Series relay 1108 closes a temporary locking circuit at its lower armature for the operated transfer relay 1109. Also, the momentary restoration of relay 1103 closes a circuit hereinbefore traced for the first party-digit counting relay 1111 over conductor 1172, inner upper contacts of transfer relay 1109, and over conductor 1178, through contacts of relays 1112 and 1113. Relay 1111, upon operating, opens the initial energizing circuit of transfer relay 1109 at the normally closed contacts controlled by its inner upper armature, while at its inner lower armature it closes a locking circuit for itself from ground through the lower contacts of series relay 1108, contacts of relays 1112 and 1114, and the lower contacts of relay 1111, to battery through the winding of the relay. Transfer relay 1109 remains operated for the time being, through its inner lower contacts and the lower contacts of relay 1108.

When line relay 1103 reoperates, it opens the circuit of series relay 1108, but series relay 1108 remains operated for a momentary interval. A circuit is closed at the front contacts of the lower armature of relay 1103, as described hereinbefore, through contacts of the party transfer relay 1109, conductor 1177, and the middle lower contacts of relay 1111 for the lower winding of driver relay 1110. Relay 1110 thereupon operates and prepares a locking circuit for itself and transfers the impulse circuit from odd conductor 1178 to even conductor 1179, as hereinbefore described.

Under this condition, when series relay 1108 restores, it opens the locking circuit of relays 1109 and 1111 at the front contact of its lower armature. With the initial circuit of relay 1109 having been opened at contacts of relay 1111 as described, relays 1109 and 1111 both restore. Driver relay 1110 restores, being open-circuited at the contacts of relays 1109 and 1111. Relay 1111, however, reestablishes the initial circuit of trans-

fer relay 1109 at the contacts controlled by its inner upper armature, whereupon transfer relay 1109 reoperates to again associate impulse conductor 1172 with the counting relays of the operated digit device, whereby the first digit dialed (the preceding operation having been an inadvertent one) is received at the party-digit device.

Revertive-call provisions

As previously mentioned, arrangements, located in the selectors, are provided for enabling a call to be made from any party-line substation to another substation on the same line. The arrangement is such that the regular directory number of the desired party-line substation on the calling line is dialed, whereupon the call is directed through the switching equipment in the hereinbefore described manner to the called line, which is also the calling line. The line called, therefore, tests busy as previously described and the usual busy-tone signal is returned to the calling substation.

Upon receiving the busy-tone signal, the calling subscriber need only replace his receiver for a short interval to allow ringing to take place, the ringing of the desired substation on the line being accomplished automatically responsive to the receiver being replaced, and is terminated automatically responsive to the removal of the receiver at either the calling or the called substation. The two subscribers may converse as desired when they have both removed their receivers.

The stated replacing of the receiver responsive to the busy-tone signal results also in the connection set up by finder action to the selector in use being cleared out to return the finder-action primary unit to common use.

Revertive call on line #110

Let it be assumed now that the subscriber at the 30-cycle substation #3110 on party line #110 (Fig. 6), desiring to converse with the subscriber at substation #6110, removes his receiver, waits for dial tone, and then dials #6110.

When the receiver is removed at substation #3110, line relay 632 operates over the calling line, through contacts of cutoff relay 633, removing ground potential from the associated tenth marking conductor 640 and applying ground potential to start conductor 600. As a result, primary #1 is actuated to select one of the units thereof, the unit 1PA for example, and to position itself into the tenth selective position to select the calling line.

If the device 1PA^1 is the one selected, the connection completed by primary finder action includes the tenth selective-position contacts of the device 1PA^1 and the primary link P1A^1.

It may be assumed that the secondary unit through which the connection is extended by secondary finder action as hereinbefore described is the unit 1SA (Fig. 7), in which case the connection is extended over the secondary link S1A^1 to the selector S5 (Figs. 10 and 11). That being the case, the selector S5 is prepared for operation and the dial-tone signal is sent back to the calling line as hereinbefore described.

When the successive digits in the desired number (6110) are dialed, operations as hereinbefore described occur, with the result that the call is directed toward called line by action of the connector S5, and by connection action of secondary #5, Fig. 7, and primary #1, Fig. 6. It may be assumed that matching occurs in column D in this case, as previously described. The units then involved in the connection between the selector S5 and the called line are the unit SD of Fig. 10, the unit 5SD^1 of Fig. 8, and unit 1PD^1 of Fig. 6.

Since the called line is also the calling line, the called line tests busy, because of the inability of idle-test relay 1133 to operate over the sleeve conductor of the called line, in series with cutoff relay 633, because of the connection therefrom, over the sleeve conductor of the finder-action portion of the connection, to battery through sleeve relay 1101. The busy-tone signalling path from lead BT, through the upper contacts of relays 1128 and 1134, therefore, remains closed, relay 1134 remaining unoperated because of the failure of relay 1133 to operate.

The party-line subscribers are preferably informed, by information cards or otherwise, as to which substations are on the same party line. This information may also be gathered from comparing the number of the calling substation with the number of the called substation.

When the number has been dialed, and the busy-tone signal has been returned as stated, the calling subscriber replaces his receiver to allow ringing current to be applied to the line to signal the desired substation #6110 thereon.

When the receiver is replaced at the calling substation, line relays 1102 and 1103 restore. Relay 1103 opens the circuit of release relay 1104, but relay 1104 remains operated for a moment, being slow-restoring. Since switching relay 1134 has not operated under the present assumed conditions, dial-tone relay 1106 has not been restored. Accordingly, the restoration of line relay 1103 closes a circuit, through the lower contacts of relays 1104 and 1106 and contacts of relay 1123 for series relay 1108. Upon operating, series relay 1108 prepares a locking circuit for itself at its inner upper armature. With relay 1108 now in operated condition, relay 1108, at its upper armature, closes a local holding circuit for sleeve relay 1101, at the same time disconnecting sleeve relay 1101 from sleeve conductor S of the link S1A^1, and consequently from cutoff relay 633 of the calling (and called) line. The local holding circuit of sleeve relay 1101 is as follows: from ground through the upper armature and front contact of series relay 1108, armature 1155 and its front contact, armature 1142 and its front contact, to battery, through the winding of sleeve relay 1101. Sleeve relay 1101 remains operated in its local circuit; cutoff relay 633 remains operated (through contacts of the devices 1PD^1, 5SD^1, and SD), through the inner upper armature of relay 1122 and its back contact, to battery through local sleeve conductor 1178 of the selector S5. From conductor 1188 one branch of the holding circuit of the cutoff relay is to battery through transfer-control relay 1127, while another branch circuit is through contacts 1146 of disconnect relay 1107, over conductor 1189, contacts of relay 1134, and the windings of idle-test relay 1133, to battery. Idle-test relay 1133 operates in its branch of the holding circuit of the cutoff relay, with results substantially as hereinbefore described, including the preparation of the ringing circuit and the operation of switching relay 1134 over the sleeve connection to the called line, through the inner upper contacts of idle-test relay 1133.

Switching relay 1134 completes the ringing circuit to the called line from armatures 1156 and 1157 of ringing relay 1131; open-circuits dial-tone

relay 1106 at armature 1116, at the same time closing a locking circuit, at armature 1166, to hold series relay 1108 operated after its initial circuit has been opened at contacts of relays 1104 and 1106.

Ringing relay 1131 now operates intermittently, through contacts of relays 1132 and 1133, from common interrupter 1139 to apply ringing current of the selected frequency to the called party line to intermittently operate the ringer at the called substation thereon.

When slow-acting release relay 1104 restores, as it does a moment after the described restoration of lined relay 1103, it closes an operating circuit for disconnect relay 1107 from conductor 1174, grounded at off-normal contacts 1136. Relay 1107 thereupon operates to control the clearing out of the finder-action portion of the connection as hereinbefore described, including the restoration to normal of the common mechanism of the selector S5.

The opening of the series holding circuit for the operating magnets of the primary and secondary units 1PA1 and 1SA1 at contacts 1147 permits the stated units to clear out, opening the portion of the connection established by finder action, and returning the primary unit 1PA1 to common use.

The secondary unit 1SA1, being linked to the selector S5 by the link S1A1, is not returned to common use, as the selector S5 is still in use. The operated condition of transfer relay 1128 maintains the start conductor ST of the link 1SA1 by-passed, at its inner lower armature, to thereby by-pass start relay 725 of unit 1SA1, even though the contacts controlled by magnet 707 are in normal position.

With series relay 1108 held locked operated (through contacts 1166 of the operated switching relay 1134), contacts 1148 of disconnect relay 1107 are shunted at contacts 1150, whereby the locking circuit remains closed for the lower winding of relay 1133, and the ringing operation is not interfered with by the described operation of relay 1107 during the clearing out of the selector. Also, with relay 1133 operated, contacts 1146 of disconnect relay 1107 are shunted (through contacts 1149 and 1159) to maintain the circuit of switching relay 1134 intact.

Assume now that the subscriber at the called substation #6110, Fig. 6, responds by removing his receiver, thereby closing the usual direct-current bridge across the conductors of line #110. When this occurs, the ringing operation of the selector S5 is terminated as hereinbefore described, relay 1133 being restored responsive to the operation of back-bridge relay 1129 over the calling line in series with retard coil 1130. At its upper contacts, back-bridge relay 1129 joins the local sleeve conductor 1188 to conductor 1189 so as to furnish a holding circuit to the sleeve conductor of the called line for switching relay 1134 after contacts 1159 have opened upon the restoration of relay 1133. As soon as the calling subscriber at substation #3110 removes his receiver, the two subscribers may converse over the party line as desired, talking current being supplied to the two substations in parallel through the windings of relay 1129 and device 1130.

When the conversation has been concluded and the two subscribers replace their receivers, the consequent restoration of back-bridge relay 1129 disconnects the local sleeve conductor 1188 from conductor 1189 thereby open-circuiting and restoring switching relay 1134, relay 1133 having been restored and contacts 1146 of disconnect relay 1107 being maintained open. Relay 1134 opens the associated tip and ring conductors; unlocks series relay 1108 at armature 1116; and at armature 1162 it disconnects ground potential from conductor 1185 and consequently from conductor 1184, disconnect relay 1107 being in operated condition, thereby opening the holding circuit previously existing through the inner contacts of cutoff relay 1125 and over conductor 1021, for seizing relay 1006 of the device SD. Relay 1006 thereupon restores, permitting the device SD, the device 5SD1 of Fig. 8, and the device 1PD1 of Fig. 6 to return to normal condition, clearing out the connection to the called line.

Series relay 1108 restores responsive to the previously mentioned opening of its locking circuit at the contacts 1166 of relay 1134. Sleeve relay 1101 restores responsive to the restoration of relay 1128, when its local holding circuit is opened at armature 1155.

When the connection is cleared out, the opening of the sleeve conductor thereof permits relay 1127 of the selector S5 to restore, followed by the restoration of relay 1128. Relay 1128 removes ground potential from conductor 1174, thereby open-circuiting disconnect relay 1107. Relay 1107 restores a moment later, followed by the restoration of relay 1105. At the lower armature of relay 1128, the associated start-in conductor STI is disconnected from the start-out conductor STO and again joined to the start conductor ST of the link S1A1, thereby placing the start relay 725 of the device 1SA1 again under the control of the associated incoming start conductor 641.

The connection established through the selector S5 to the called line is thus completely cleared out and the selector S5 and the associated secondary unit 1SA1 of Fig. 7 are again rendered available for use.

Calls to other hundreds

As described, the selector S5 has ten selective-position stackups in each of its devices SA to SD (Fig. 10), and each of the selective-position stackups of any device SA to SD leads to an incoming branch link of a separate hundreds group, as shown for the #1 selective-position stackups of the said devices (leading to links of the first hundreds), and indicated for the remaining selective-position stackups. This arrangement is as described hereinbefore in connection with Figs. 1 and 2. Through the other selective position contacts of devices SA to SD calls to any other hundreds group may be made, the dial and match-test leads being taken to the called hundreds group by brushes 1001 and 1000.

Calls from other hundreds

As shown in Fig. 9, the conductors reached through the first selective position contacts of the selector S5 (DL—5 and MT—5, and the conductors of links S5A1—I to S5D1—I) are reached, not only from selector S10 (Fig. 2) of the same hundreds, but also from selectors in hundreds #2 to #10. As shown in Fig. 2 and explained hereinbefore in connection therewith, calls from the selectors of the other hundreds reach the incoming links of the first hundreds and proceed thereover, in the same way as calls originating in the first hundreds group.

It is to be observed that leads DL—1 and

NM—1 (Fig. 7) of secondary #1 are labeled "From hundreds 1 to 10," and that the same label is applied to the incoming link S1A1—I (Fig. 11) and to the links S1B1—I to S1D1—I (Fig. 9), all associated with secondary #1. Similarly, as shown and described in connection with Figs. 1 and 2, the incoming branch links of secondaries #2 to #4 are accessible from the selectors of all the hundreds groups.

Finder action in other columns

In the foregoing description, finder action in column A (through primary #1 and secondary #5) was described. From this description, it will be clear how finder action occurs from the column-A unit of any primary through the column-A unit of any secondary, as the primaries are all similar and as each secondary unit, on operation, extends the starting control downwardly to the next succeeding secondary to enable that secondary to respond in the same column to a further calling condition in column A of the primaries. Consideration will now be given briefly to finder action in the other columns.

It will be recalled that the order of preference for finder action is from column A to column D. It was further explained that when the column-A unit 1PA1 of primary #1 (Fig. 6) is operated, it shifts the finder-action control (at the upper contacts of its stackup *b*, to the column-B unit 1PB1, if idle, and so on the column-C unit 1PC1, finally to the column-D unit 1PD1, when the preceding units are all in use. Suppose now that any one of the units 1PB1 to 1PD1 is operated in finder action. In this case, the concerned one of the start conductors BS, CS, and DS is grounded to thereby cause operation of the concerned one of the marking-control relays XB to XD, as described hereinbefore in connection with relay XA. Whichever one of these relays operates places ground potential, at its lower contacts, on the associated start conductor of the corresponding column of secondary units, causing the first idle one thereof to be allotted or selected for finder action by the operation of the concerned one of the individual start relays, such as 726 to 728 of secondary #1.

It will be recalled that there is a secondary start chain for each column and that when the unit in a secondary column operates it extends the starting control to the next idle unit, to thereby cause finder action in such unit, under the control of the common secondary mechanism associated therewith.

Dummy-selector operation

The operation of the dummy selectors (such as DS1 to DS10 of the first hundreds, and DS11 to DS20 of the second hundreds, Fig. 2) is exemplified by the following description of the operation of the dummy selector DS10 (Figs. 2 and 12) when it is seized during one of those rare times when finder-action calls overflow temporarily from the selectors into the dummy selectors.

When the dummy selector DS10 (Fig. 12) is taken for use, it is through finder action of secondary unit 5SD1, responsive to finder action in column D of any one of the primaries. When this occurs, battery potential is applied at the upper contact pair of the *b* stackup of the device 5SD1 to the branch hold lead H1 of link S5D1, and thence over hold conductor H of the said link, through the H contacts in the operated selective-position stackup, to operate the primary link relay (such as relay 628), to extend the sleeve and hold conductors of the actuated primary device to the associated primary link, such as P1D1. When this occurs, an operating circuit for sleeve relay 1201 in series with the cutoff relay of the calling line is completed, over the sleeve lead of the primary link, through contacts of device 5SD1 to the sleeve conductor S of the link S5D1, and thence, through contacts of the actuated start relay 628, over the branch sleeve conductor S1 of link 5SD1, to battery through the winding of sleeve relay 1201. Sleeve relay 1201 thereupon operates and locks itself to the sleeve conductor S of the link 5SD1, at the same time disconnecting the sleeve conductor S of the incoming branch S5D1—I; it extends the tip and ring conductors T and R of the link S5D1 to the windings of line relay 1203; and at its inner armature it disconnects the hold conductor H of the incoming link S5D1—I and completes a holding circuit for operating magnet 816 as follows: from battery through the winding of magnet 816, upper contacts of associated *a* stackup, conductor H2 of link S5D1, contacts of relay 1205, contacts of the operated sleeve relay 1201, conductor H of link S5D1, contacts of the operated sleeve relay 1201, conductor H of link S5D1, contacts of unit 5SD1, and thence to ground over the H lead of the connected primary link, such as link P1D1.

A moment later start relay 628 restores responsive to being disconnected upon the operation of magnet 816, disconnecting conductor S1 from the sleeve conductor S, leaving sleeve relay 1201 locked operated over the associated sleeve conductor S.

Line relay 1203 operates over the calling line responsive to being connected up by sleeve relay 1201; it brings about the successive operation of relays 1204 and 1205. Relay 1204 shunts the inner contacts of relay 1205 to prevent a premature opening of the holding circuit for magnet 816. At the upper contacts of relay 805, conductor H1 of the link is disconnected from conductor H, thereby opening the initial circuit over which battery potential was applied to the H lead of the primary link through the resistor associated with the upper contact pair of the *b* stackup of the unit 5SD1, leaving battery potential applied to the said conductor through the operating magnet 816, by way of the holding circuit previously traced therefor.

The relays 1201 and 1203 to 1205 of the dummy selector DS10 remain operated for as long a time as the calling subscriber leaves the receiver off the hookswitch. From the foregoing description, it will be recalled that the calling subscriber hears a dial-tone signal almost immediately when the call is successfully extended to a selector. When the connection is extended to a dummy selector such as DS10, no dial-tone signal is heard, and the calling subscriber is expected to replace his receiver and again remove it to clear out the unsuccessful finder-action connection and cause finder action to again occur, which second finder action will extend connection to a selector in the event that one has become available in the meantime.

When the receiver is replaced at the calling substation, line relay 1203 restores, followed a moment later by the restoration of release relay 1204, followed in turn a moment later by the restoration of auxiliary relay 1205. In the interval required for slow-restoring relay 1205 to

restore following the restoration of relay 1204, the conductor H2 of the link S5D[1] is disconnected from conductor H thereof, opening the holding circuit of the operating magnet 816 of unit 5SD[1], and of the operating magnet of the calling primary unit, whereupon the primary and secondary units clear out as hereinbefore described. When these units clear out, sleeve relay 1201 restores. The clearing-out operation is completed upon the restoration of auxiliary relay 1205, returning the dummy selector DS10 to its illustrated normal condition.

Connector action in other columns

In the foregoing, connector action in column D, through unit SD of the selector S5 (Fig. 10), secondary unit 5SD[1] (Fig. 8), and primary unit 1PD[1] (Fig. 6), was described. The column in which connector action takes place, as indicated in the foregoing description, depends upon the matching operation, for the one of the seizing relays (such as 1003 and 1006 of selector S5) which operates is dependent upon in which column matching occurs.

It was described hereinbefore that the mutually exclusive action of the U relays (including U1 of secondary #1, and U5 of secondary #5, Figs. 7 and 8) prevents more than one secondary and one primary from being in matching condition at the same time; that is, during a matching operation the vertically extending matching conductors AR, BR, CR, DR, AG, BG, and CG (Figs. 6 to 8) are rendered temporarily individual to one calling secondary and its called primary, during the moment required for the matching operation to occur.

Assuming again that the selector S5 of Figs. 10 and 11 is in use, in a call to a line in the 10-line group served by primary #1 of the first hundreds (Fig. 6), the matching operation will be described for each of the four columns.

Review of the matching operation in column D

Let it be assumed that the operation has proceeded until relay U5 (Fig. 8) has been operated by secondary #5, following the positioning of the secondary in accordance with the tens digit 1 onto primary #1 (Fig. 6), and the matching relays S5J (Fig. 8) and P1J (Fig. 6) have operated in series over the previously traced circuit, including the brush of the commutator COM—S5 in its first selective position, contacts of the operated relay U5, and conductor J1 of the cable J. If the column-D device 5SD[1] of the calling secondary and the column-D device 1PD[1] of the called primary are both idle, matching takes place in column D, and column D only, as herebefore described, because none of the ground leads CG, BG, and AG of the other columns is energized, wherefore matching cannot take place in the other columns. With the units 1PD[1] and 5SD[1] both idle, a matching circuit hereinbefore traced is effective for energizing the lower winding of shift relay 824 and the lower winding of shift relay 624 in series over the column-D relay bus DR. This matching circuit is from ground through the outer contacts (shown in Fig. 8 part 3) of the secondary matching relay S5J (shown in Fig. 8 part 1) through *b*-stackup contacts of unit 5SD[1], the lower winding of shift relay 824, column-D relay bus DR, lower winding of shift relay 624, the associated *b*-stackup contacts, and thence, through contacts of relay P1J, to battery.

Matching in column C

If the column-D unit of 1PD[1] of the called primary is in use, the above-traced matching circuit is held open at the lower contact pair of the *b* stackup thereof, whereby matching in column D is prevented. Under this condition, ground potential is extended to the column-C ground bus CG at contacts of relay P1J, through the upper contact pair of the actuated *a* stackup of contacts of device 1PD[1], to enable matching to occur in column C.

On the other hand, if the column-D primary unit is idle, and the column-D secondary unit 5SD[1] is in use, the previously traced matching circuit is open at the lower set of stackup *b* of the unit 5SD[1], and ground potential is extended, through the outer contacts of relay S5J, through the shofted lower *b* contacts, and thence through the lower contacts of shift relay 824, to the column-C ground bus CG.

If the column-D units are in use in both the calling secondary and the called primary, the column-D matching circuit is open at two points, and ground potential is extended at two points to the column-C bus CG.

With ground potential thus applied to the column-C ground bus CG, under either of the three conditions named above, matching can take place in column C and column C only, provided the concerned column-C primary and secondary units are both idle. Under this condition, the matching circuit for the lower windings of relays 823 and 623 is as follows: from ground potential on bus CG, through contacts of relay S5J, the lower contacts of stackup *b* of the unit 5SC[1], the lower winding of shift relay 823, column-C relay bus CR, lower winding of shift relay 623, and thence to battery, through contacts of the associated *b* stackup and of relay P1J.

Matching in column B

If matching cannot occur in column D, and the column-C unit 1PC[1] of the called primary is in use, the above-traced matching circuit is open at the shifted *b* stackup of contacts thereof, preventing matching in column C. At the same time, ground potential, obtained from the grounded column-C bus CG, is extended through contacts of the operated relay P1J, and through the upper contact pair of the shifted *a* stackup of unit 1PC[1], to the column-B ground bus BG.

On the other hand, if the primary unit is idle and the secondary unit 5SC[1] is in use, the above-traced column-C matching circuit is open at the shifted *b*-stackup contacts, and the ground potential on the column-C ground bus CG is extended through contacts of relay S5J, the shifted contacts, by way of the lower contacts of shift relay 823, to the column-B ground bus BG. If the column-C primary unit and the column-C secondary unit are both in use, the column-C matching circuit is open at two points, and a double connection is made from the grounded bus CG to the bus BG.

Under any of the three conditions named, if the column-B units of the calling secondary and the called primary are both idle, the following column-B matching circuit is complete: from ground on column-B ground bus BG, through contacts of relay S5J, the lower contacts of the *b* stackup of unit 5SB[1], the lower winding of shift relay 822, the column-B relay bus BR, the lower winding of shift relay 622, and thence to battery through the associated *b*-stackup contacts, and contacts of relay P1J.

Let it be assumed now that the column-A secondary devices are all in use when primary device 1PA[1] is operated in finder operation. In this event, the holding circuit established for magnet 607 (through contacts of link relay 625, over conductor A of cable 668, to battery through relay 673) remains closed long enough for the release timer RT to operate, assuming that a column-A secondary unit does not become idle in the meantime.

Column-A start relay 673 operates when the holding circuit is established through its winding for any column-A primary unit. Upon the first closure of the interrupter 678 following the operation of column-A start relay 673, a circuit is closed through the inner contacts of start relay 673, and through contacts of relay 672, for relay 671 of the pick-up pair. Relay 671 thereupon operates and closes a locking circuit for itself in series with relay 672, to ground through the lower contacts of start relay 673. Relay 672, however, does not operate for the time being because it is short-circuited by ground potential applied to both terminals of its winding.

When interrupter 678 next opens (a moment later), the shunt is thereby removed from around the winding of relay 672, whereupon relay 672 operates in series with relay 671. Upon operating, relay 672 prepares a circuit for cutoff relay 677.

Upon the next operation of interrupter 678 (two seconds later for example), cutoff relay 677 operates, unless start relay 673 has in the meantime been restored by secondary finder action having occurred. Upon operating, cutoff relay 677 locks itself directly to the brush of interrupter 678 at its lower contacts, at the same time disconnecting each of the start relays 673 to 676 and maintaining them disconnected for as long a time as the interrupter remains closed. The operated start relay 673 thereupon restores, clearing out the pick-up relays 671 and 672.

Cutoff relay 677 restores as soon as the interrupter 678 next opens, clearing out the release timer.

Responsive to the disconnection of battery potential (applied through relay 673) from conductor A of cable 668, operating magnet 607 of unit 1PA restores, whereby the calling line is freed, and remains free if the calling subscriber has in the meantime replaced his receiver. Since the release timer RT treats all four columns alike, any other unit of the primary #1 can be cleared out similarly. Additionally, the units of the other primaries may be cleared out in the same way, for each of the conductors A to D of cable 668 is common to the ten primary units of the associated column.

Delay in dialing the tens and units digits

The purpose and operation of the delay timer, including relays 1124 and 1125 of the selector S5, will now be explained. The purpose of the delay timer is to time and to forcibly free a seized primary or secondary, as the case may be, and return a busy signal to the calling line, if the dialing of either the tens digit or the units digit is unduly delayed. The utility of this timing arrangement will be appreciated when it is recalled that two selectors in each hundreds group (twenty selectors in all) have common access to one secondary for connector action and that all of the secondaries of the same hundreds group have access to any primary for connector action. Delay in dialing the party digit or in dialing the hundreds digit, while it extends the holding time of the selector, is not particularly objectionable as only the concerned link path is thereby held up.

Let it be assumed now that the selector S5 has been taken for use, and that a party digit has been dialed, followed by the dialing of a hundreds digit to set the mechanism of the selector S5, shown in Fig. 10, into a position corresponding to the desired hundreds group. At the end of this digit, transfer relay 1118 operates responsive to the hereinbefore described operation of change-over relay 1117, and locks itself to ground through contacts of relay 1121 in series with the *b*-stack-up contacts of devices SD to SA, Fig. 10, to ground on conductor 1171. As described, relay 1118 remains operated over this circuit until the tens digit has been dialed, whereupon the locking circuit is opened when group-connect relay 1120 brings about the operation of units SA to SD, relay 1118 restoring shortly thereafter.

In the event that the calling subscriber delays in beginning to dial the tens digit, following the described operation of transfer relay 1118, the following operation of delay-timer relays 1124 and 1125 occurs.

The first time (after transfer relay 1118 operates) that interrupter 1138 reaches pick-up position and momentarily grounds pick-up conductor 1181, pick-up relay 1124 operates through the lower contacts of relay 1118 and connects cutoff lead 1182 to cutoff relay 1125. At its lower armature relay 1124 locks itself to ground through contacts of relay 1118, at the same time freeing the pickup lead 1181. Then, when interrupter 1138 next reaches cutoff position (say, 5 seconds later) and grounds cutoff conductor 1182, cutoff relay 1125 is operated through contacts of pick-up relay 1124. Upon operating, cutoff relay 1125 locks itself to conductor 1175 (grounded at the middle lower contacts of release relay 1104), at the same time opening its initial circuit to free lead 1182. At its upper contacts, cutoff relay 1125 removes ground potential from armatures 1145 of dial-tone relay 1106 to preclude operation of any one of the seizing relays 1003 to 1006; it disconnects the grounded conductor 1184 from locking conductor 1021 to thereby preclude any one of the relays 1003 to 1006 from locking operated or remaining locked operated; and at its lower contacts it completes a connection from the grounded conductor 1175 to the upper winding of special-test relay 1121, whereupon relay 1121 operates to disconnect the dial-tone lead DT and to substitute the busy-tone lead BT, thereby returning a busy signal to the calling substation. Transfer relay 1118 restores incident to the opening of the lower contacts of relay 1121, freeing the dial lead seized through commutator 1001, by disconnecting the brush thereof at the front contact of the middle upper armature of relay 1118.

In the event that the subscriber has dialed the tens digit, followed by a successful matching operation as hereinbefore described, and then delays too long before dialing the units digit, the described operation of relays 1124 and 1125 occurs responsive to the closure of the lower contacts of relay 1123 when connection is established by connector action to the called primary. In this event, the described operation of cutoff relay 1125 results in the clearing out of the mechanism of the selector to free the matched unit of the secondary and the called primary, in addition to operating relay 1121 to return a busy signal.

Matching in column A

In the event that matching cannot occur in either column D or column C, and the column-B primary unit 1PB[1] is busy, the column-B matching circuit is open at the associated *b*-stackup contacts, and ground potential from the ground bus BG is extended through contacts of relay P1J and through the shifted *a*-stackup contacts to the column-A ground bus AG.

On the other hand, if the column-B primary unit is idle, and the column-B secondary unit is in use, the above-traced matching circuit is open in the unit 5SB[1], and ground potential from the column-B ground bus BG is extended to the column-A ground bus AG.

If the column-B primary unit and the column-B secondary unit are both in use, the column-B matching circuit is open at two points, and ground potential is extended at two points to the column-A ground bus AG.

Under any one of the three conditions last named, if the column-A units of the calling secondary and called primary are both idle, the column-A matching circuit is complete as follows: from ground on the column-A ground bus AG, through contacts of relay S5J, *b*-stackup contacts of unit 5SA[1], lower winding of shift relay 621, column-A relay bus AR, lower winding of shift relay 621, the associated stackup-*b* contacts, to battery, through contacts of relay P1J.

If either of the column-A units of the calling secondary and the called primary is in use, the above-traced matching circuit is open at the shifted *b*-stackup contacts, in which case matching cannot take place in column A. In this event, the previously described action of special-test relay 1121 in the calling selector S5, controlled over the matching-test lead MT—5, sends back a busy signal to the calling line to inform the calling subscriber that the connection cannot be completed for the moment.

Returning again to the selector S5 of Figs. 10 and 11, it was described hereinbefore that matching in column D is followed by operation of seizing relay 1006 to close a holding circuit for magnet 1016 of the unit SD, taking the matched column-D path to the called primary for use. When matching occurs in one of the other columns, relay 1006 is not operated and the concerned one of the seizing relays 1003 to 1005 is operated, depending upon in which column matching takes place. The other actuated units of the selector mechanism are cleared out as hereinbefore described upon restoration of relay 1120, which occurs a moment after the short interval allotted for matching.

Matching through other primaries and other secondaries

When secondary #1 for example is the calling secondary instead of secondary #5, relays U1 and S1J are operated instead of relays U5 and S5J, relay S1J being operated through contacts of relay U1 and the brush of the commutator COM—S1, over one of the conductors J1 to J10 of cable J, in series with the J relay of the called primary. Relay S1J associates the common matching conductors with the units 1SA to 1SD of secondary #1 as described hereinbefore in connection with the units of secondary #5, and matching takes place in one of the columns from D to A as hereinbefore described, unless all the available paths are in use.

When the called primary is some other than primary #1, Fig. 6, the J relay therein corresponding to relay P1J is operated in place of relay P1J, and the units of the other primary are thereby associated in a similar manner with the common matching conductors.

It has been pointed out hereinbefore how only one secondary J relay can be operated at a time, because of the mutually exclusive action of the U relays. This action suffices to insure that only one J relay (such as P1J) of a primary can be operated at a time, because any primary relay is operated in series with the J relay of the calling secondary, and that J relay can be connected at any one time with only one of the ten leads J1 to J10 of cable J.

Secondary finder action delayed

As seen from the foregoing description, secondary finder action ordinarily takes place immediately following primary finder action, to extend a connection from the calling line to an idle selector. It happens occasionally that primary action in a given column is not followed immediately by secondary action in that column because all the secondary devices in the concerned column are in use.

When all of the secondary devices in a given column are in use, the corresponding one of relays XA to XD (Fig. 6) cannot operate. The reason is that the associated group conductors (681 and 682 for column A, 683 and 684 for column B, 685 and 686 for column C, and 687 and 688 for column D) are separated when all the secondary units are in use. Considering group conductors 681 and 682, for example, when all the column-A secondary units are in use, conductors 681 and 682 are separated at the lower contact pair of the *a* stackup of each of the column-A secondary units, thereby preventing relay XA from operating, thus preventing needless association of the common marking conductors M1 to M10 with the column-A marking conductors AM1 to AM10.

Under a busy condition of the column-A secondaries, any column-A primary unit which operates in finder action is temporarily held in a locked condition not immediately subject to release upon the replacing of the receiver at the calling substation. Consider, for example, the column-A unit 1PA[1] of primary #1. When this unit operates, the operating magnet thereof closes a holding circuit for itself at the lower contact pair in the associated *a* stackup, to battery through normally closed contacts controlled by the middle armature of link relay 625. Ordinarily, this holding circuit is transferred through a secondary device to a selector, and is subsequently opened as hereinbefore described when the selector clears out responsive to the receiver being replaced at the calling substation. The replacing of the receiver at the calling substation has no control over the releasing of the operated primary device until link relay 625 has been operated as a result of the primary unit being found by one of the column-A secondary units.

In order to enable operated primary units to be cleared out when all of the secondary units in the same column are busy, the previously mentioned release timer RT (Fig. 6) is provided. This release timer includes four start relays 673 to 676, associated respectively with the temporary primary holding circuits of columns A to D. In the normal operation of the system, the release timer RT has insufficient time to operate before the holding circuit is cleared therefrom by secondary finder operation.

mutator is passing from one contact to another.

When the mechanism of the primary reaches the position occupied by the calling link Z1, the brush of commutator 1601 is deprived of ground potential, because ground potential has been removed from the marking conductor M of link Z1 by the upper armature of the operated zero-call relay 1126 of the selector S5 as described. Under this condition, no further operation of the motor magnet MM occurs, and the holding circuit for the lower winding of test relay 1603 is open.

A moment later, relay 1603 restores and opens the initial circuit of shift magnet 1633, leaving this magnet operated through resistor 1607 and the upper contacts of hold relay 1604. Relay 1603 also open-circuits hold relay 1604. Being slow-restoring, relay 1604 remains operated for an interval. At the same time, the inner lower armature of relay 1603 closes a circuit, through contacts of slow-restoring hold relay 1604, over conductor 1665, and through contacts of the actuated shift magnet 1633, for operating magnet 1631. Magnet 1631 thereupon operates. When it does so, in addition to shifting the associated *a* and *b* stackups, it closes the selected #1 stackup, thereby extending the conductors of the link Z1 through the device 1PA^x to link P1A^x. The closing of the sleeve contacts of the actuated stackup #1 completes a circuit in parallel with the winding of magnet 1631 for cutoff relay 1621 as follows: from ground, on operating conductor 1665, through contacts of the actuated shift magnet 1633, sleeve contacts of the associated #1 stackup, the associated sleeve conductor S, and thence to battery through the winding of cutoff relay 1621. Cutoff relay 1621 thereupon operates. Upon so doing, it replaces ground potential on mark conductor M and disconnects the grounded incoming sleeve conductor S from the start conductor 1608, thereby terminating the calling condition of the link Z1. The grounded sleeve conductor S incoming from the calling selector S5 is connected, through the front contacts of the upper armature of relay 1621, to the sleeve conductor S local to the multiple of units 1PA^x and 1PB^x, thereby completing a holding circuit, through the sleeve contacts of the actuated stackup #1 of unit 1PA^x for the operating magnet 1631, whereby this magnet is maintained operated after the initial application of ground potential to operating conductor 1665 has been terminated and shift magnet 1633 has restored.

As a result of the shifting of the *b* stackup of unit 1PA^x, unit-selecting conductor 1661 is disconnected from shift magnet 1633 and transferred to conductor 1662, extending to the column-B unit 1PB^x, to prepare for the handling by the unit 1PB^x of the next zero-operator call from the same hundreds group.

Shift magnet 1633 is slow-restoring, as indicated, whereby the contacts thereof maintain the initial circuit of operating magnet 1631 closed until cutoff relay 1631 has operated as described to complete the described locking circuit for magnet 1631. Upon restoring, a slight interval following the operation of magnet 1631, shift magnet 1633 permits the shift plate 1632 to return to its normal position and the associated contacts to open, thereby opening the initial circuit of the now-locked operating magnet 1631.

The holding resistor 1607, through which ground potential is maintained applied to conductor 1661 after test relay 1603 restores to effect operation of the selected primary unit, so limits the current flow over conductor 1661 that shift magnet 1636 of unit 1PB^x is not operated at this time.

If one of the other links of the same hundreds group, the link Z10 for example, has in the meantime been seized at another of the selectors, the described operation of cutoff relay 1621 (while removing one ground connection from start conductor 1608) leaves conductor 1608 grounded through the upper contacts of cutoff relay 1622, whereby start relay 1605 does not restore.

With start relay 1605 being held operated, when hold relay 1604 restores, as it does a moment after test relay 1603 restores, test relay 1603 is immediately reoperated, through contacts of the restored hold relay 1604, to again start the mechanism of the primary #1 in search of the last-named calling link. At this time, the ground potential applied at the upper contacts of test relay 1603, through contacts of start relay 1605, to selecting conductor 1661, reaches conductor 1662 through the shifted *b* stackup of unit 1PA^x, thereby operating shift magnet 1636 of the unit 1PB^x. The unit 1PB^x is thereby selected for operation, and the concerned selective-position stackup thereof makes connection with the calling link when the mechanism of the primary (which operates again as described responsive to the reoperation of test relay 1603) reaches the position occupied by the last-named calling link.

On the other hand, if no further call has arrived in the meantime (as is usually the case), the described operation of cutoff relay 621 removes ground potential from start conductor 1608, whereupon start relay 1605 restores. Under this condition, test relay 1603 does not reoperate responsive to the restoration of hold relay 1604, a moment later.

Secondary finder action

Upon the shifting of the *a* stackup contacts incident to the described operation of unit 1PA^x, ground potential is disconnected from the associated mark conductor (conductor 1 in cable 1666), and is applied through contacts of link relay 1642 to start conductor 1669, common to the first-choice column-A and column-B secondary units. When this occurs, if the column-A or the column-B unit of the secondary #1 (Fig. 17) is idle, the following start circuit is closed: from ground on start conductor 1669, through *b*-stackup contacts of one or both of units 1SA^x and 1SB^x, contacts of start relay 706 (assuming relay 706 to be in restored condition), through start relay 1705 to battery. Relay 1705 thereupon operates. At the inner upper contacts of relay 1705, the upper winding of test relay 1703 is energized through contacts of hold relay 1704. Relay 1703 thereupon operates, and (assuming that the secondary is in some position other than the #1 position occupied by the calling link P1A^x, and is in position 4, for example) it locks its lower winding to the brush of commutator 1701, through contacts of start relay 1705. At its upper contacts, assuming the secondary unit 1SA^x to be idle, test relay 1703 closes a circuit, through the middle upper contacts of the start relay 1705, over conductor 1761, and through the lower *b*-stackup contacts of unit 1SA^x for shift magnet 1733. Magnet 1733 thereby operates to prepare the unit 1SA^x for operation by shifting the plate 1732 and closing a point in the circuit of operating magnet 1731.

Hold relay 1704 operates responsive to the operation of test relay 1703. At its inner upper contacts, it opens the initial circuit of relay 1703, leaving relay 1703 operated in the previously described locking circuit including its lower winding.

Motor magnet 1702 operates through the lower contacts of relays 1703 and 1705 and the brush of commutator 1701 until the position occupied by the calling link P1A^x is reached, whereupon the operation ceases because of the ungrounded condition of marking conductor 1 of cable 1666, previously ungrounded (as described) at the *a* stackup contacts of unit 1PA^x. At the same time, the lower winding of test relay 1703 is open-circuited resulting in the restoration of relay 1703 a moment later. Upon restoring, relay 1703 disconnects its lower winding and the motor magnet 1702 from the brush of the commutator 1701 at its lower contacts, and at its inner lower armature it open-circuits slow-restoring hold relay 1704, and completes a circuit through contacts of relay 1704, over conductor 1765, for the winding of operating magnet 1731, through contacts of the operated shift magnet 1733. Shift magnet 1733 is being maintained operated at this time through the upper contacts of hold relay 1704 and resistor 1707.

When operating magnet 1731 operates, in addition to shifting the *a* and *b* stackups, it closes the selected #1 stackup of contacts, seizing the calling primary link P1A^x. When this occurs, the ground potential on conductor 1165 is extended temporarily, through contacts of shift magnet 1733, and the sleeve contacts of the actuated selective-position stackup, to the sleeve conductor S of the link P1A^x. When this occurs, link relay 1643 operates and locks itself to the grounded sleeve conductor S of the calling zero link Z1, through contacts of the actuated device 1PA^x. Ground potential from the calling selector S5 is thereby locked onto the sleeve lead S of the link P1A^x to maintain operating magnet 1731 actuated after its initial circuit is opened, as it shortly is, upon the restoration of slow-restoring shift magnet 1733, a moment later.

At its inner armature, relay 1643 removes ground potential from start conductor 1669 and applies it to the associated marking conductor, thereby regrounding marking conductor 1 in cable 1666. The calling condition of the link P1A^x is thereby terminated, whereupon start relay 1705 restores.

Shortly after the described restoration of test relay 1703, slow-restoring hold relay 1704 falls back, completing the clearing out of the common equipment of the secondary.

Upon the actuation of the upper contact set in the *b* stackup of unit 1SA^x, the start conductor 1669 is extended to the *b* stackup of unit 1SB^x, whereat it may be extended to the column-A and B units of the second secondary in the event that the unit 1SB^x is then in use, or is later taken for use.

At the lower set of contacts of the *b* stackup of unit 1SA^x, the selecting circuit is shifted from shift magnet 1733 to shift magnet 1736, open-circuiting shift magnet 1733. Magnet 1733 is slow-restoring, as indicated, to give time for the described holding circuit for magnet 1731 to become closed by the operation of link relay 1643.

Signalling the zero operator

Upon the closure of the lower pair of contacts of the *a* stackup of unit 1SA^x, retard coil 1743 is bridged across the conductors T and R of the two-conductor trunk line TR1, extending to the jack J1 at the switchboard of the zero operator. When this occurs, line relay 1781 is operated over the trunk line TR1, through contacts of cutoff relay 1782. Upon operating, line relay 1781 lights the individual call lamp 1783.

When the zero operator responds to the lighted condition of lamp 1783, by inserting the answering plug of a cord circuit into the jack J1, connection is thereby made with the tip and ring conductors T and R of the trunk TR1. When this occurs, cutoff relay 1782 operates through the sleeve of the jack J1 to disconnect line relay 1781. Relay 1781 thereupon restores, extinguishing the call lamp 1783.

The zero operator may now converse with the calling subscriber over the talking conductors T and R of the links Z1 and P1A^x, and the trunk line TR1. The zero operator may further extend the connection in any well known or desired manner.

Clearing out the connection

When the calling subscriber replaces his receiver, following the completion of the desired connection to the switchboard of the zero operator, the connection to and including selector S5, Figs. 10 and 11, is cleared out as described hereinbefore, responsive to the restoration of line and release relays 1103 and 1104, followed by the restoration of auxiliary relay 1105.

When auxiliary release relay 1105 removes ground potential from locking conductor 1173, the actuated zero relay 1126 restores. Upon restoring, relay 1126 disconnects the tip and ring conductors T and R of the link Z1, and at its upper armature it removes ground potential from the sleeve conductor S of the link and replaces it on the marking conductor M thereof.

Referring now to Figs. 16 and 17, the described removal of ground potential from the sleeve conductor S of the link Z1 permits the associated cutoff relay 1621, operating magnet 1631, link relay 1643, and operating magnet 1731 to restore. Upon the restoration of operating magnet 1731, the retard coil 1743 is removed from in bridge of the tip and ring conductors of the trunk TR1, which operation may be utilized in the usual manner in the cord-circuit equipment (not shown) at the switchboard of the zero-operator to give a disconnect signal.

The zero operator is now expected to take down the connection to the jack J1.

Calls through other primary units

When a call is received from one of the Z links accessible to the column-A and B units of primary #1 at a time when unit 1PA^x is in use and unit 1PB^x is idle, shift magnet 1636 operates over conductor 1662 to select unit 1PB^x, and this unit is operated under the control of the common equipment substantially as hereinbefore described. In this case the start conductor grounded by the *a*-stackup contacts is start conductor 1670, associated with the second-choice finder-unit group, comprising units 1SC^x and 1SD^x of secondary #1 and the corresponding units of secondary #2.

When start conductor 1670 is grounded, from any one of the second-choice primary units, if either of the units 1SC^x and 1SD^x is idle, start relay 1706 operates through contacts of start relay 1705, thereby initiating action substantially

as hereinbefore described of the common equipment of secondary #1. At this time, commutator 1751, which has access (through the conductors of cable 1667) to the start leads of the second-choice primary links, is connected up at the contacts of start relay 1706, and unit-selecting conductor 1763 is connected up instead of conductor 1761, whereby a column-C or column-D unit is selected for operation in accordance with the position assumed by the common operating mechanism.

When a call is received from one of the zero links, such as Z51 or Z60, accessible to the column-C and column-D units of primary #1 of Fig. 16, start conductor 1609 is thereby energized to operate start relay 1606, through contacts of start relay 1605. Start relay 1606 connects up unit-selecting conductor 1663 instead of 1661, and it connects up commutator 1651 instead of 1601, whereby the ensuing operation of the primary is with respect to the column-C and column-D units thereof.

Operation of secondaries #2 and #3

In the event that a call through a column-A or column-C primary unit is received in the secondaries at a time when units 1SA[x] and 1SB[x] of secondary #1 are both in use, start conductor 1669 is at that time extended, through the *b*-stackup contacts of the engaged units, to start conductor 1769 leading to the column-A and column-B units of secondary #2, whereby secondary #2 is started, if one or the other of the column-A and column-B units thereof is idle. In the event that both said units of secondary #2 are in use at such time, the start conductor is further extended to secondary #3, causing operation thereof.

A similar arrangement is employed with respect to the column-C and column-D start conductor of secondaries #1 and #2. When units 1SC[x] and 1SD[x] are both in use, start conductor 1670 is extended through, the *b*-stackup contacts of the engaged units 1SC[x] and 1SD[x], to the conductor 1770, leading to the column-C and column-D units of secondary #2.

Busy condition in the first-choice secondary group

Let it be assumed now that the six secondary units (in columns A and B of the three secondaries) constituting the first-choice secondary group are all in use. Under this condition, ground potential is removed at all points from conductor 1668, permitting group relays 1647 and 1648 to restore. Upon the restoration of these relays, all idle first-choice primary units are bypassed, whereby any further calls received are received at second-choice primary units, and no further calls are directed toward the busy first-choice secondary group until one or more units thereof becomes idle. For example, at the upper contacts of relay 1647, start conductor 1661 is disconnected from the lever contact element of the *b* stackup of unit 1PA[x], and is transferred to the column-B unit, 1PB[x].

When the busy condition of the first-choice secondary group is ended, by one or more of the units thereof becoming idle, relays 1647 and 1648 reoperate responsive to the replacing of ground potential on group conductor 1668.

I claim:

1. In a switching system; large groups of lines; each large group being divided into small groups; groups of primary switching devices assigned respectively to said small groups of lines; each large group of lines having groups of secondary switching devices assigned thereto, the devices in each secondary group having access to a primary device in each of the primary groups assigned to the same large group of lines; each large group having link paths incoming respectively to secondary switching devices thereof, and having link paths outgoing respectively from secondary switching devices thereof; means responsive to a call being originated on any one of said lines for causing a connection to be extended therefrom, through an idle primary switching device assigned to the small group in which the calling line is located, and thence through an idle secondary device to an idle link path outgoing from the concerned large group; group-selecting means operable over the calling line for further extending the connection to an incoming link path of the large group containing the desired called line; means controlled over the calling line for indicating which small group in the called large group contains the desired called line, and for indicating which line therein is the desired called line; means responsive thereto for setting the secondary device reached over the last-named link path onto an idle primary device in the called small group, and for setting the last-named primary device on the desired called line.

2. In a switching system; large groups of lines; each large group being divided into small groups; groups of primary switching devices assigned respectively to said small groups of lines; each large group of lines having groups of secondary switching devices assigned thereto, the devices in each secondary group having access to a primary device in each of the primary groups assigned to the same large group of lines; each large group having link paths incoming respectively to secondary switching devices thereof, and having link paths outgoing respectively from secondary switching devices thereof; means responsive to a call being originated on any one of said lines for causing a connection to be extended therefrom, through an idle primary switching device assigned to the small group in which the calling line is located, and thence through an idle secondary device to an idle link path outgoing from the concerned large group; group-selecting means operable over the calling line for selecting a plurality of link paths incoming to the desired large group of lines; means controlled over the calling line for indicating which small group in the called large group contains the desired called line; means responsive thereto for setting an idle one of the secondary devices reached over the last named link paths onto an idle primary device in the called small group and for extending connection from the last-named outgoing link path, through said group-selecting means, through the link path incoming to the last-named idle secondary device, and through such secondary device, to the last-named idle primary device; means thereupon effective for terminating selection of the remaining ones of said plurality of link paths; means for indicating which line in the called small group is the desired called line; and means responsive thereto for setting the last-named primary device on the desired called line.

3. In a switching system; large groups of lines; each large group being divided into small groups; small-group selectors in each large group; link paths incoming respectively to said small-group

selectors; large-group selectors having access to all said link paths; means responsive to a call being originated on any one of said lines for causing a connection to be extended therefrom to an idle one of said large-group selectors; means controlled over the calling line for setting the last-named selector in accordance with the large group in which the desired called line is located, said selector responding by selecting all said link paths incoming to the called large group; means controlled over the calling line for indicating which small group contains the desired called line; means responsive thereto for causing an idle small-group selector to extend connection to the indicated small group of lines and for causing seizure of the corresponding incoming path to the exclusion of the other ones of said selected paths.

4. In an automatic switching system, separately designated groups of link paths, switching means for each group of link paths for extending any link path of the group, a separate control circuit for the said switching means of each group, a group selector having access to all said link paths, means for setting said selector in accordance with the designation of any of said groups, means in said selector thereupon effective for selecting all said link paths of the designated group and for seizing the control circuit thereof, means controlled over the seized control circuit for setting the switching mechanism of the selected group in accordance with a further designation, means thereupon effective for causing said switching mechanism to extend one of the selected link paths, and means in said group selector responsive thereto for seizing the extended link path to the exclusion of all the other selected ones.

5. In an automatic switching system, groups of lines, each group being provided with a group of switching devices for completing connections to the lines thereof, groups of link paths incoming respectively to said groups of switching devices, the switching devices and incoming link paths of each of said groups being divided into subgroups, the subgroups in each group having traffic-carrying capacities ranging from high to low, selectors divided into subgroups equal in number to the subgroups of link paths incoming to any one of said groups of lines, any subgroup of selectors having access to but one of the subgroups of link paths of each of the groups, all of the subgroups of link paths accessible to the same subgroup of selectors being those having the same relative traffic carrying capacity within their respective groups, there being a similar number of selectors in all said subgroups of selectors, originating link paths over which traffic reaches said selectors, said originating link paths being equal in number to said selectors, and being arranged by subgroups to offer specifically different amounts of traffic through the selectors to called subgroups of link paths, and means for supplying incoming traffic to the said subgroups of selectors substantially in accordance with the traffic-carrying capacities of the subgroups of links accessible to said selectors in the various groups, said means including means for connecting a proportionate number of relatively high-traffic-offering incoming links and relatively low-traffic-offering incoming links to the selectors of any subgroup according to the relative traffic-handling capacity of the links reached by such subgroup of selectors.

6. In an automatic switching system, a group of finders, an equal number of selectors linked respectively to said finders, means including said finders for extending calling lines to said selectors, means including said selectors for extending connections to desired called lines, a start chain over which the first idle one of said finders can be started to search for a calling line, means for transferring the start chain to the next idle finder of the group when a calling line has been found and extended to the associated selector, means effective when the connection through a finder has been released for again including the released finder in said start chain, means enabling the connection established from the selector to a called line to be held from the calling line after the calling end of the connection has been cleared out, and means in the selector for maintaining the associated finder excluded from the start chain in favor of the next idle finder until the connection through the selector to the called line has been released.

7. In an automatic switching system, a group of finders, selectors linked respectively with said finders, means including said finders for extending connections from calling lines to said selectors, means including said selectors for completing connections to the called line from the said calling line, means including a start conductor for starting the first idle one of said finders in search of a calling line, start-conductor transfer means in each finder, and alternative transfer means in the selector linked therewith for transferring the start conductor from such finder to the next succeeding finder.

8. In an automatic telephone system, an automatic switchboard section, a group of links extending therefrom, each of said links being arranged to carry calls from said switchboard section and to carry calls to said switchboard section, each link having an incoming branch over which incoming calls may be received and an outgoing branch over which outgoing calls may be extended, each of said links ending in the switchboard section in a switching device through which both incoming and outgoing calls pass, the said outgoing branch of said links being normally disconnected, each link having a relay for connecting the outgoing branch to the link circuit, and means in each of said switching devices operable only when the device is operated pursuant to an outgoing connection for bringing about the operation of the associated relay to connect up the outgoing branch of the link.

9. In a party-line automatic telephone system, call-extending links, means responsive to a call being originated on any calling line for extending such calling line to an idle one of said links, means associated with said links for responding to trains of impulses corresponding to called telephone numbers for further extending the connection over the link in use to the desired called line, each of said links having associated therewith a party-digit device responsive to a train of digit impulses representing the first digit in the called number to thereby predetermine which substation on a called party line is the one to be called, the succeeding trains of digit impulses being those which control the extension of the connection to the desired called line, means included in said party-digit device for producing a circuit transfer at the end of the first train of impulses to enable the succeeding trains of digit impulses to direct the setting up of the desired connection, and means included in the party-digit device responsive to a single

impulse, such as may be produced by an inadvertent manipulation of the hookswitch contacts at the calling substation when the receiver is being removed, for clearing out the party-digit device and preventing the said transferring operation from occurring, whereby the first train of intended impulses is received at said party-digit device notwithstanding the inadvertent transmission of a preliminary impulse from the calling substation.

10. In a party-line automatic telephone system, call-extending links, means responsive to a call being originated on any calling line for extending such calling line to an idle one of said links, means associated with said links for responding to trains of impulses corresponding to called telephone numbers for further extending the connection over the link in use to the desired called line, each of said links having associated therewith a party-digit device responsive to a train of digit impulses representing the first digit in the called number to thereby predetermine which substation on a called party line is the one to be called, the succeeding trains of digit impulses being those which control the extension of the connection to the desired called line, a group of special-service lines, certain first-digit values being assigned to called-substation predetermination, another first-digit value being assigned to said special-service lines, and means controlled by the party-digit device of any of said links when set in accordance with a first digit of the last-named value for causing a connection to be extended from the concerned link to one of said special-service lines.

11. In combination, a train of impulse-responsive counting relays composed of successively operable odd-impulse relays and successively operable even-impulse relays, an odd-impulse conductor over which said odd-impulse relays are arranged to be operated by successive odd impulses of a train, an even-impulse conductor over which the even-impulse relays are arranged to be successively operated by the even impulse of a train, an incoming impulse conductor over which all impulses of the train are received, a driver relay having transfer contacts for connecting said incoming impulse conductor alternately to said odd-impulse and even-impulse conductors, the first impulse of a train received over said incoming impulse conductor being directed by said driver relay to the odd-impulse conductor, means for operating said driver relay at the termination of each odd-numbered impulse of a series to transfer the incoming impulse conductor to said even-impulse conductor, circuit connections for maintaining the driver relay operated until the next succeeding even impulse is received and terminated, and for thereupon restoring the driver relay to transfer the incoming impulse conductor back to the odd-impulse conductor.

12. In combination, a train of impulse-responsive counting relays composed of successively operable odd-impulse relays and successively operable even-impulse relays, an odd-impulse conductor over which said odd-impulse relays are arranged to be operated by the successive odd impulses of a train, an even-impulse conductor over which the even-impulse relays are arranged to be successively operated by the even impulses of a train, an incoming impulse conductor over which all impulses of the train are received, a driver relay having transfer contacts connecting said incoming impulse conductor alternately to said odd-impulse and even-impulse conductors, the first impulse of a train received over said incoming impulse conductor being directed by said driver relay to the odd-impulse conductor, said driver relay having an energizing winding and a holding winding, means for operating said driver relay by its energizing winding at the termination of each odd-numbered impulse of the series and for maintaining it operated thereby until the beginning of the next succeeding impulse, and means for maintaining said driver relay operated by its holding winding, in a circuit including said even-impulse conductor, throughout each even-numbered impulse, the driver relay restoring at the end of each even-numbered impulse to transfer the incoming impulse conductor back to the odd-impulse conductor.

13. In an automatic telephone system wherein subscriber lines are divided into groups, primary and secondary line finders for each group, selectors for extending connections from any group to any other group, means for completing a connection from a calling subscriber line of one group to a called subscriber line of the other group which includes serially related primary and secondary line finders in the calling group, one of said selectors, and serially related secondary and primary finders in the called group.

14. In a telephone system, a group selector including a shaft and means for stepping it into any one of a group of positions each corresponding to a separate value of a digit in a telephone number, a plurality of selecting devices each controlled according to the position of said shaft, means effective after the shaft has been stepped into position for operating each of said devices to make a connection according to the position of the shaft, and means effective thereafter for selecting and making connection through one of said selecting devices to the exclusion of the others.

15. In a telephone system, a group selector comprising a group of selecting devices, means for setting each of said devices in accordance with the value of a digit in a telephone number and for operating each such device to make a connection depending upon its setting, and means for subsequently selecting one such device and its connection and for releasing the remaining devices to open their respective connections.

16. In a telephone system, a group selector comprising a group of devices, means for operating each said device to make a connection corresponding to the value of a digit in a called telephone number, means operable over one such connection to select the corresponding device, and means for opening the other connections.

17. In combination, a train of impulse-responsive counting relays composed of two groups of counting relays, two local conductors associated with said groups respectively, the relays of each group being arranged to be operated successively by impulses received successively over the associated one of said conductors, an incoming conductor over which all impulses of a train are received, a driver relay having contacts for connecting said incoming conductor alternatively to said local conductors, and means for operating said driver relay to connect the incoming conductor to the first of said local conductors during the receipt of alternate impulses over said incoming conductor, and to connect the incoming conductor to the second of said local conductors during the receipt of the remaining impulses of the train.

18. In combination, a driver relay and a series of counting relays, said counting relays corresponding respectively to the successive impulses of a train, means controlled by said driver and counting relays for operating a counting relay upon the receipt of the corresponding impulse and for restoring it upon the receipt of the next succeeding impulse, and means controlled by said driver and counting relays for operating said driver relay at the end of each alternate impulse of a train and for restoring it at the end of the next succeeding impulse thereof.

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