Oct. 26, 1943. E. S. PETERSON 2,333,039

TELEPHONE SYSTEM

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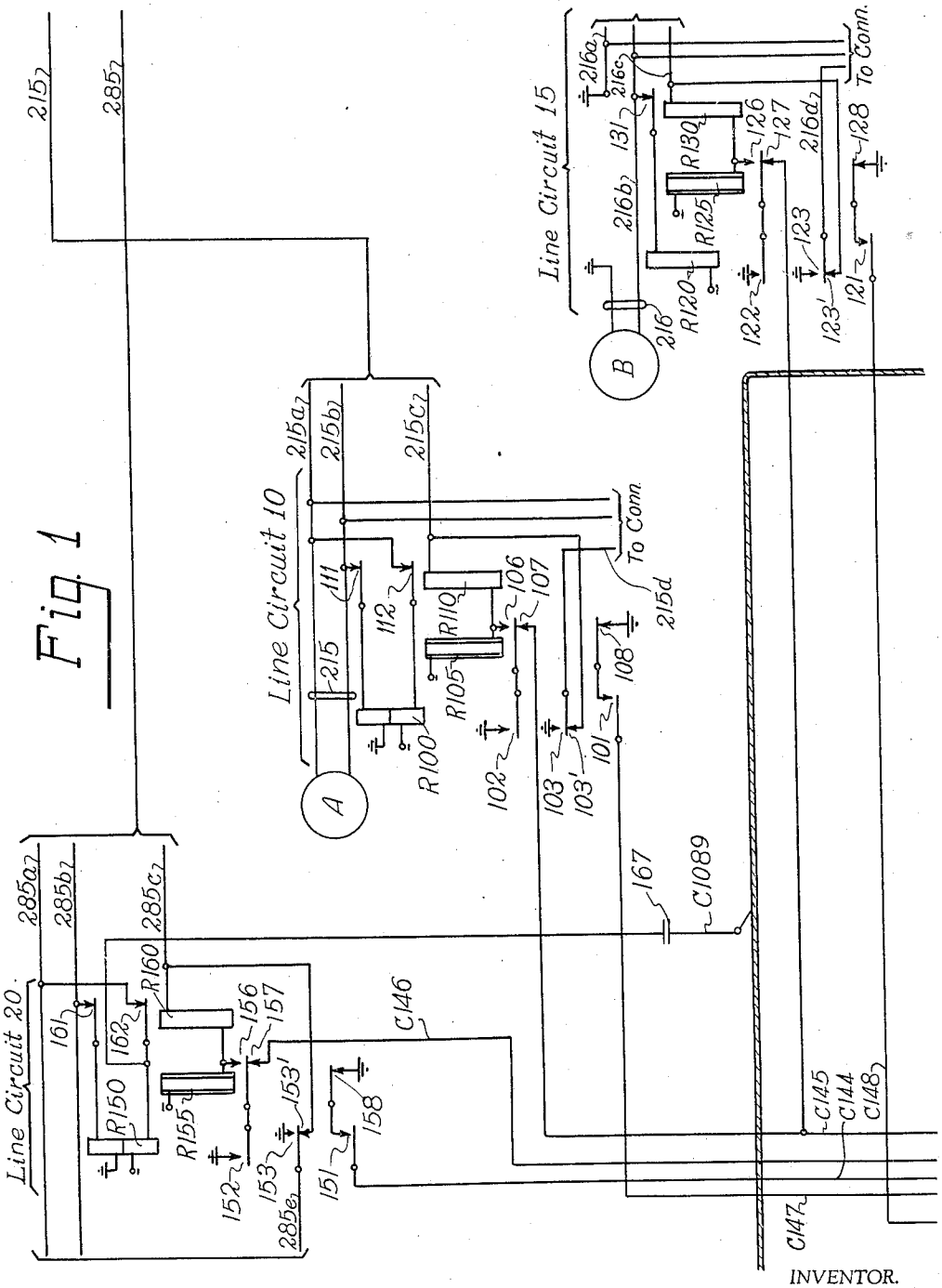


Fig. 1

INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shorts

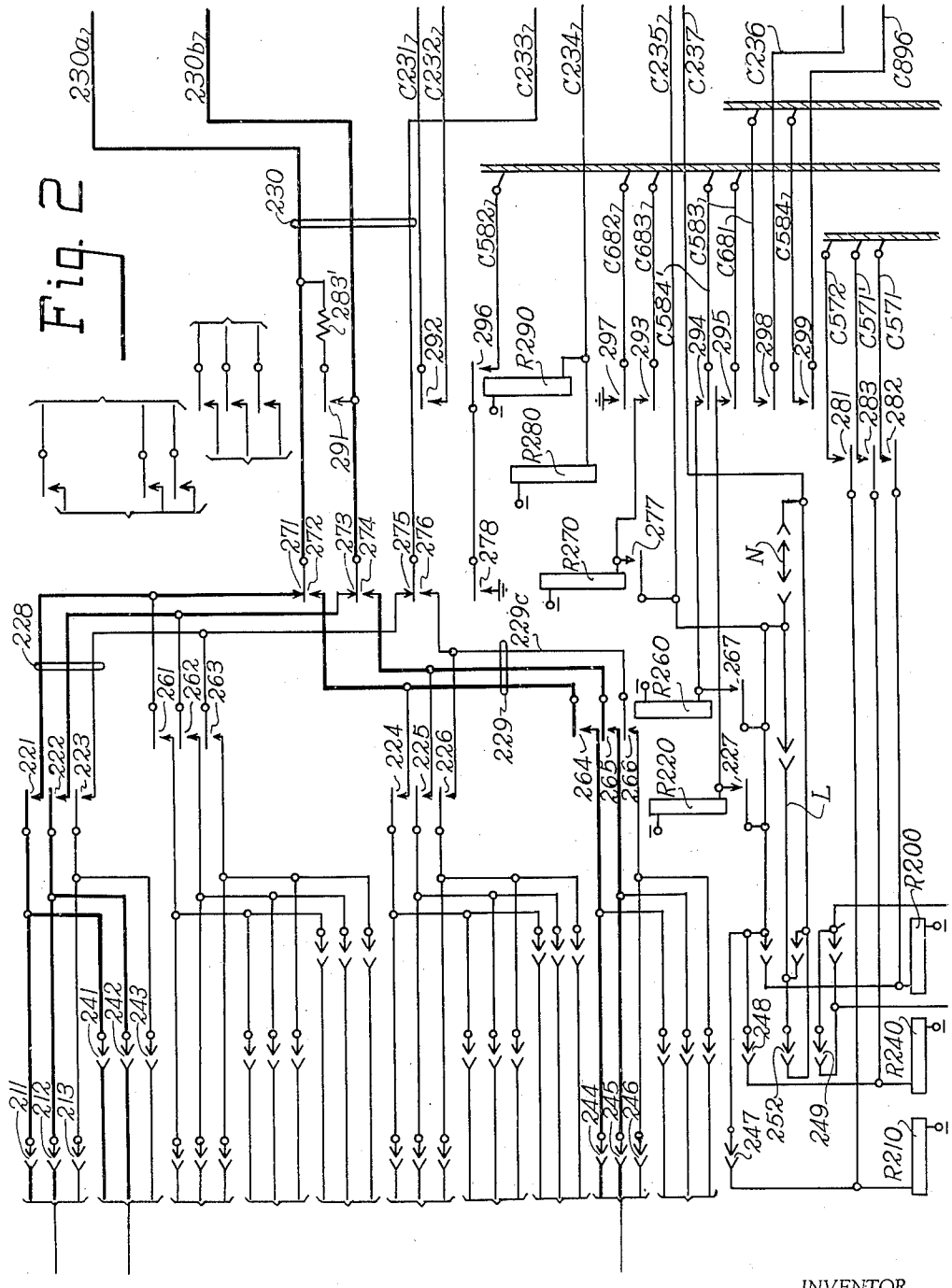
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TELEPHONE SYSTEM

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Fig. 2



INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shorts

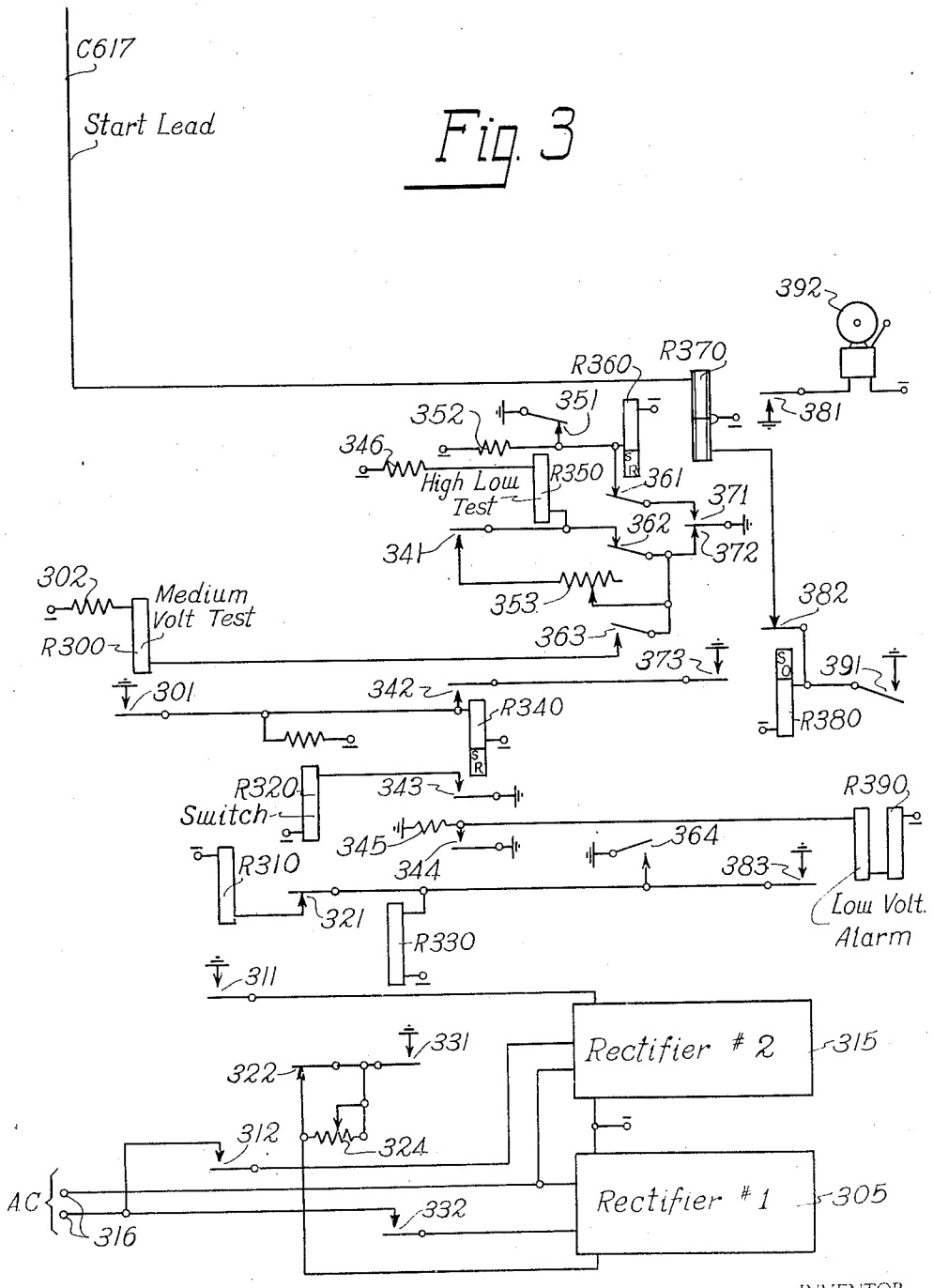
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Fig. 3



INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shonts
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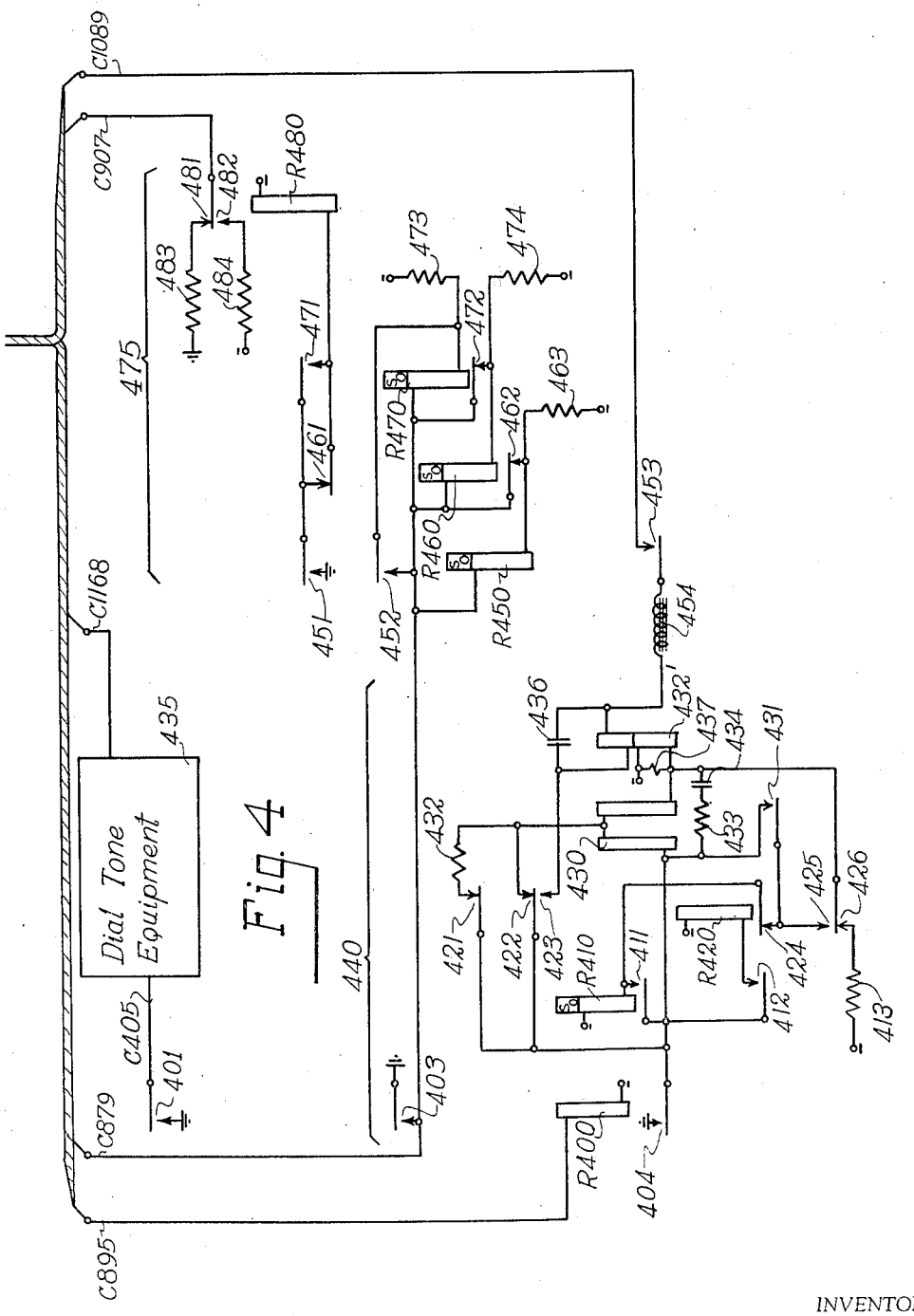


Fig. 4

INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shorts

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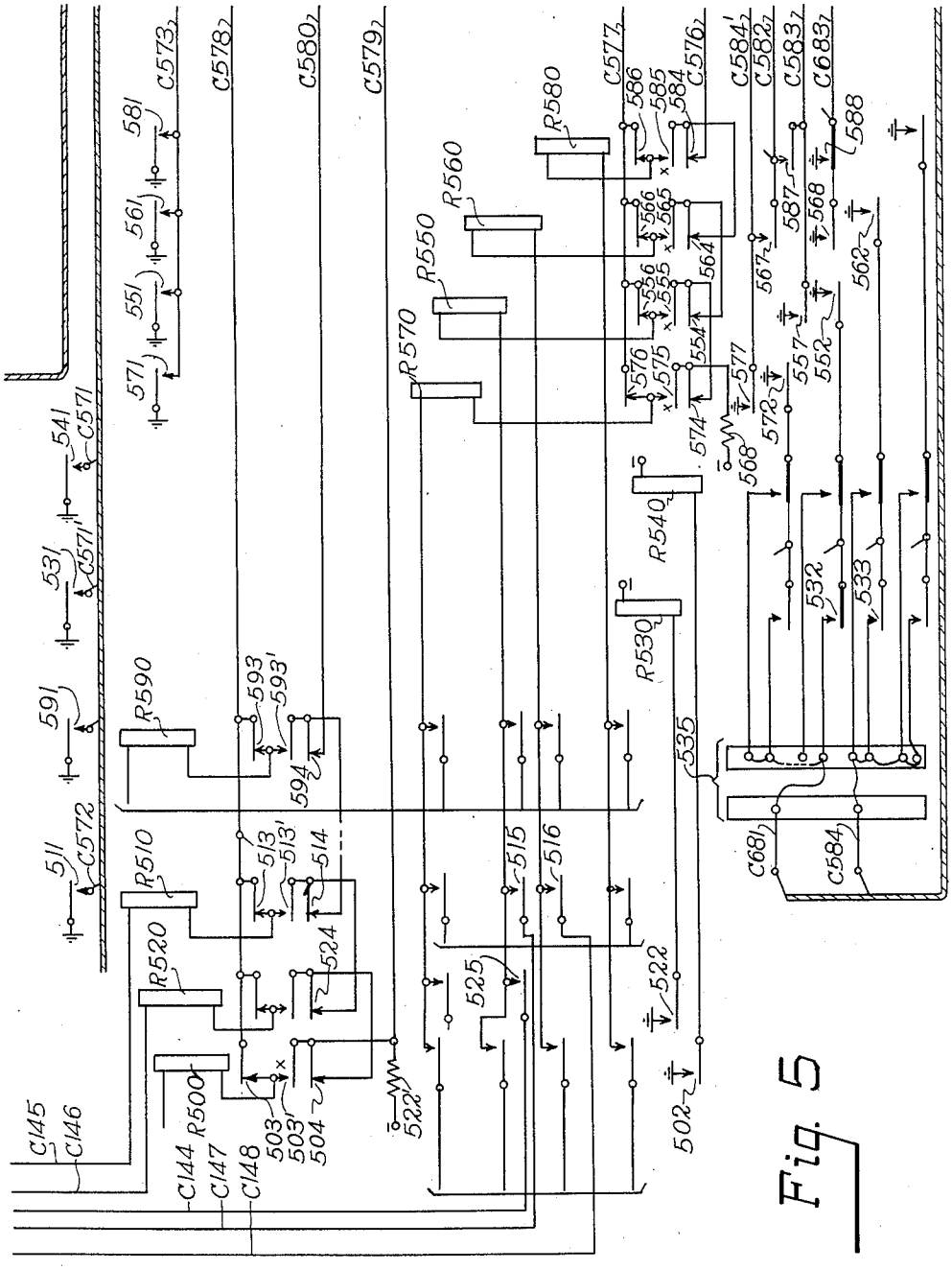


Fig. 5

INVENTOR.
EDWARD S. PETERSON

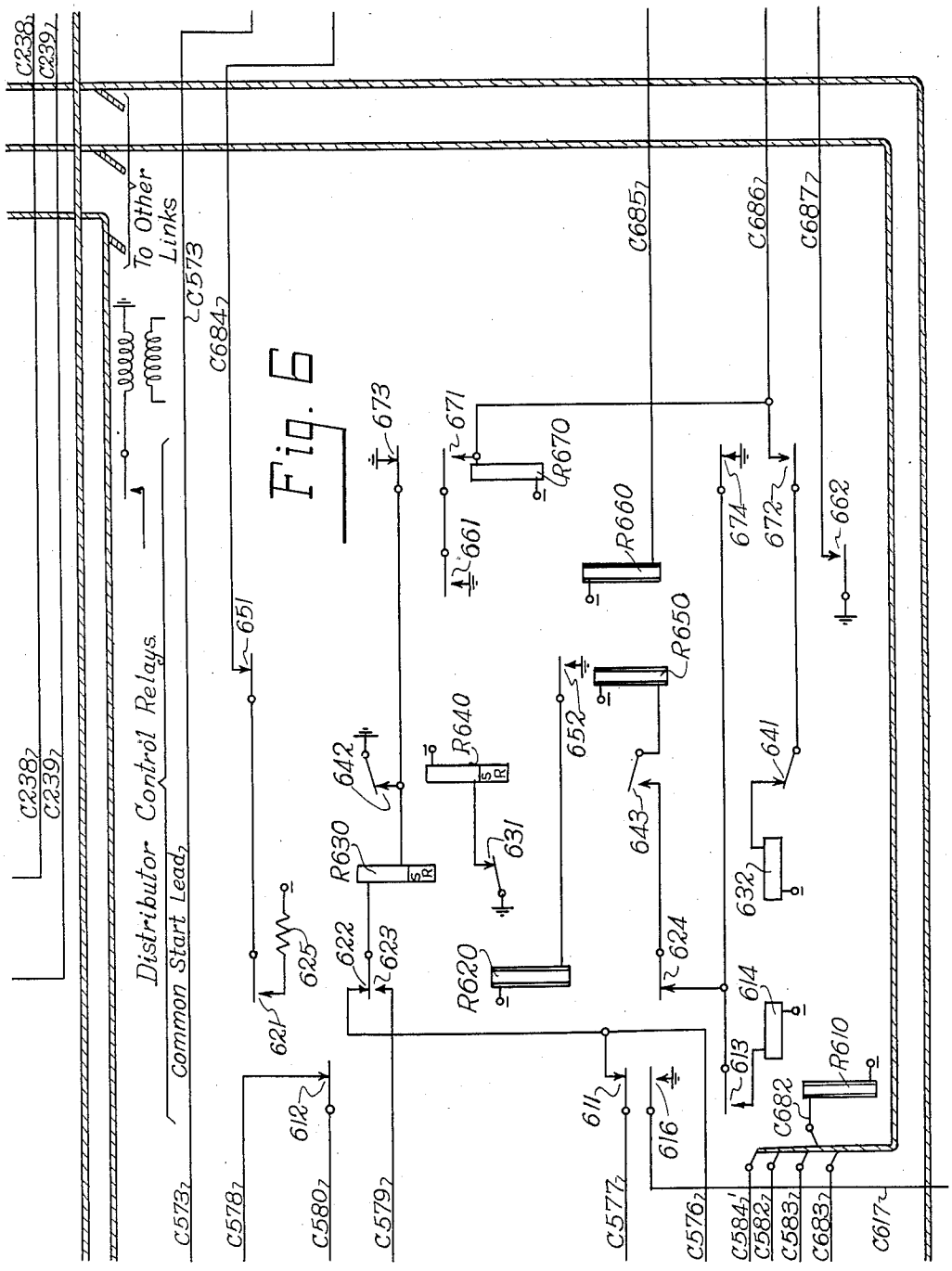
BY Davis, Lindsey, Smith & Shonts

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INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shonts

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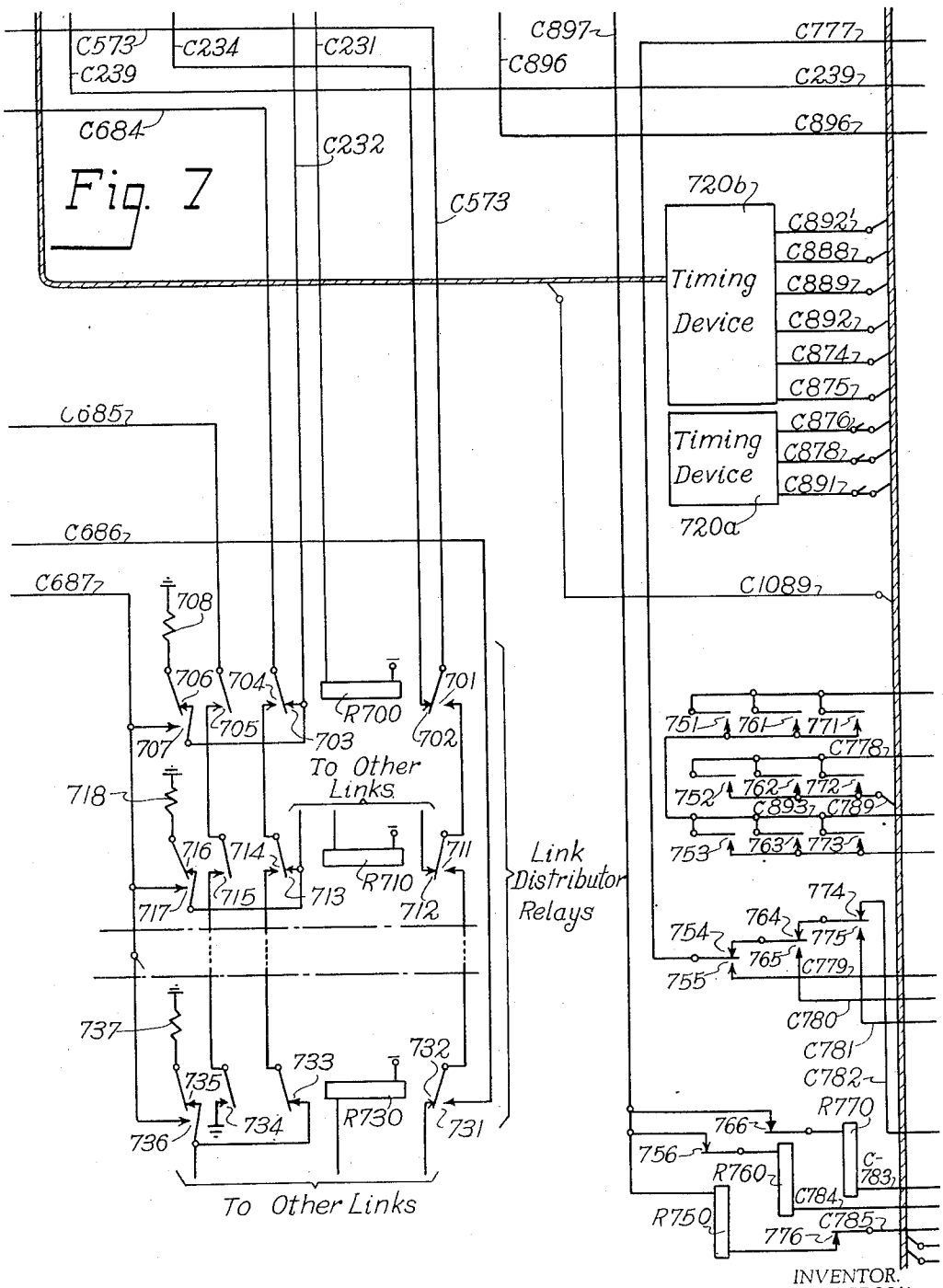


Fig. 7

INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shonts

ATTORNEYS

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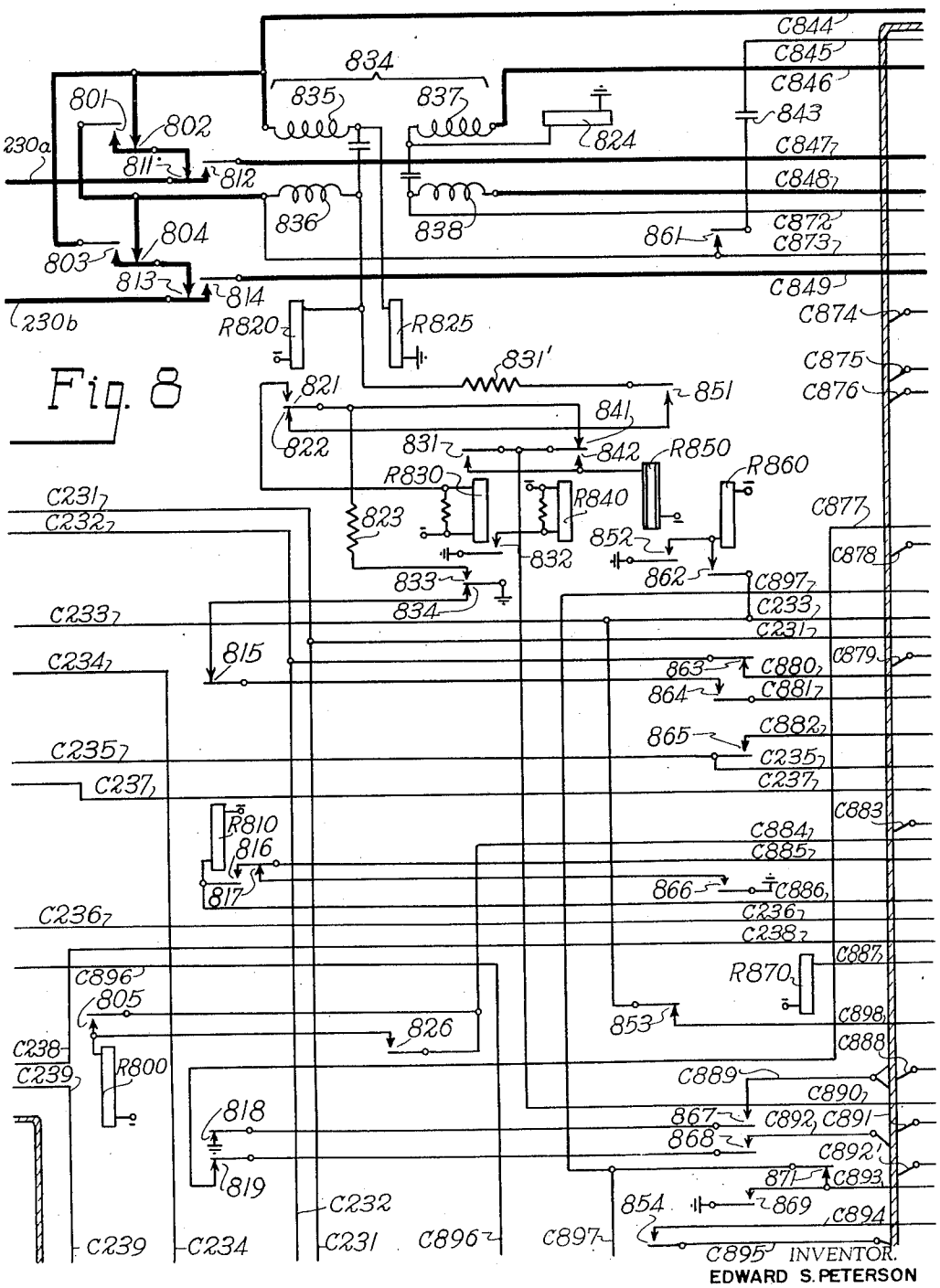


Fig. 8

INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shonts

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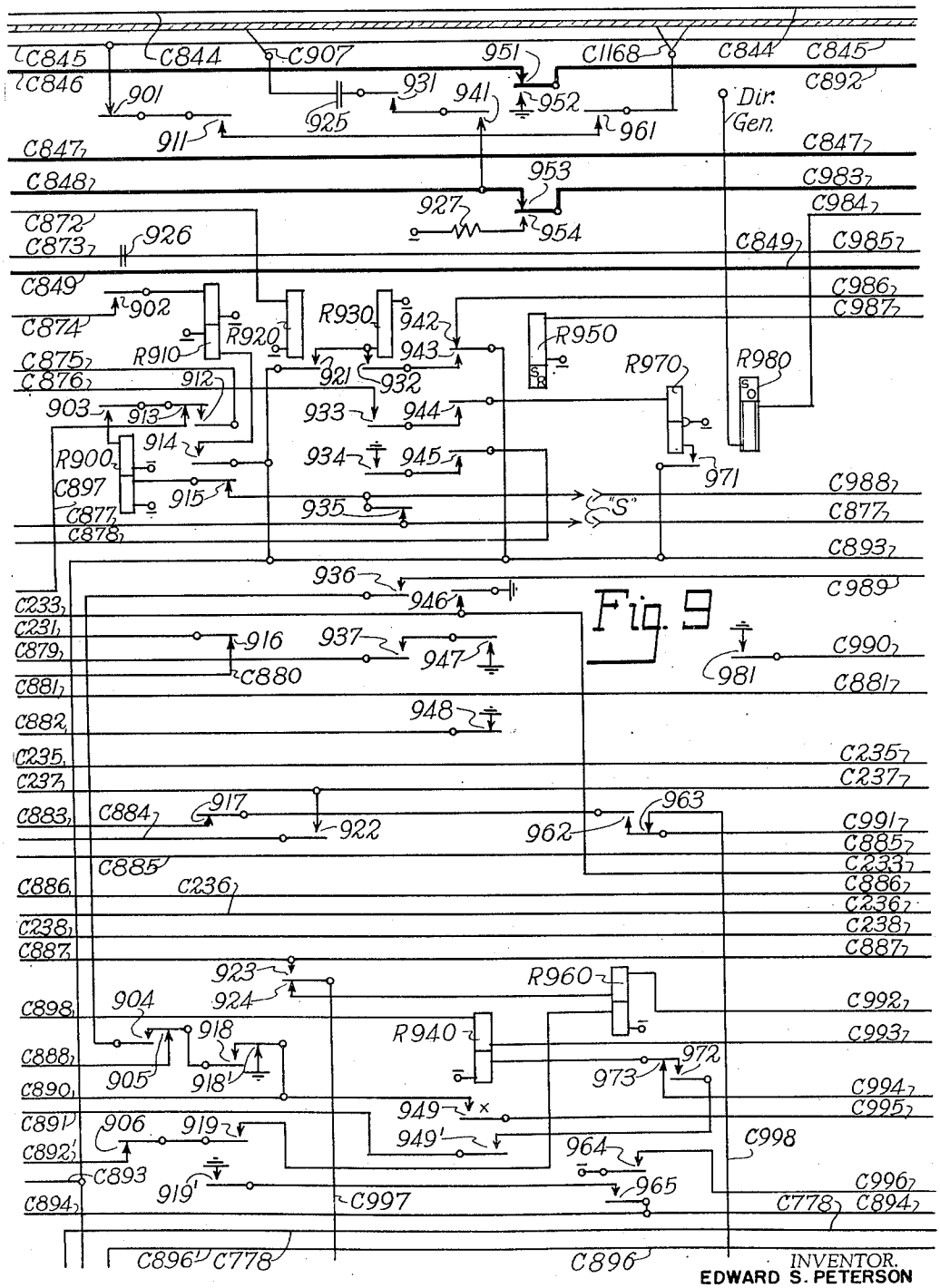


Fig. 9

INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shorts

ATTORNEYS

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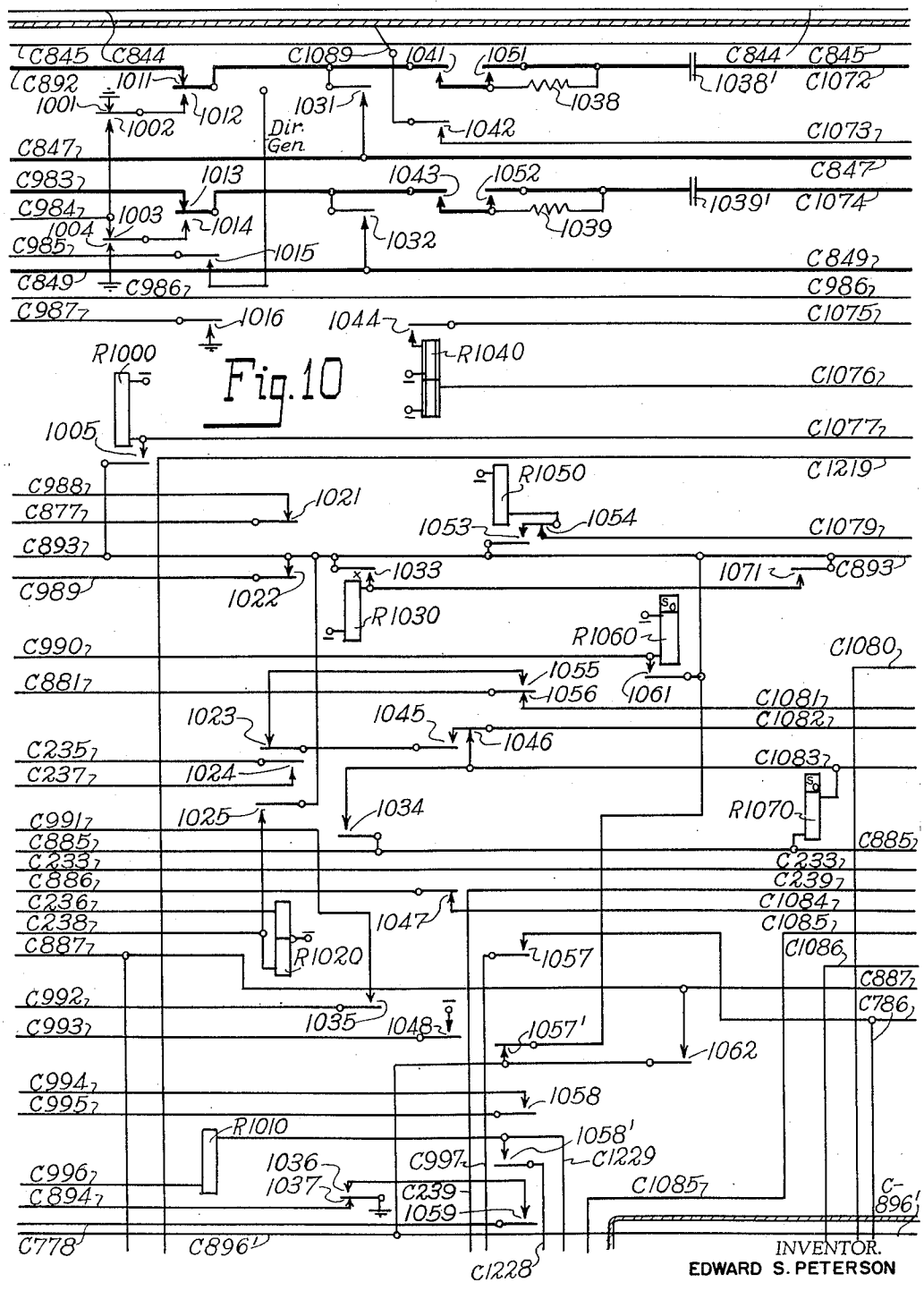


Fig. 10

INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shonts

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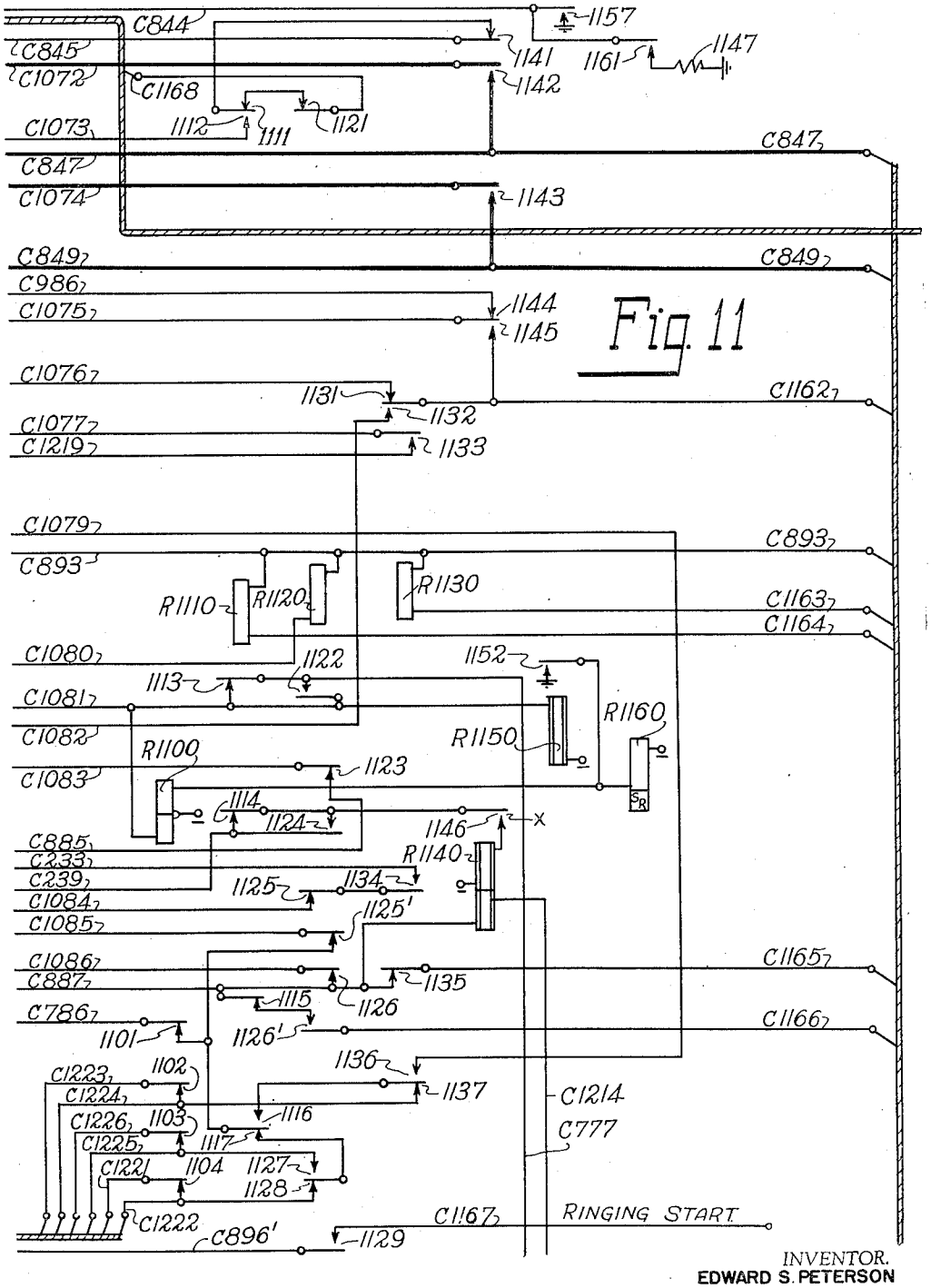


Fig. 11

INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shonts

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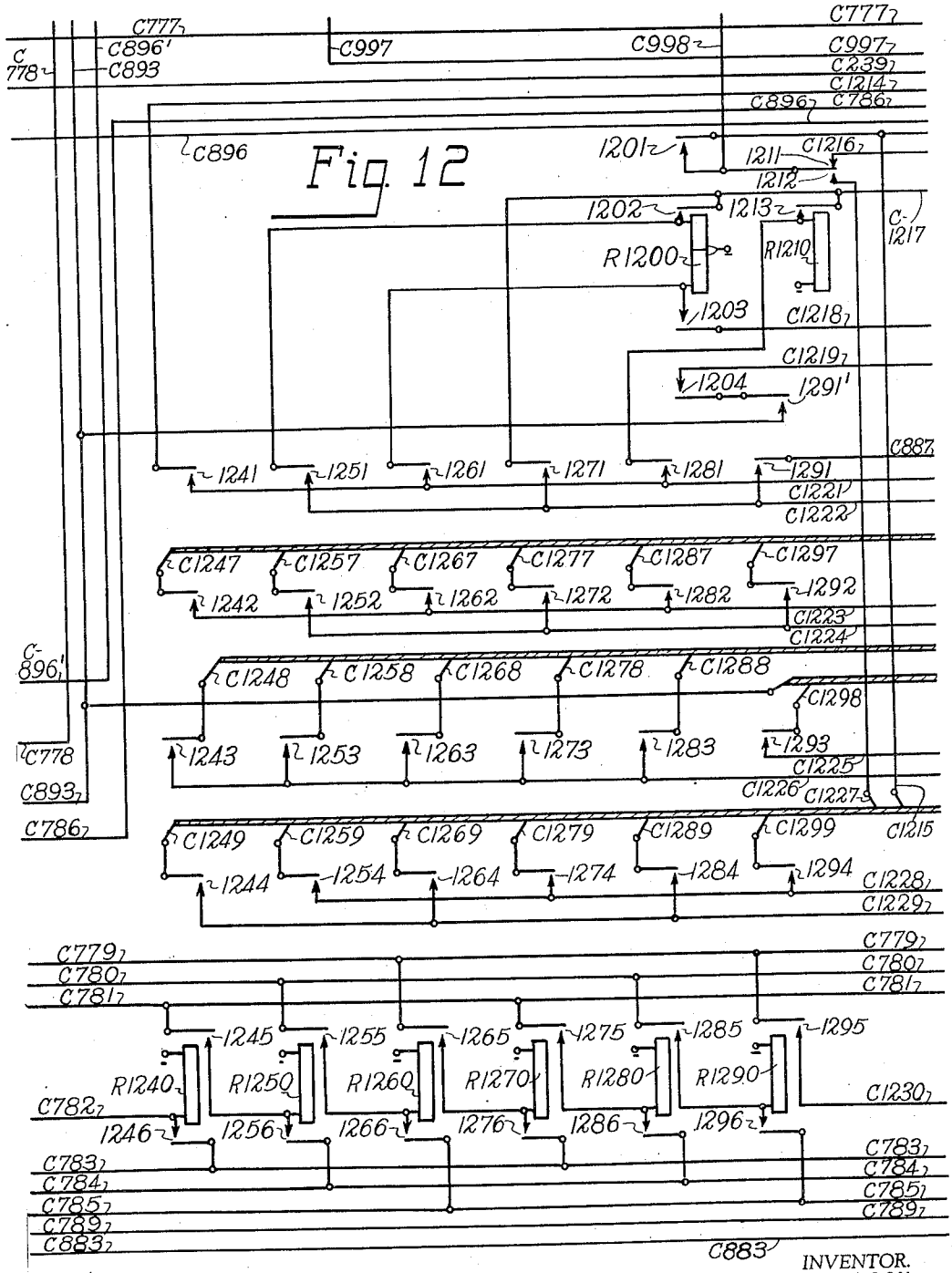


Fig. 12

INVENTOR.
EDWARD S. PETERSON

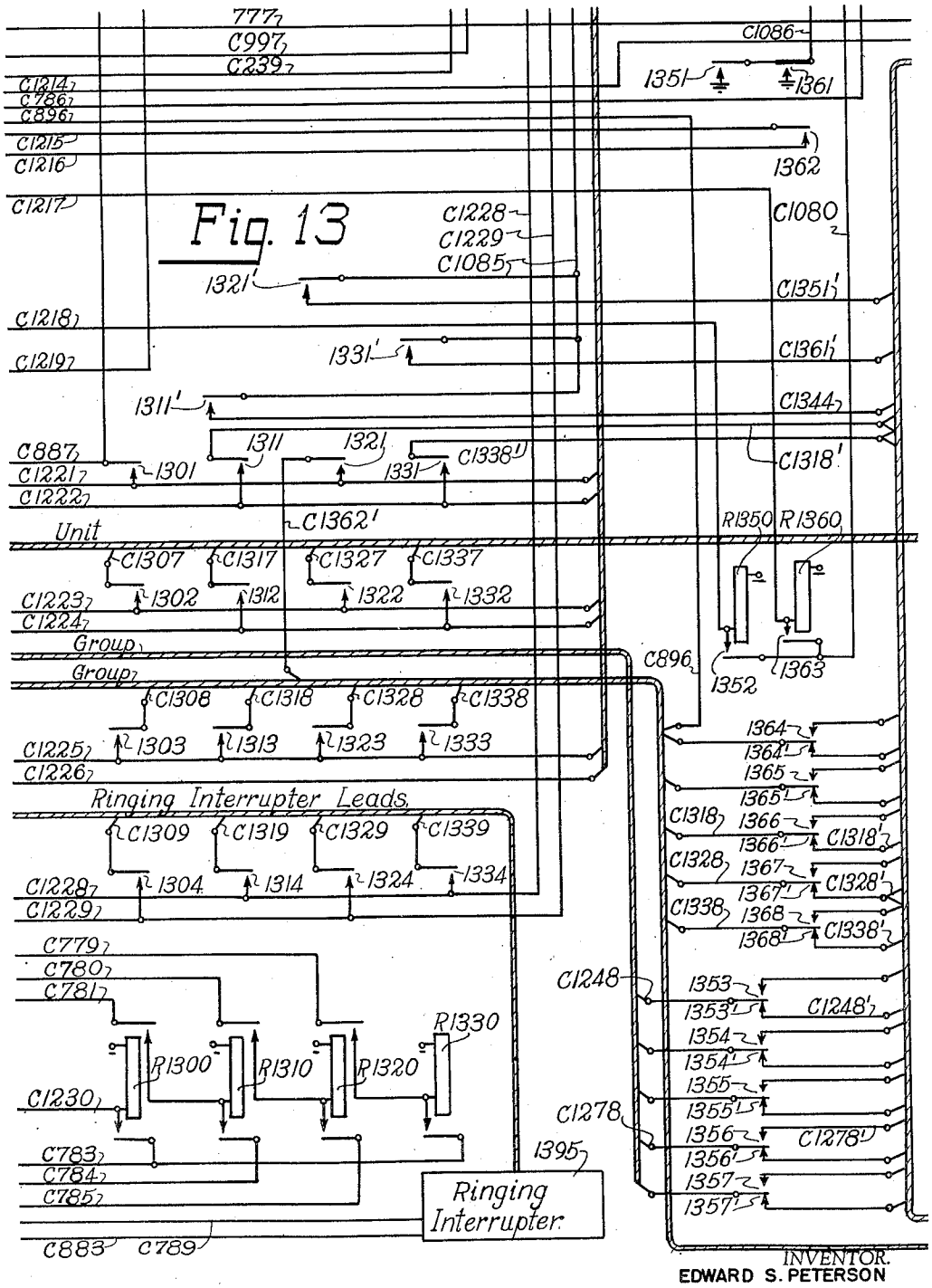
BY Davis, Lindsey, Smith & Shonts

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INVENTOR.
EDWARD S. PETERSON

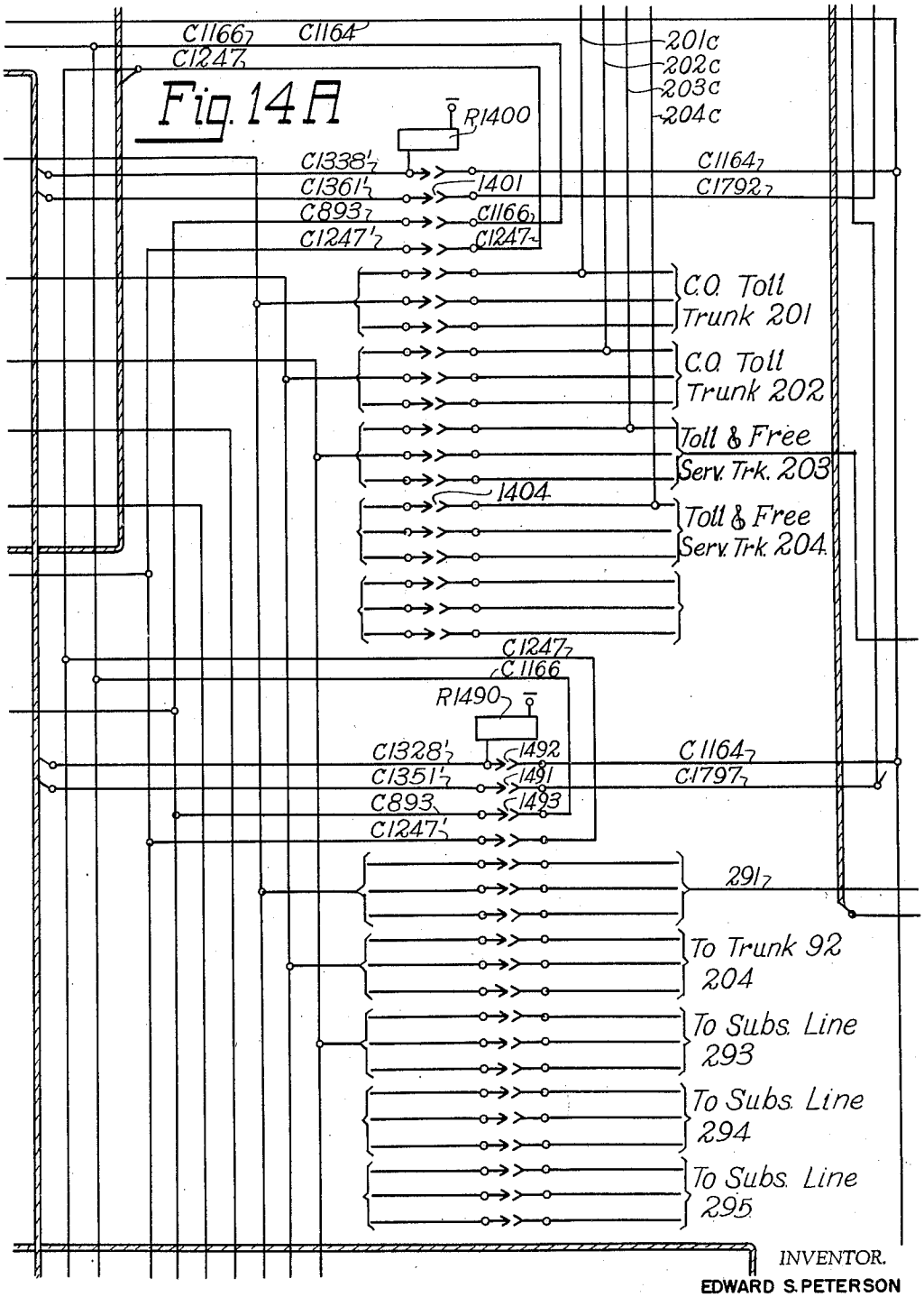
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INVENTOR.
EDWARD S. PETERSON

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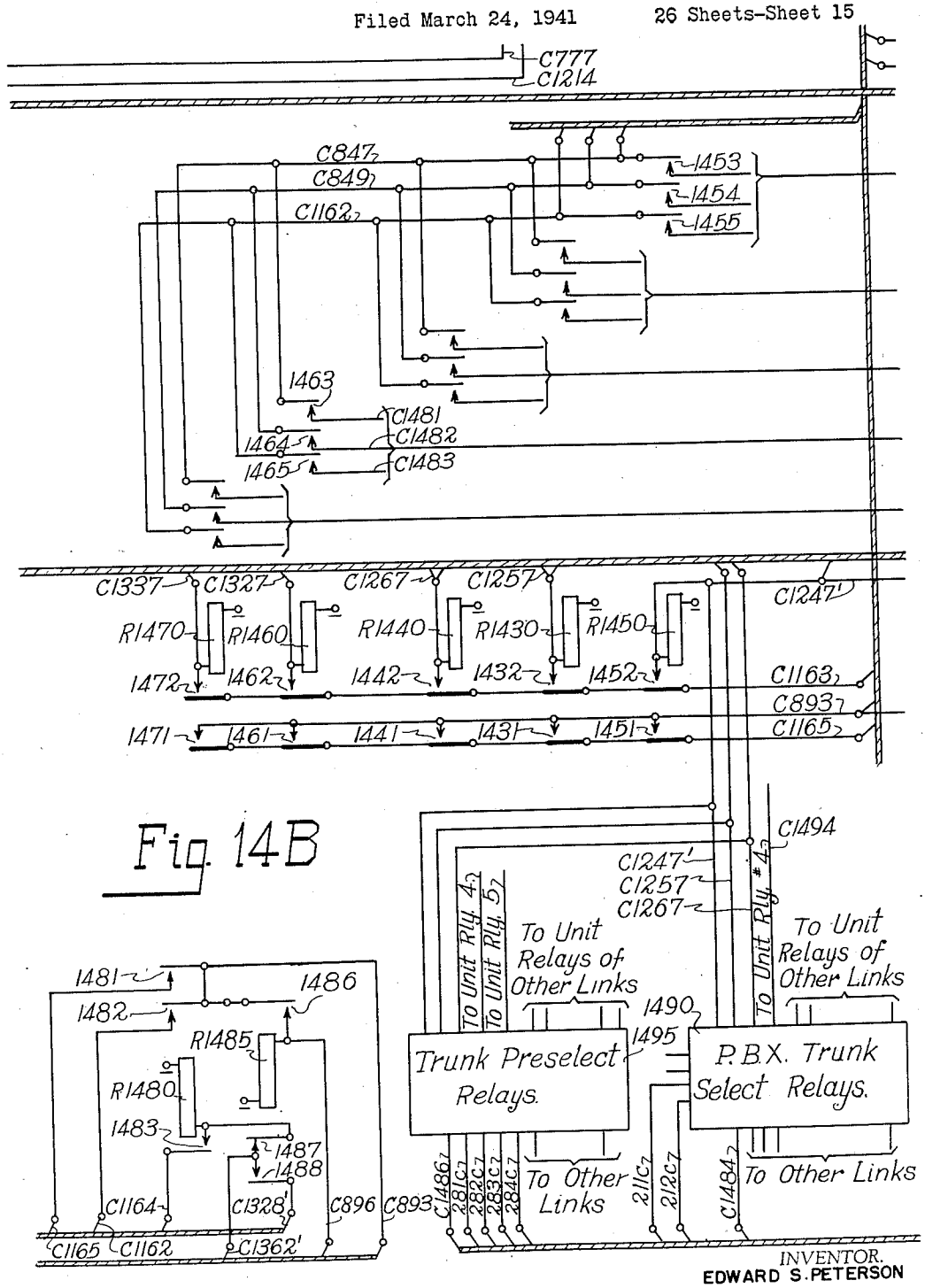


Fig. 14B

INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shontz

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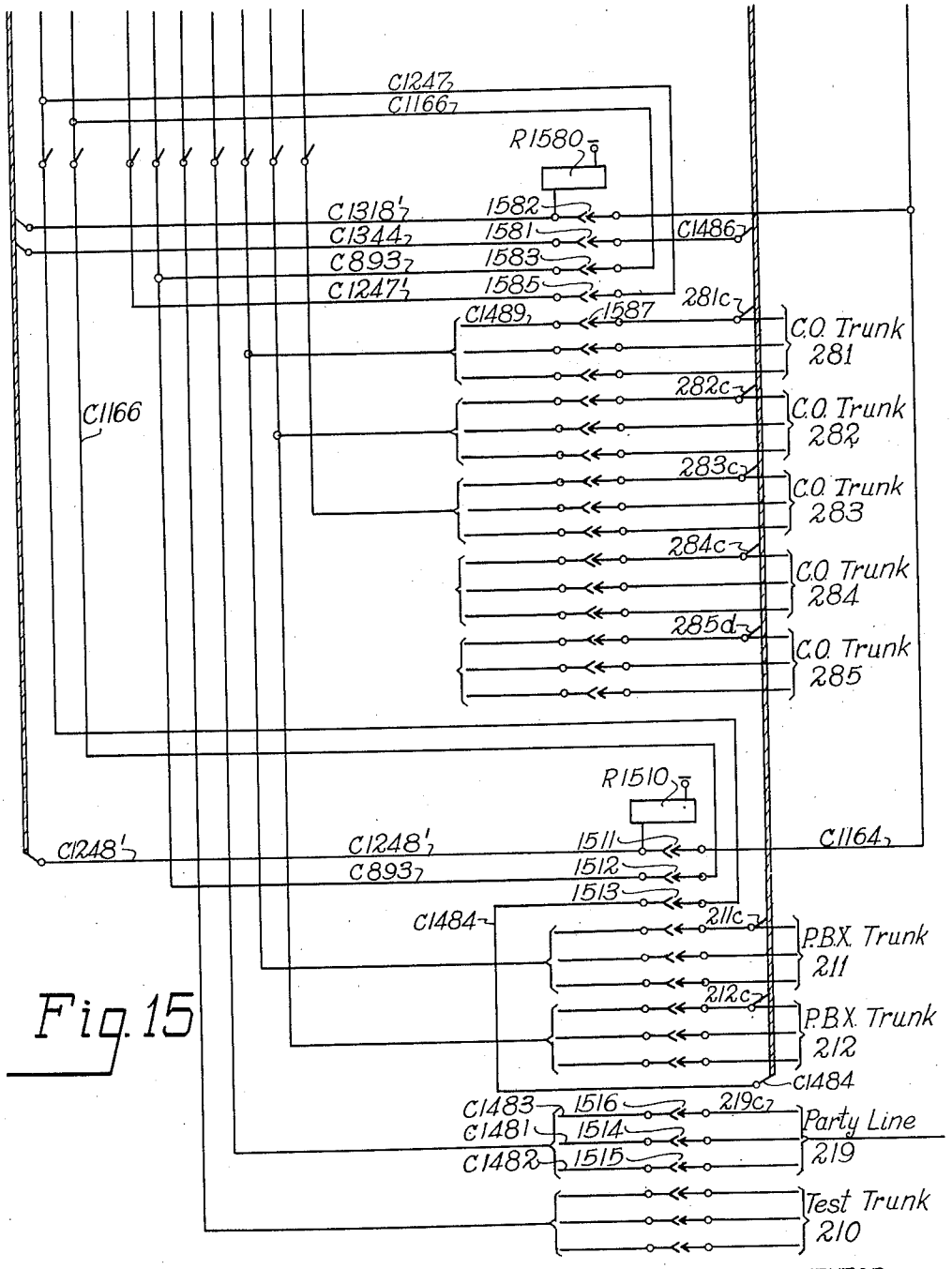


Fig. 15

INVENTOR
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shouts

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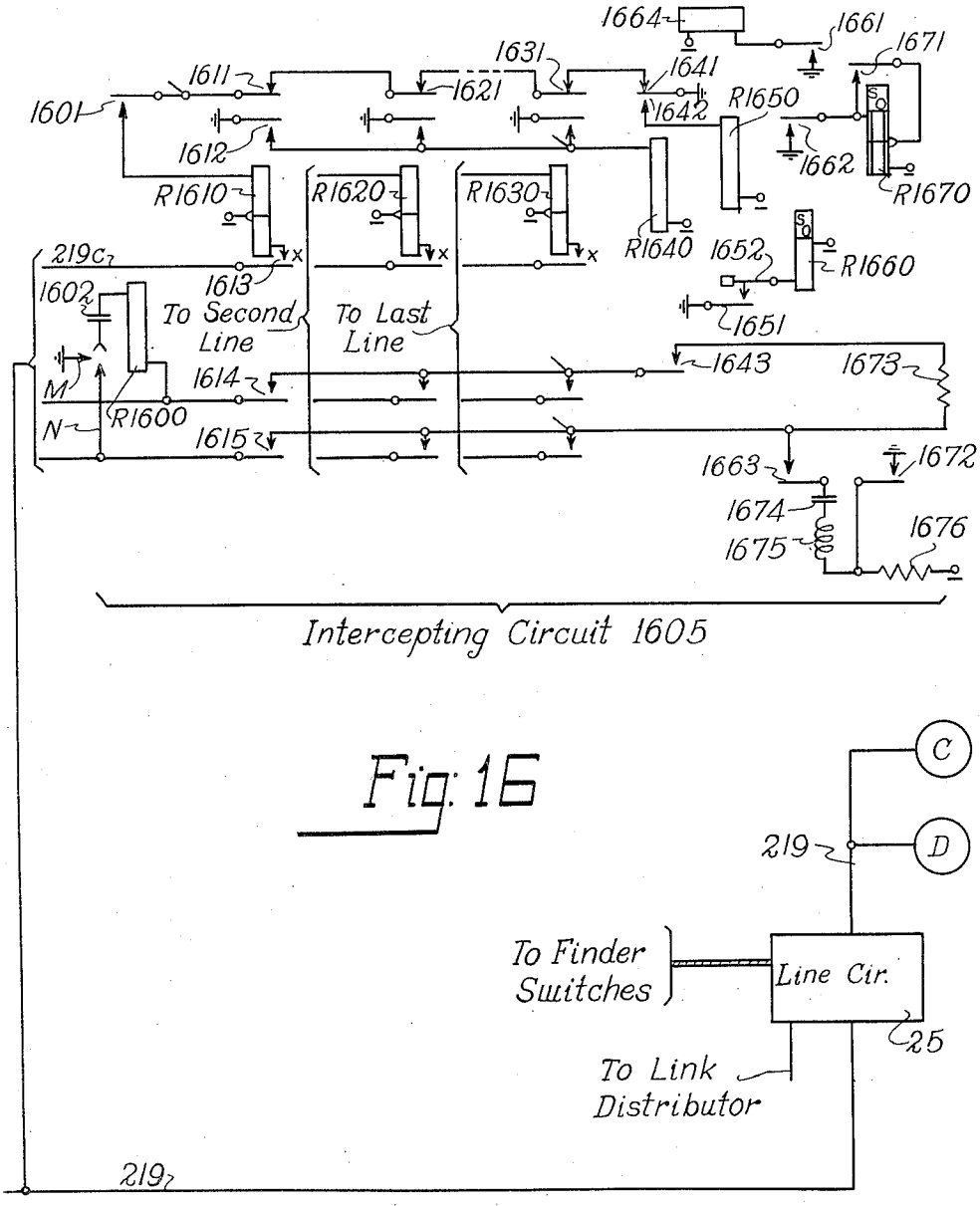


Fig. 16

INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shonts

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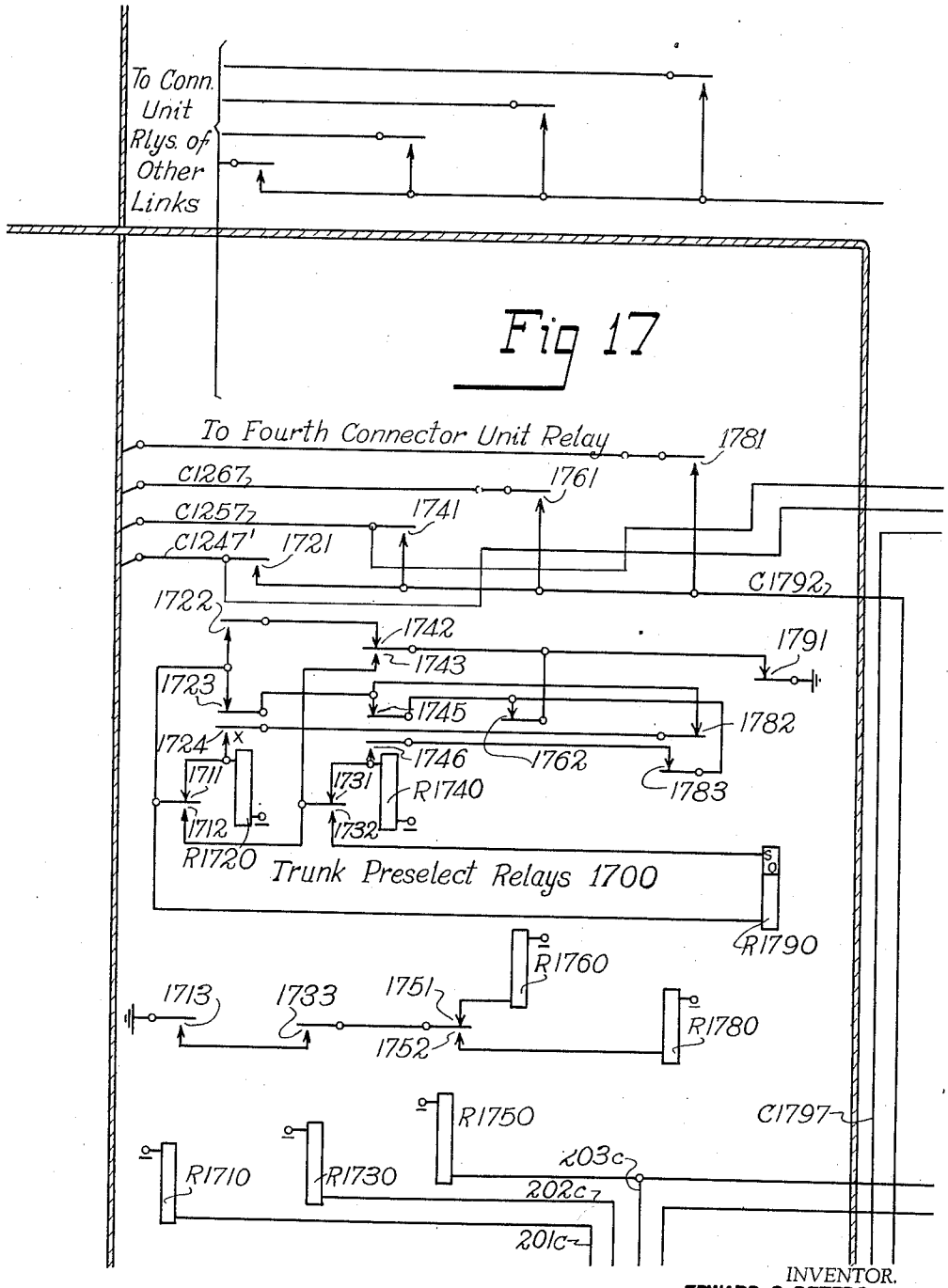


Fig 17

INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shonts

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Fig. 24

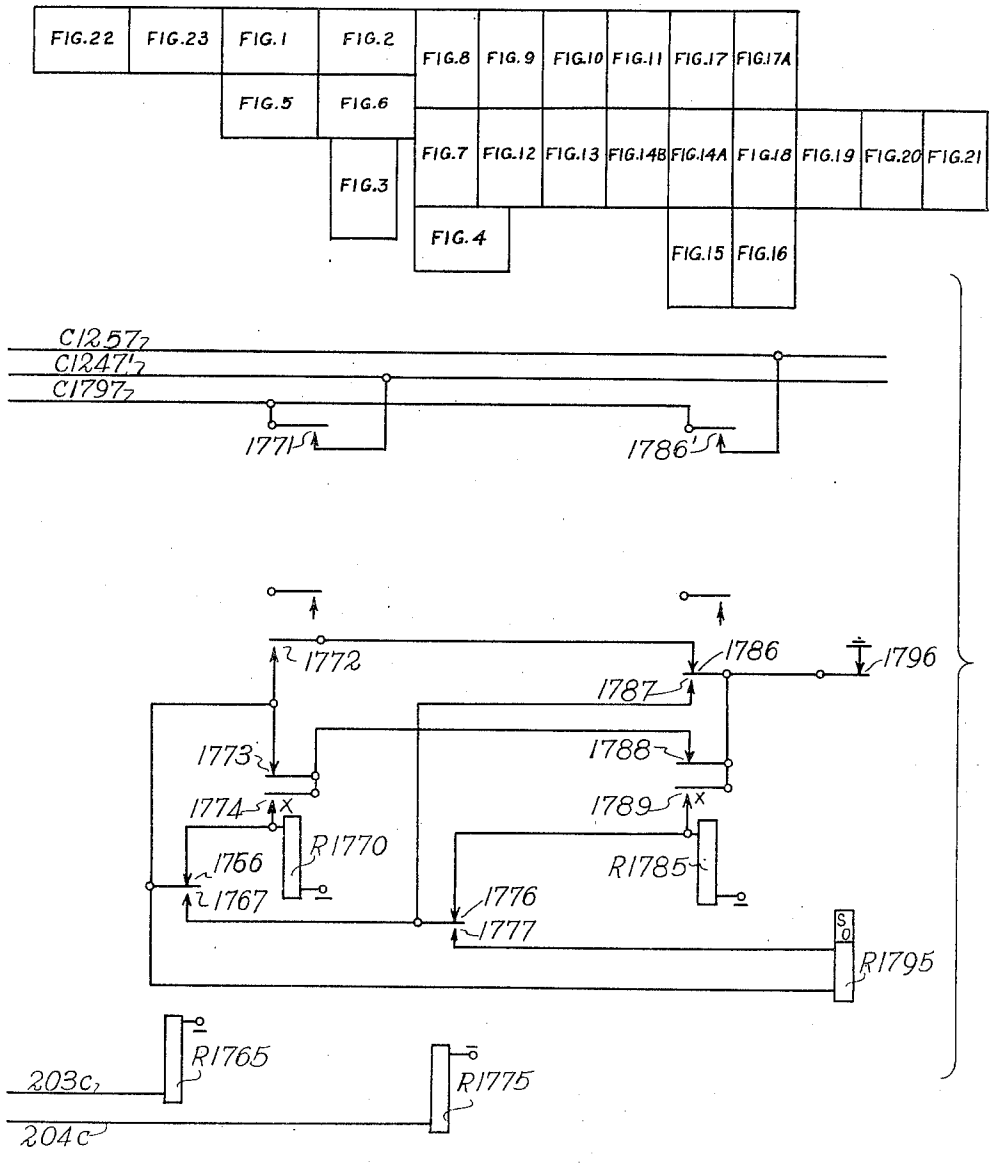


Fig. 17A

INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shorts

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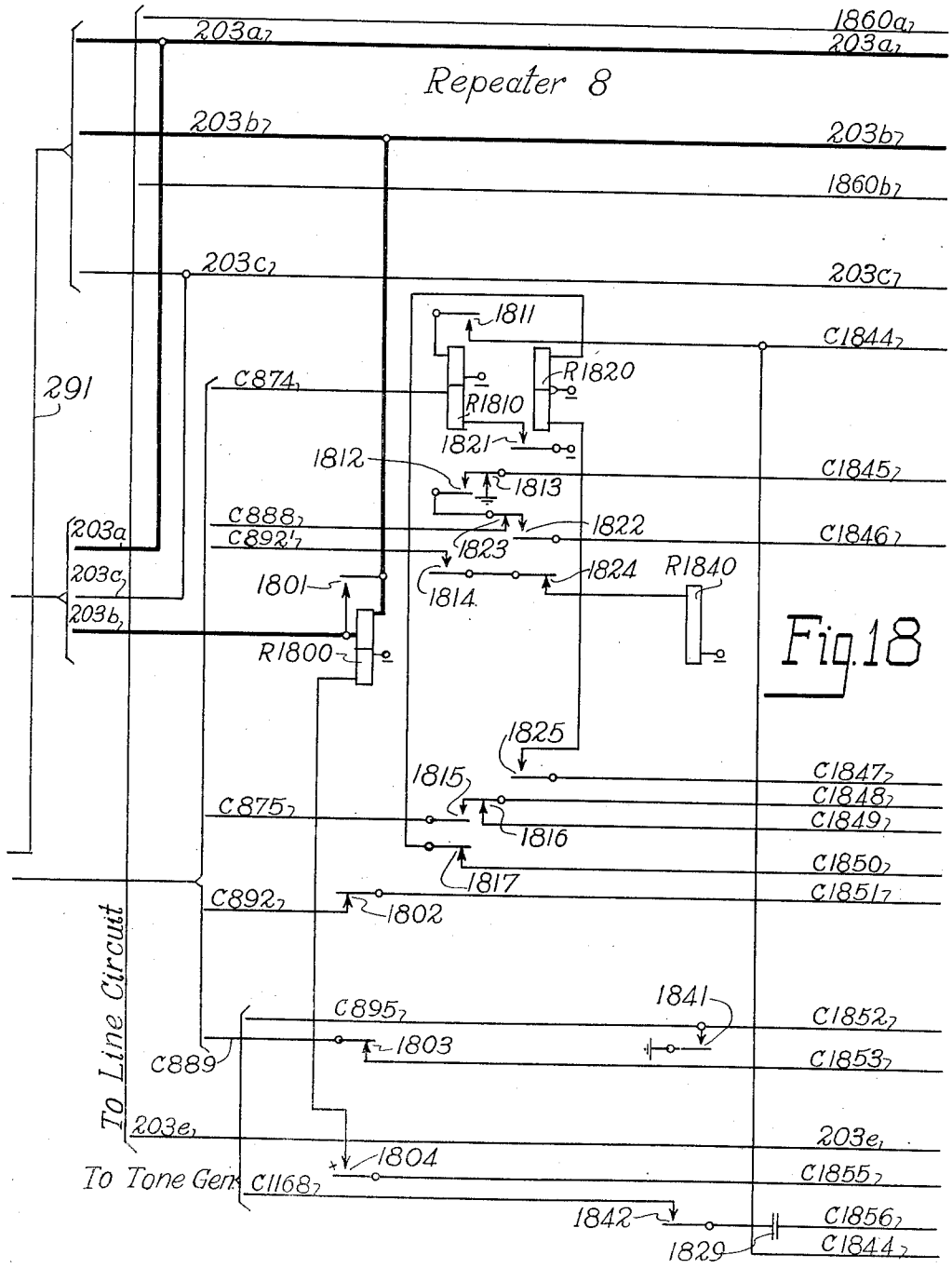


Fig. 18

INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shorts

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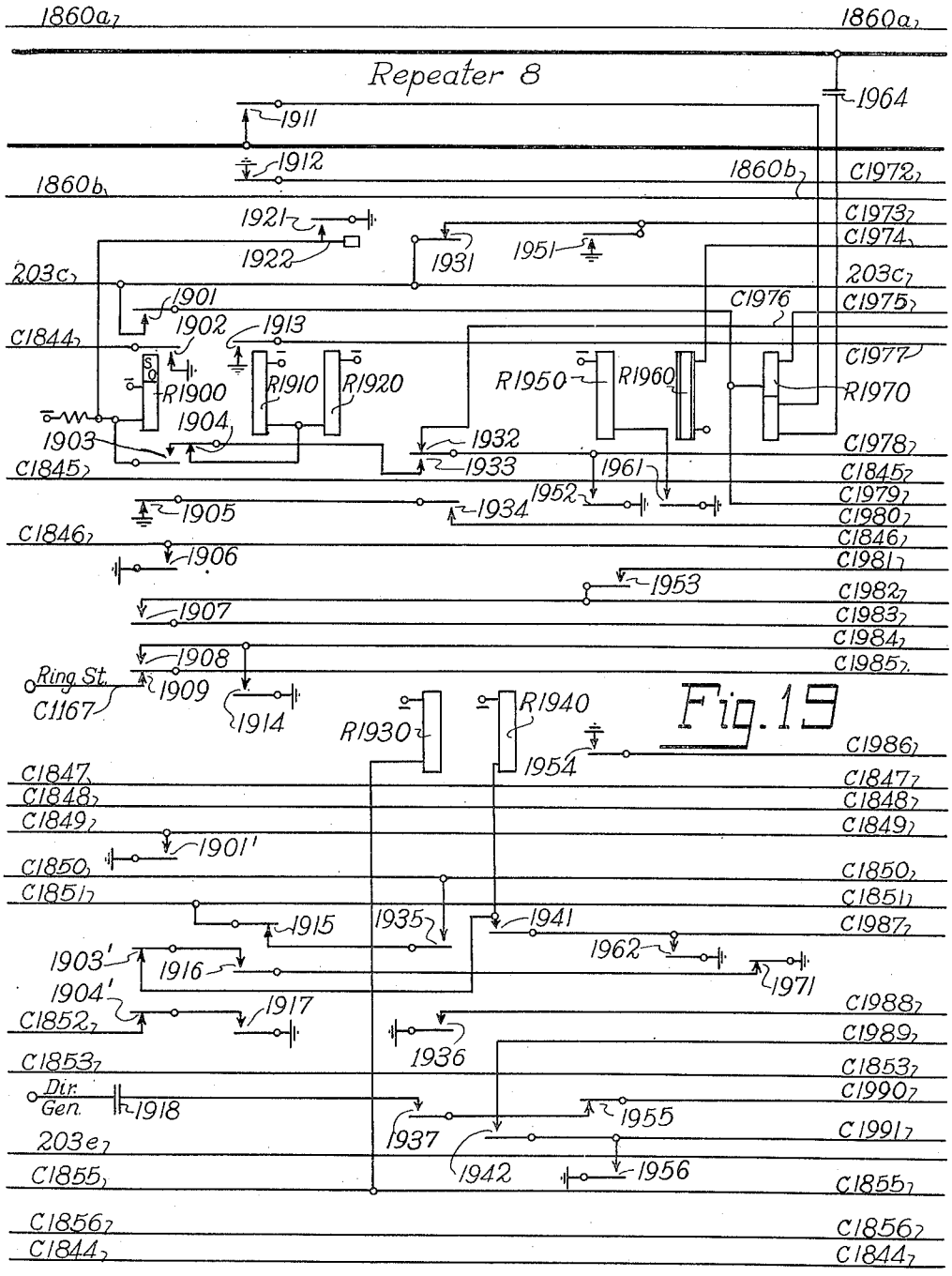


Fig. 19

INVENTOR.
EDWARD S. PETERSON

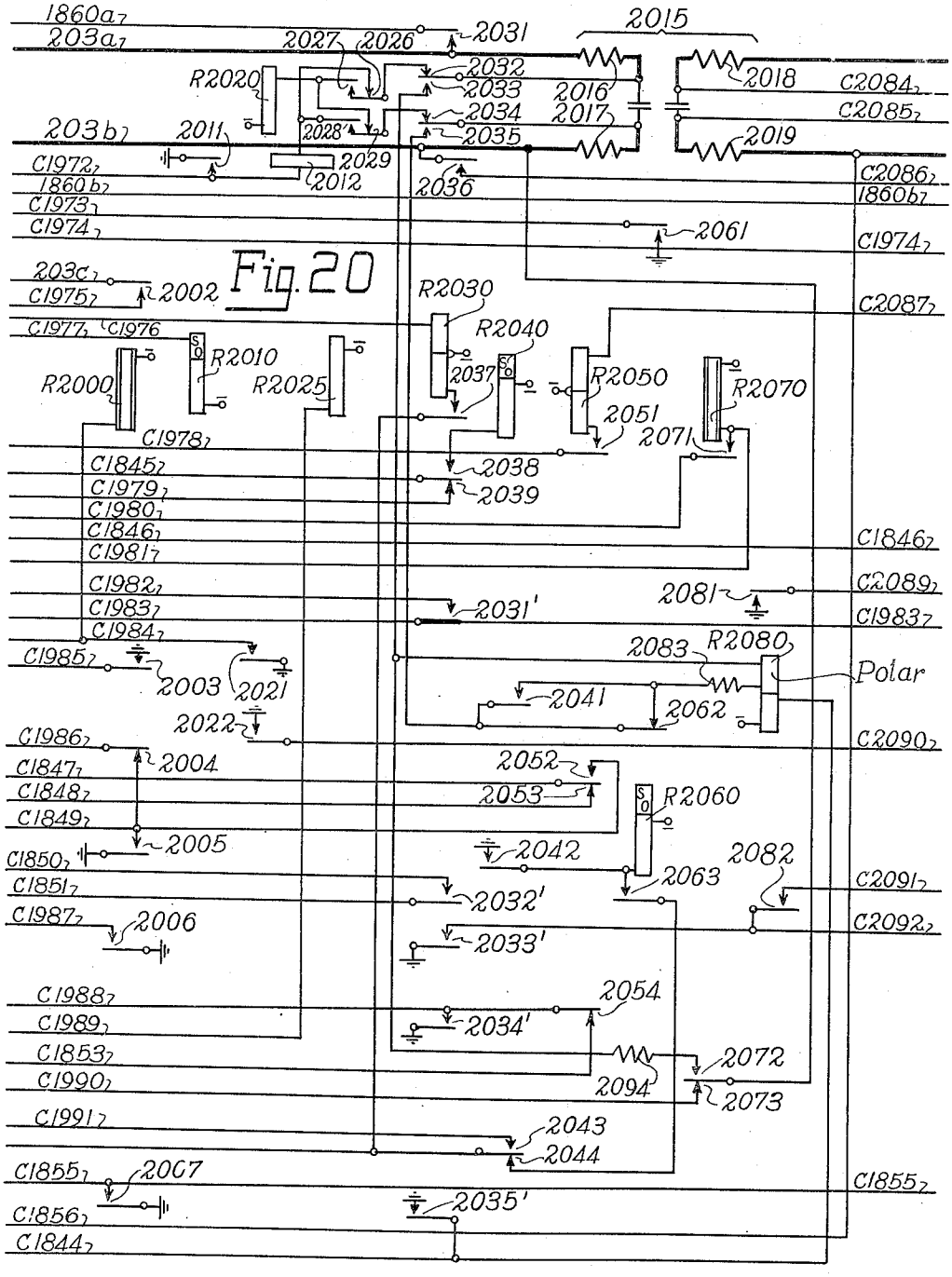
BY Davis, Lindsey, Smith & Shontz

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TELEPHONE SYSTEM

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INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shontz

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Oct. 26, 1943. E. S. PETERSON 2,333,039

TELEPHONE SYSTEM

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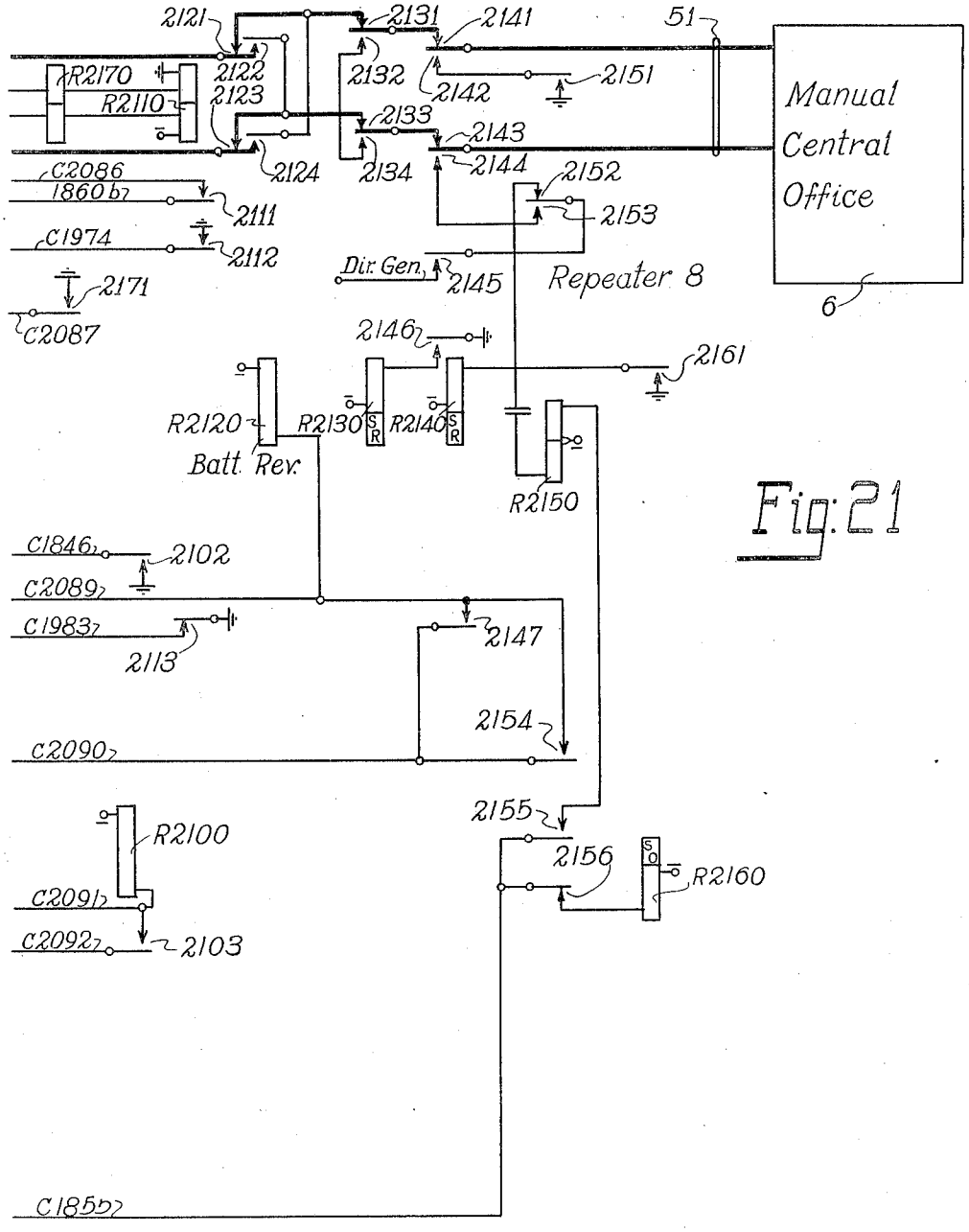


Fig. 21

INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shonts

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TELEPHONE SYSTEM

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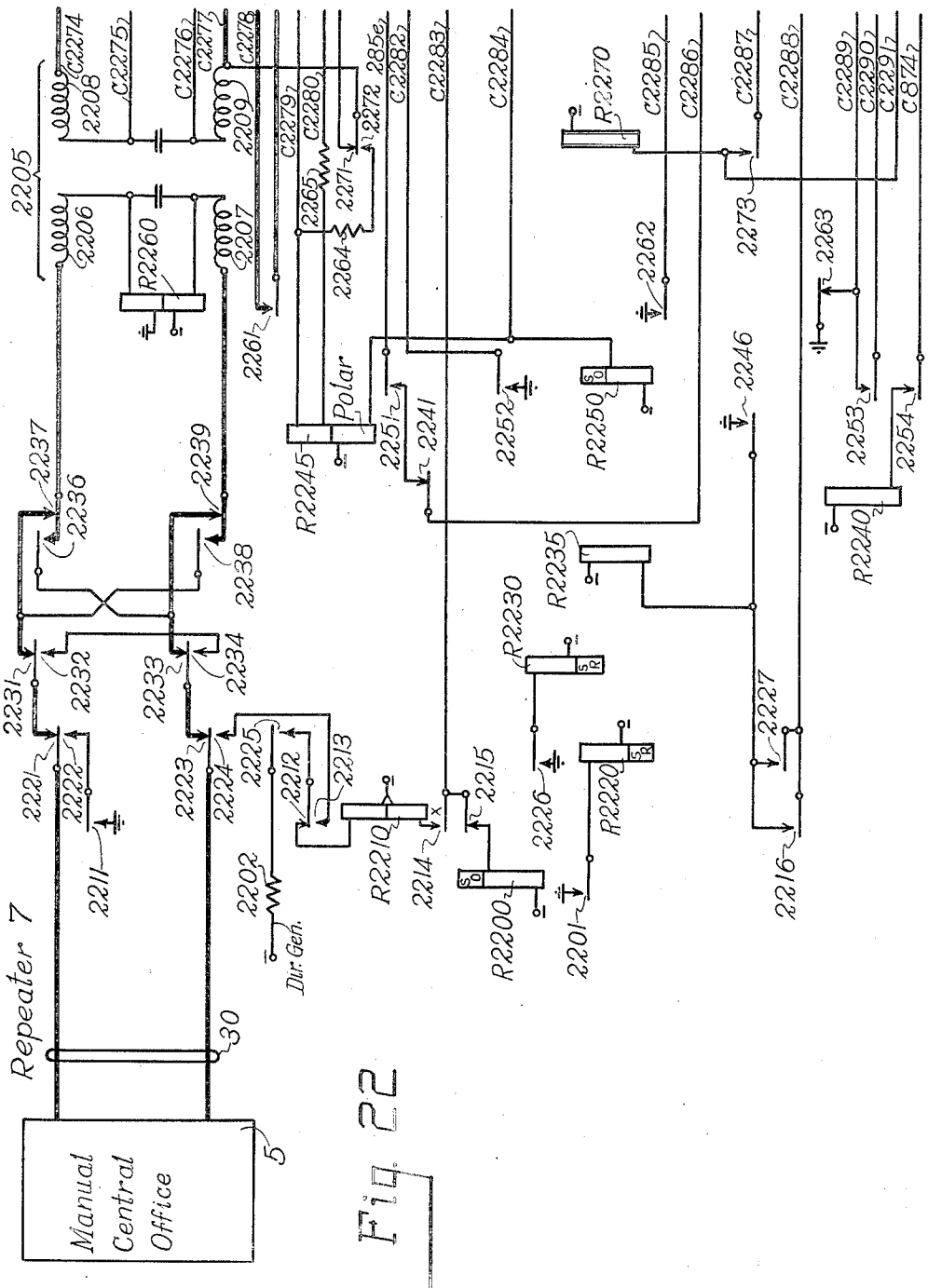


Fig. 22

INVENTOR.
EDWARD S. PETERSON

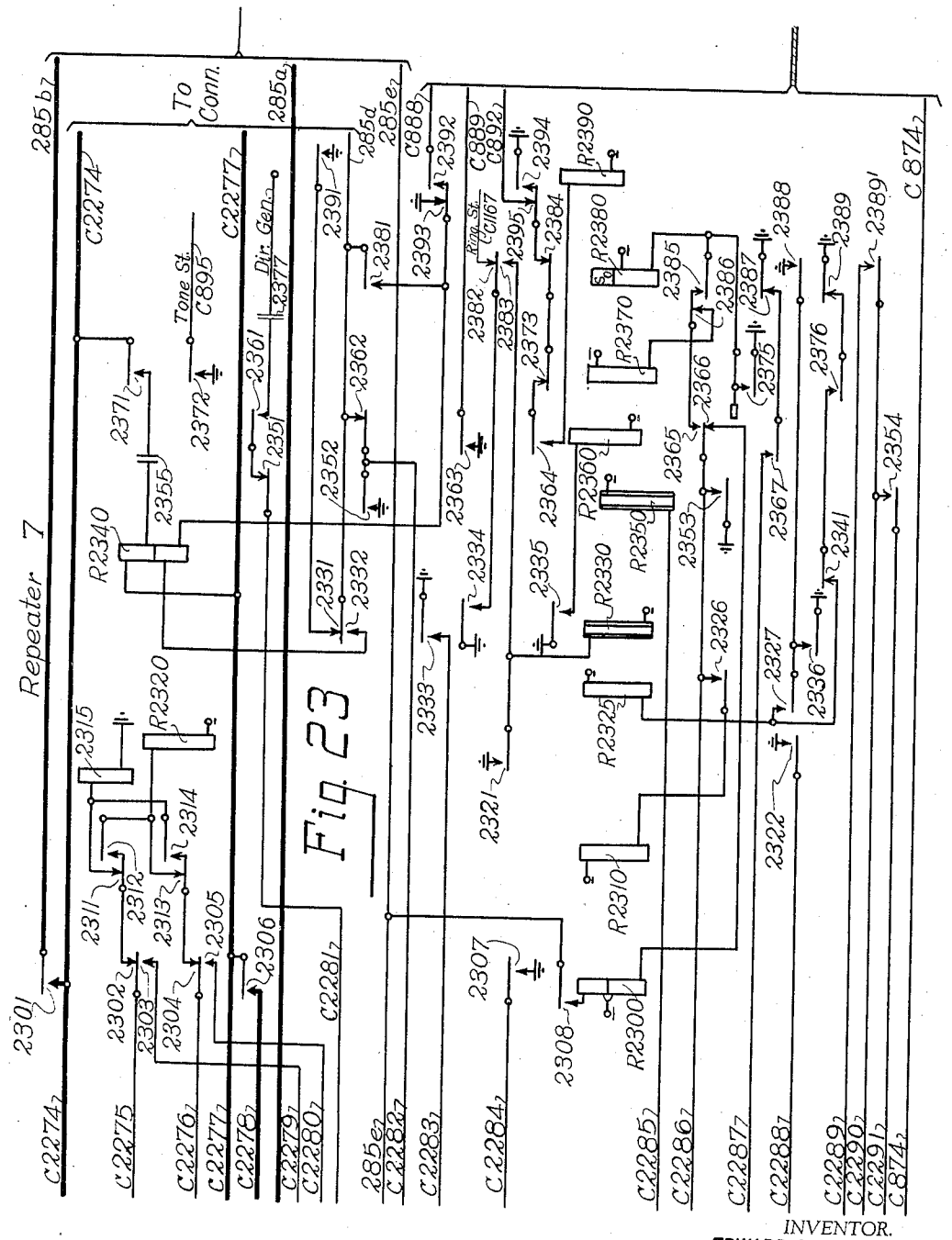
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TELEPHONE SYSTEM

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INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shontz

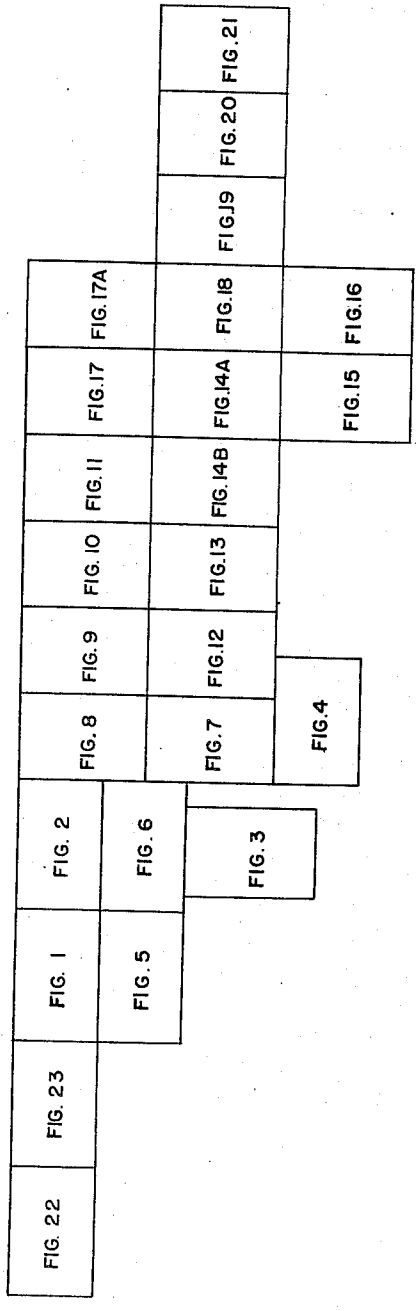
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Oct. 26, 1943. E. S. PETERSON 2,333,039

TELEPHONE SYSTEM

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Fig. 24



INVENTOR.
EDWARD S. PETERSON

BY Davis, Lindsey, Smith & Shonts

ATTORNEYS

Patented Oct. 26, 1943

2,333,039

UNITED STATES PATENT OFFICE

2,333,039

TELEPHONE SYSTEM

Edward S. Peterson, Elmwood Park, Ill., assignor to Automatic Electric Laboratories, Inc., a corporation of Delaware

Application March 24, 1941, Serial No. 384,899

60 Claims. (Cl. 179—18)

The present invention relates to automatic telephone systems and, more particularly, to improvements in automatic switching apparatus adapted for use in exchanges serving the subscribers of small communities. Community automatic exchanges of this type usually include trunking facilities to one or more nearby central offices of the manual or automatic type, and varied operating requirements must be met depending upon the location of the community and central exchanges and the grade and type of service to be rendered the community exchange subscribers. Accordingly, the present invention has for one of its objects the provision of improved automatic switching equipment which lends itself to the ready adaptation of special service facilities and is so arranged that all service facilities normally required in exchanges of the type mentioned may be incorporated therein with a minimum of added equipment.

It is another object of the invention to provide, in an automatic telephone system of the character described, improved inter-office trunking facilities of the two-way transmission type, which are so arranged that two cascade-connected two-way repeaters may be included in a tandem connection through one of the switch links of the community exchange and two-way supervision may be exercised over the connection without prematurely releasing the connection.

It is a further object of the invention to provide an improved two-way repeater which is arranged to permit the forcible release of a link operatively associated therewith and which includes provisions for preventing the release circuits, utilized for switch train holding purposes during the supervisory signaling, from interfering with the forced release of the associated link.

It is another object of the invention to provide in an automatic telephone system of the character described, improved automatic switching apparatus which is so arranged that the equipment common to a plurality of the switching links is controlled on a per line basis to permit certain subscribers to obtain access to the central office trunks of a specified class and to prevent other subscribers, for which a different type of service is provided, from obtaining access to the trunks of the specified class.

It is another object of the invention to provide in a telephone system of the character described, improved switching and central office trunking facilities which are so arranged that calls routed over the central office trunks are normally limited to intervals of measured duration through the automatic operation of conversation timing equipment provided in the community exchange, and wherein provisions are made for blocking the conversation timing equipment under the control of an operator handling the calls in the distant central office.

It is a further object of the invention to provide in a telephone system of the character described, improved switching facilities which are so arranged that certain of the central office trunks may be seized through each link of the community exchange over either of two paths, and wherein provisions are made for imposing a restriction on the use of the trunks only when seized over certain of the paths.

It is another object of the invention to provide in a telephone system of the character described, central office trunking facilities of two classes together with trunk preselect apparatus which functions automatically to select the trunks of one class in rotation and to select the trunks of the other class on a preferential basis in accordance with a predetermined preference pattern.

It is a further object of the invention to provide in a telephone system of the character described, improved trunking facilities which are so arranged that certain of the central office trunks may be seized through each link of the community exchange over either of two paths together with trunk preselect apparatus which functions to seize the trunks in rotation over certain of the paths and to seize the trunks over the other paths on a preferential basis.

It is still another object of the invention to provide in a telephone system of the character described, an improved call intercepting circuit of simple arrangement which may be associated with the lines or line terminals serving substations that have been disconnected and which functions automatically to signal calling subscribers that the disconnected substations are out of service, without the intervention of an operator.

It is a still further object of the invention to provide an improved and exceedingly simple circuit arrangement for charging the exchange battery conventionally provided in a community exchange of the character described.

In the illustrated embodiment of the invention there is provided a system which includes a community exchange for serving as many as two hundred lines and which includes trunking facilities to each of two central offices of the manual type. The automatic switching equipment of the

community exchange comprises a plurality of finder-connector links of the all-relay type which, in conjunction with equipment common to the links, operate to set up connections between the lines terminated at the community exchange. The trunking facilities over which the community exchange is connected to one of the manual offices includes trunks of two different classes, i. e., toll trunks and combination toll and free service trunks. Each of these trunks is terminated in the community exchange in a two-way repeater of novel arrangement. More specifically, the repeaters individual to the combination toll and free service trunks are accessible to the connector switches of the links over either of two paths, i. e., toll and free service paths. Conversation timing equipment is provided in association with these repeaters, which functions to control the repeaters so that when seized through the links over the free service paths the connections set up by way of the links and repeaters are automatically released after a predetermined time interval. Provisions are also made in the repeaters of this group for rendering the timing equipment inoperative to release connections routed by way thereof when the repeaters are seized over the toll paths of the link connector switches. Each repeater also includes apparatus for blocking the operation of the conversation timing equipment, which apparatus is controllable from the operator's switchboard in the distant manual office.

Apparatus is also provided in the community exchange for automatically preselecting the central office trunks for use. More specifically, the trunk preselect apparatus associated with the above-mentioned toll trunks and combination toll and free service trunks, is so arranged that the toll trunks are seized in rotation, whereas the combination trunks are seized in rotation over the free service paths of the links and are seized over the toll paths of the links on a preferential basis in the order of increasing directory number assignments. Provisions are also made in the link circuits whereby the free service trunks can only be seized through the links from the subscriber substations for which free central office trunk service is to be provided. To this end, right of way circuits are provided in the links which are controlled by the auxiliary group and unit relays of the equipment common to the links. These right of way circuits are so controlled that use of the free service trunks is granted or denied the subscribers' lines on a per line basis, thus making it possible to terminate both restricted and non-restricted lines in the same line groups.

The arrangement of the system is such that the community exchange may be utilized as a tandem exchange between the two distant manual offices. In this case, two of the repeaters and one of the links provided in the community exchange are connected in tandem incident to the setting up of a connection between the two offices. This connection as set up comprises a release circuit which extends through the operated link to each of the two operated repeaters and comprises two branches which are respectively completed in the two repeaters. With this arrangement a connection release operation may be performed in either of the two manual offices, thereby to transmit a supervisory signal to the other office, without releasing the established connection. This mode of controlling the repeater release circuits complicates the problem of releasing a link seized through one of the repeaters over a trunk having a permanent calling condition thereon. More specifically, when a repeater and link are seized over a trunk characterized by a permanent calling condition, the release circuit is completed both in the repeater and the link and, accordingly, the timing equipment, which normally operates only on the link circuits per se, is rendered inoperative to release the operated link. In order to obviate this difficulty, provisions are made for concurrently opening the release circuit in both the repeater and the link which are being held from the permanent trunk.

In accordance with another feature of the present invention, an improved call intercepting circuit is provided. This circuit includes line relays which individually correspond to the lines arranged for intercepting service, and apparatus operative in response to the transmission of ringing current to the circuit for energizing the particular line relay which corresponds to the line seized. A lockout arrangement is included in the circuit, which functions to prevent more than one of the line relays from operating at any time. The circuit also includes a signal current generator which is operative in response to the operation of any one of the line relays to transmit an out of service signal from the circuit to the calling line over which the circuit is seized.

In accordance with another feature of the invention, improved charging equipment is provided in the community exchange for delivering charging current to the exchange battery from an available alternating current source. This equipment includes a relay which functions to test the voltage of the exchange battery each time a call is routed to the exchange, and apparatus controlled by the test relay for completing the charging circuit each time a test indicates that the battery voltage is below a predetermined value. Auxiliary test means are provided which function to cause the completion of the charging circuit independently of the calls routed to the exchange when the voltage of the battery falls below a predetermined low value.

The novel features believed to be characteristic of the invention are set forth with particularity in the appended claims. The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the specification taken in connection with the accompanying drawings, in which Figs. 1 to 13, inclusive, 14A, 14B, 15, 16, 17 and 17A, and 18 to 23, inclusive, when combined in the manner indicated in Fig. 24 of the drawings, illustrate an automatic telephone system having incorporated therein the features of the invention briefly outlined above.

Description of the Apparatus Incorporated in the Telephone System

Referring to the drawings, the system there illustrated comprises a community automatic exchange which is connected with the two manual offices **5** and **6** by means of two groups of two-way trunks which respectively include the trunks **30** and **51**. The community exchange has a capacity of two hundred lines, certain of which have been indicated in the drawings by the directory number designations assigned thereto. More specifically, these lines are divided into two groups of one hundred lines each, each 100-line group including ten subgroups of ten lines each. Thus,

the subscriber's line 215, which is of the metallic type and extends to the substation A, is the fifth line of the first subgroup of lines in the first 100-line group, whereas the line 216, which is of the ground return type and serves the common battery substation B, is the sixth line of the same subgroup of lines. Both of these lines are illustrated as being of the single party type. The line 219, on the other hand, which is the ninth line of the first subgroup of lines in the first 100-line group, is illustrated as being of the multiparty type, serving the substations C and D. This subgroup of lines also includes four trunks of the well-known ring-down type which extend to a private branch exchange of the manual type. The lines of this trunk group are assigned the first four unit numbers, namely the numbers 1 to 4, inclusive, of the subgroup, and are automatically preselected for use through the provision of a trunk preselect relay group 1490. For switching purposes, each subgroup of ten lines terminating at the finder ends of the links is further subdivided into two smaller subgroups of five lines each in accordance with the units designations of the lines included therein. Thus, the lines having directory numbers ending in 1, 2, 3, 4 and 5 comprise one smaller subgroup of lines in each ten-line subgroup, and the lines having directory numbers ending in the units designations 6, 7, 8, 9 and 0 comprise the second smaller subgroup of lines in each ten-line subgroup. The central office trunk 30, which extends to the central office 5, terminates in the community exchange in a two-way repeater 7 which is connected by a link line to the set of contacts having the directory number 285. In order to preselect idle ones of the trunks extending to the manual office 5 as these trunks successively become busy, a second group of trunk preselect relays 1495 is provided in association therewith. The two trunk preselect relay groups 1490 and 1495 are identical in arrangement and are wired in accordance with the wiring of the trunk preselect relays disclosed in Figs. 11 and 13 of the copending application of John H. Voss, Serial No. 189,121, filed February 7, 1938, and assigned to the same assignee as the present invention, upon which Patent No. 2,252,309 issued on Aug. 12, 1941. The central office trunk 51, which extends to the manual office 6, terminates in the community exchange in a two-way repeater 8 which is connected by two link lines to the two sets of contacts having the directory numbers 291 and 203, respectively. For the purpose of preselecting idle ones of the trunks extending to the manual office 6, the two sets of trunk preselect relays respectively illustrated in Figs. 17 and 17A are provided. More specifically, this trunk group includes four trunks, two of which are strictly toll trunks and the other two of which are combination toll and free service trunks. The trunk preselect relays R1710, R1720, R1730, R1740, R1750, R1760, R1780 and R1790, illustrated in Fig. 17 of the drawings, are provided for preselecting any one of the four trunks for toll use, the wiring arrangement of these relays being such that the first two trunks, i. e., those reserved for toll use exclusively, are selected in rotation and the last two trunks, i. e., the combination trunks, are selected over the toll paths of the links on a directory number preference basis. The trunk preselect relays R1765, R1770, R1775, R1785 and R1795, illustrated in Fig. 17A of the drawings, on the other hand, are provided for selecting the two combination trunks in rotation for free service use.

As indicated above, in order to set up connections between the various lines of the system, a plurality of finder-connector links of the all-relay type are provided. The details of one of the links are illustrated in Figs. 2, 7, 8, 9, 10, 11, 12, 13, 14A, 14B and 15 of the drawings. The other links included in the exchange are identical in arrangement with the link illustrated. These links are arranged to be controlled by common equipment which comprises a link distributor, also shown in Fig. 7 of the drawings, a group of distributor control relays illustrated in Fig. 6 of the drawings, and a plurality of guard or auxiliary relays which are illustrated in Fig. 5 of the drawings. Briefly described, the finder portion of the illustrated link comprises twenty group relays, three of which are indicated at R200, R240 and R210, which respectively correspond to the different ten-line subgroups. These relays are preferably of the character disclosed and claimed in Patent No. 2,135,832, granted November 11, 1938, to Herbert F. Obergfell, and only three thereof have been shown in the interests of simplifying the disclosure. The finder portion of the link also comprises five unit relays, each of which corresponds to two lines in each of the ten-line subgroups. Thus, the relay R220, for example, is operative in conjunction with any one of the group relays to select the lines having the unit designations of 5 and 0 in each of the twenty different subgroups of lines. The unit relay R260, on the other hand, is operative to select the lines having the unit designations 1 and 6. It will be understood that with one of the group relays and any one of the unit relays operated, two lines are selected from the plurality of lines to which the finder switch has access. In order to select one of the two lines thus selected by the group and unit relays, there is provided a subgroup relay R270 which functions to switch the conductors of the link line 230 between the two link lines 228 and 229. For the purpose of associating the relays of the finder switch with the common equipment illustrated in Figs. 5, 6 and 7 of the drawings, a pair of connect relays R280 and R290 are provided.

The connector portion of the link is similar to the finder switch just described in that twenty group relays, including the four relays R1400, R1490, R1510 and R1580, and each including contacts terminating ten lines of the system, are provided. These relays are also preferably of the construction disclosed and claimed in the above-cited patent to Obergfell. The connector portion of the link further comprises ten unit relays which individually correspond to different lines of each of the ten-line subgroups. Only five of these relays, R1430, R1440, R1450, R1460 and R1470, have been illustrated in the drawings, these relays respectively corresponding to the first, second, third, ninth and tenth lines of each ten-line subgroup. As indicated previously, the lines terminating at the connector switches of the system are divided into two groups of one hundred lines each. The connector group relays are likewise divided into two groups, each comprising ten relays. For the purpose of selectively controlling the operating circuits of these two groups of connector group relays, two group select relays R1350 and R1360 are provided in the link illustrated.

In order selectively to control the group select relays, the connector group relays, and the connector unit relays to cause the proper relay oper-

ations for the selection of a desired called line and the selective signaling of the substations served by called ones of the multiparty lines terminating at the exchange, an impulse-counting chain is provided. This counting chain is illustrated in Figs. 7, 12 and 13 of the drawings, as comprising ten counting relays R1240, R1250, R1260, R1270, R1280, R1290, R1300, R1310, R1320 and R1330, and three associated common control relays R750, R760 and R770.

The control equipment of the link comprises a switching-through relay R800 which is operative to by-pass the repeating coil 834 in handling central office trunk calls routed through the link, a battery reversing relay R810, a pair of line relays R820 and R825, and an impulse-correcting network which includes the two control relays R830 and R840, a slow-acting control relay R850, and a hold relay R860. In order to control the release of the counting chain illustrated in Figs. 7, 12 and 13 of the drawings, there is provided a counting chain release relay R870.

The control equipment embodied in the connector portion of the link also includes a pair of link release relays R900 and R910, a back-bridge relay R920, a control relay R930 which is connected to operate as a slave to the back-bridge relay R920, a pair of reverting-call control relays R940 and R970, a slow-to-release line discharge control relay R950, a ring pickup relay R960, and a slow-to-operate ring cut-off relay R980.

As illustrated in Fig. 10 of the drawings, the control apparatus of the link further comprises a ringing transfer relay R1000 which is utilized to determine the side of a selected line over which ringing current is to be projected, a ringing control relay R1010, a right-of-way control relay R1020, a line-switching relay R1030, a busy test relay R1040, another line-switching relay R1050, a slow-to-operate idle test relay R1070, and a slow-to-operate relay R1060 which is used in conjunction with the relay R980 to effect instantaneous ring cut-off. The control equipment illustrated in Fig. 11 of the drawings comprises a verification relay R1140 which is utilized in the establishment of communication connections to busy called lines terminating at the connector end of the link. This equipment also includes three impulse-controlled relays R1100, R1150 and R1160, the last two of which are of the slow-to-release type, a first digit transfer relay R1120, a second digit transfer relay R1110, and a third digit transfer relay R1130.

For the purpose of selecting the type of ringing to be utilized in signaling over a called subscriber's line of the multiparty type, of controlling the group select relays R1350 and R1360, and of partially selecting the code of the ringing current to be used in signaling called substations served by the multiparty lines terminating at the exchange, all in response to the impulses comprising a first digit transmitted to the connector portion of the link, two relays R1200 and R1210 are provided which are arranged selectively to be controlled by the relays of the impulse-counting chain during the response of this chain to the impulses of a first digit transmitted to the link. The arrangement referred to above, whereby certain of the subscribers' lines terminating at the finder-connector links are permitted to have access to the central office trunks while other subscribers' lines are prevented from obtaining access to these trunks, includes a pair of restricted service relays R1480 and R1485 which are controlled in the manner pointed out hereinafter by the relays of the equipment common to the links.

Referring now more particularly to the arrangement of the two-way repeaters individual to the trunks extending to the manual office 5, the repeater 7 terminating the trunk 30 is exemplary. This repeater is illustrated in Figs. 22 and 23 of the drawings as comprising a repeating coil 2205 and a group of interconnected control relays. More specifically, these relays include four ring-down signal control relays R2200, R2210, R2220 and R2230, a battery reversing relay R2235, a release relay R2240 which is arranged to be controlled by the timing device 720b, an electropolarized back-bridge relay R2245, a slow-to-operate release circuit control relay R2250, a line relay R2260, and a slow-acting pulse-controlled relay R2270. The relay equipment of the repeater 7 further includes a line switching relay R2300, a battery reversing relay R2310, a line relay R2320, a trunk identification relay R2325, a slow-acting hold relay R2330, a tone relay R2340, a second slow-acting hold relay R2350, a control relay R2360 which is wired to operate as a slave to the hold relay R2330, a timing relay R2370, a slow-to-operate tone cut-off relay R2380, and a repeater release relay R2390. The various enumerated relays are connected and arranged to operate in the manner more fully described hereinafter.

The repeater 8 which terminates the trunk 51 in the community exchange is illustrated in Figs. 18, 19, 20 and 21 of the drawings, and is substantially similar to the repeater 7, but certain additional relays are provided therein for the purpose of obtaining the timing of calls in the manner referred to above. Briefly described, the repeater 8 comprises a time blocking relay R1800, a pair of repeater release relays R1810 and R1820, a warning tone control relay R1840, a slow-to-operate release circuit control relay R1900, a pair of paystation tone control relays R1910 and R1920, a transfer relay R1930, a trunk identification relay R1940, a pair of hold relays R1950 and R1960, and a paystation tone relay R1970. The relay equipment of this repeater further comprises a second slow-acting hold relay R2000, a slow-to-operate control relay R2010, a line relay R2020, a battery reversing relay R2025, a line switching relay R2030, a slow-to-operate loop circuit control relay R2040, a slow-to-operate release and loop circuit control relay R2060, a slow-acting pulse-controlled relay R2070, an electropolarized back-bridge relay R2080, a line relay R2110, a battery reversing relay R2120, four ringdown signal control relays R2130, R2140, R2150 and R2160, and a pair of additional relays R2059 and R2170 which are controllable from the operator's switchboard in the manual office 6 to block the operation of the conversation timing facilities of the repeater. The manner in which the various enumerated relays are wired is fully explained hereinafter in connection with the operation of the system.

As indicated above, provisions are made in the community exchange for intercepting calls routed to lines of substations which have been taken out of service. These facilities include the intercepting circuit 1605, which is illustrated in Fig. 16 of the drawings as comprising a plurality of line relays R1610, R1620, R1630, etc., which are individual to the lines arranged for this type of service. These relays are respectively controlled by alternating current relays individual to the lines and energized by ringing current

transmitted thereover. Thus, the alternating current relay R1600 is provided in association with the line 219 and is arranged to control the first line relay R1610. The equipment common to the lines and included in the circuit 1605 includes a pair of start relays R1640 and R1650, the last of which is of the well-known pendulum type, and a signal current generator which comprises the slow-to-operate relay R1660 and the slow-acting relay R1670. The relay R1660 is also arranged to control a metering device 1664 which is provided for the purpose of registering each call intercepted by the circuit 1605.

As pointed out above, the equipment common to the several links comprises a plurality of guard or auxiliary relays which individually correspond to the relays embodied in each of the finder switches. More specifically, this equipment comprises twenty auxiliary group relays, four of which are indicated at R500, R510, R520 and R590, which individually correspond to the twenty group relays of the finder switches. Thus, the two relays R500 and R510 are arranged individually to control the finder group relays R200 and R210 of the link illustrated. The sixteen group relays which are not shown are indicated by the multiple and chain conductors extending between the contacts of the four illustrated auxiliary group relays R500, R510, R520 and R590. Ten auxiliary unit relays including the four relays R550, R560, R570 and R580 are also provided, which relays individually correspond to the ten lines of each ten line group.

The link distributor or allotter equipment is also of the all-relay type, a group of link distributor relays R700, R710, R730, etc., being provided which individually correspond to the links and operate in a cyclic manner to assign the respective associated links for use in a predetermined order. These link distributor relays are arranged to be controlled by a group of control relays which are illustrated in Fig. 6 of the drawings and include a slow-acting relay R610 for controlling the auxiliary relay start circuits and the call metering device 614, a group of slow-to-release link transfer and distributor control relays R620, R630, R640 and R650, a slow-acting distributor reset relay R660, and an all-links-busy relay R670 which is operated only when an all-busy condition of the respective associated links prevails. The relay R670 is also arranged to control an all-busy metering device 632 which functions to register those instances when calls fail due to an all-busy condition of the links. The common equipment further includes control relays R530, R540, etc., which are individual to the line groups containing trunks and non-restricted subscribers' lines, and are provided for the purpose of controlling the trunk identification and right-of-way or restricted service circuits referred to above and described with particularity hereinafter.

For the purpose of initiating the operation of the common equipment just described, each line and trunk of the system is terminated in the usual line circuit which conventionally comprises line, cut-off and lockout relays. Thus, the line 215 which extends to the substation A terminates at the exchange in a line circuit 10, which includes a line relay R100, a cut-off relay R110 and a line lockout relay R105. Similarly, the line 216 which extends to the substation B is terminated at the exchange in a line circuit 15 which includes the line, cut-off and lockout relays R120, R130 and R125, respectively. The line circuit 25 which is diagrammatically illustrated as terminating the multiparty subscriber's line 219, is identical in arrangement with the two line circuits 10 and 15. It will also be observed that the line circuit 20 which is provided in association with the two-way repeater 7 and includes the line cut-off and lockout relays R150, R160 and R155, respectively, is substantially similar in arrangement with the line circuits 10 and 15.

The equipment common to the links also includes the usual ringing apparatus, battery charging equipment, timing apparatus and tone-generating apparatus. More specifically, the timing apparatus includes a timing device 720a, preferably of the all-relay type, which is provided for the purpose of controlling the release of the links after reverting calls routed by way thereof have been successfully completed. A second timing device 720b, also preferably of the all-relay type, is provided for the purpose of forcibly releasing any link held operated over a faulty line or a line having a permanent calling condition thereon, and of controlling the link release relays of the links for the purpose of timing local call connections established by way of the links. These two timing devices may be any well-known construction and arrangement, the operation of which is well understood in the art and, accordingly, the details thereof have not been illustrated. The ringing apparatus provided in association with the links includes a ringing current generator, preferably of the pole changer type, and a ringing code interrupter 1395. This interrupter is so arranged that it provides on its associated ten interrupter leads ten sets of differently coded ringing control pulses so that ten fundamental ringing codes are produced. The ringing interrupter also includes provisions for preceding each of the ten fundamental codes by a short ringing code pulse so that ten additional codes are effectively produced. This is accomplished by providing an arrangement for selectively controlling the application of the pickup relay operating potential to the two pickup leads C1215 and C1221. More specifically, the arrangement is such that if one of these pickup leads is utilized in the control of the ring pickup relay of an operated link, the preliminary short rings are omitted from the ringing code, whereas if the other pickup lead is utilized as a part of the operating circuit for the ring pickup relay in the operated link, the short or preliminary ringing interval is included in each of the ten ringing codes. Since this type of code ringing and the arrangement of the ringing interrupter whereby it may be achieved are well known in the art, the details of the ringing equipment have not been illustrated in detail.

The tone-generating equipment is illustrated in Fig. 4 of the drawings as comprising a dial tone generator 435, a busy tone generator 440, and a reverting-call tone generator 475. The dial and busy tone generators are of identical arrangement and, accordingly, only the details of the busy tone generator have been illustrated in the drawings. Briefly described, this generator comprises a start relay R400 which is common to the tone-generating equipment, a buzzer 430, a slow-to-operate start relay R410, a control relay R420 and a transformer 432. The reverting-call tone generator 475 includes a pole changing relay R480 which is arranged to be controlled by three slow-to-operate, cyclically operating timing relays R450, R460 and R470. These relays are also arranged to control the ap-

plication of the busy tone potential, generated through operation of the tone generator **440**, to the busy tone current lead C1089.

The battery charging equipment is illustrated in Fig. 3 of the drawings as comprising a pair of rectifiers **305** and **315** which are preferably of the dry disk or thermionic type and are included in a charging circuit which extends from the alternating current feeder circuit terminals **316** to the terminals of the exchange battery. This charging circuit is completed and interrupted through operation of a control circuit which comprises a slow-acting pulsing relay R370, a high and low voltage test relay R350, a medium voltage test relay R300, a pair of slow-to-release control relays R340 and R360, and three heavy duty switching relays R310, R320 and R330. Auxiliary means comprising an additional low voltage test or alarm relay R390 and a slow-to-operate control relay are provided for controlling the three enumerated switching relays and the alarm device **392** in the manner more fully described hereinafter.

Seizure of the Link and Operation of the Finder Switch

Referring now more particularly to the operation of the apparatus, a call initiated at the substation A served by the common battery line **215** may be considered by way of example. When the party initiating the call at the substation A removes the receiver provided at this substation from its associated switchhook or cradle, a loop circuit is established which includes the exchange battery and the winding of the line relay R100. This circuit extends from ground by way of the upper winding of R100, the contacts **111**, the conductor **215***b*, the direct current bridge across the conductors of the line **215** at the calling substation, the conductor **215***a*, the contacts **112**, and the lower winding of R100 to battery. In operating, the relay R100 prepares, at its contacts **101**, a circuit for energizing the auxiliary unit relay R550 which corresponds to the line **215**. At its contacts **103**, the relay R100 connects the private conductor **215***d* to ground, thereby to mark the line **215** as busy in the connector switches having access thereto. At its contacts **103**, the relay R100 completes a circuit for energizing the auxiliary group relay R510 which corresponds to the first group of ten lines. This circuit extends from ground by way of the contacts **102** and **107**, the start conductor C145, the winding of R510, the contacts **513**, C578, the contacts **612**, C580, the contacts **594**, **514**, **524** and **504**, the chain-connected contacts controlled by the other auxiliary group relays, and the resistor **522'** to battery. When energized over this circuit the relay R510 completes, at its X contacts **513'**, an obvious holding circuit for itself, and opens, at its contacts **514**, a point in the common portion of the operating circuits for the twenty auxiliary group relays. At its contacts **515**, **516**, etc., the relay R510, in operating, prepares the operating circuits for the ten auxiliary unit relays. In the present case, however, only the auxiliary unit relay R550 is operated, the circuit for energizing this relay extending from ground by way of the contacts **108** and **101**, C147, the contacts **515**, the winding of R550, the contacts **556**, C577, the contacts **611**, C576, the contacts **584**, **564**, **554** and **574**, similar chain-connected contacts of the other auxiliary unit relays, and the resistor **568** to battery. At its contacts **511**, the relay R510 prepares a circuit for energizing the corresponding group relay of the assigned link.

When energized over the above-traced circuit, the auxiliary unit relay R550 operates and completes, at its X contacts **555**, an obvious locking circuit for itself. After this circuit is completed, the relay R550, at its contacts **554**, opens a point in the common portion of the operating circuits for all of the auxiliary unit relays. At its contacts **557**, the relay R550 prepares a circuit for energizing the unit relay of the assigned link which corresponds to the units designation **5** of the calling line **215**. At its contacts **552**, the relay R550 prepares two paths for impressing ground potential upon the leads C584 and C681. At its contacts **551**, the relay R550 completes a circuit for energizing the connect relays of the link previously selected for use by the link distributor relays. Assuming that all of the links are idle, all of the link distributor relays are operated so that the link illustrated is assigned to the use of the calling line **215**. In such case the relay R550, upon operating, completes a circuit for energizing the two connect relays R280 and R290 in parallel, this circuit extending from ground by way of the contacts **551**, the common start lead C573, the contacts **702**, C234, and the windings of the relays R280 and R290 in parallel to battery. The relay R290, in operating, completes, at its contacts **297**, a circuit extending by way of the common guard lead C682 for energizing the slow-acting relay R610. The relay R610 now operates to complete, at its contacts **613**, a circuit extending from ground at the contacts **674** for energizing the call metering device **614**, whereby the call is registered. At its contacts **611**, the relay R610 opens another point in the common portion of the operating circuits for all of the auxiliary unit relays. At its contacts **612**, the relay R610 opens another point in the common portion of the operating circuits for all of the auxiliary group relays. Thus, the auxiliary relays are prevented from responding to another call until the finder switch illustrated has completed its operation to seize the calling line **215**. At its contacts **616**, the relay R610 completes an obvious path for impressing ground potential upon the charge control start lead C617. The relay R280, in operating, prepares, at the contacts controlled thereby, the operating circuits for the twenty group relays embodied in the finder switch illustrated. In the case under consideration, only the relay R210, which terminates the first group of ten lines, is energized in response to operation of the relay R280, the operating circuits for the other nineteen group relays being held open at the restored contacts of the other auxiliary group relays. More specifically, the circuit for energizing the relay R210 extends from ground by way of the contacts **511**, C572, the contacts **281**, and the winding of R210 to battery. This relay, in operating, prepares, at its contacts **211** to **213**, inclusive, connections between the conductors of the line **215** and the conductors of the link line **228**, and, at its contacts **247**, prepares a holding circuit for itself. At the remaining contacts controlled by this group relay, connections are prepared between the other nine lines terminating at these contacts and the two link lines **228** and **229**.

The relay R290, upon operating, prepares the operating circuits for the five unit relays of the finder switch. In the case under consideration only the operating circuit for the relay R220 is completed, this circuit extending from ground by

way of the contacts 557, C583, the contacts 295, and the winding of R220 to battery. When energized over this circuit the relay R220 operates to prepare a locking circuit for itself at its contacts 227. At its contacts 221, 222 and 223, the relay R220 connects the conductors of the calling line 215 to the conductors of the link line 228. At its contacts 224, 225 and 226, the relay R220 connects the conductors of the line 210 to the other link line 229. At its contacts 293, the relay R290 prepares a circuit for energizing the subgroup relay R270. In the present case, wherein the line 215 is in the first subgroup of the first group of lines, the subgroup lead C683 of the common equipment is not connected to ground and hence the operating circuit for the subgroup relay R270 is held open at the contacts 568, 588, etc., of the restored unit relays corresponding to lines having the unit designations 6, 7, 8, 9 and 0. Accordingly, the relay R270 remains in its restored position for the duration of the call under consideration. At its contacts 296, the relay R290 prepares alternative operating circuits for the five unit relays of the finder switch, these alternative circuits being held open at the restored contacts 567, 587, etc., of the unit relays. At its contacts 292, the relay R290 completes a multiple holding circuit for the link distributor relay R700 individual to the link illustrated, this multiple circuit extending from ground by way of the resistor 708, the contacts 706, C232, the contacts 292, C231, and the winding of R700 to battery. At its contacts 298, the relay R290 prepares a circuit including the trunk call identification lead C681 for energizing the right-of-way control relay R1020.

The relay R290, in operating, also completes a circuit for energizing the two line relays R820 and R825, this circuit extending from ground by way of the winding of R825, the winding 835, the contacts 802 and 811, the conductor 230*a*, the resistor 283', the contacts 291, the conductor 230*b*, the contacts 813 and 804, the winding 836 and the winding of R820 to battery. When energized over this circuit the relay R820 operates to complete, at its contacts 821, a circuit for energizing the pulsing relay R830, this circuit extending from ground by way of the contacts 918', C890, the contacts 841 and 821, and the winding of R830 to battery.

The relay R825 also operates when energized in series with the relay R820, and, upon operating, prepares, at its contacts 826, the operating circuit for the battery reversing relay R800.

The relay R830, in operating, completes, at its contacts 832, an obvious circuit for energizing the relay R840. At its contacts 834, the relay R830 opens a point in the pulsing circuit, traced hereinafter, over which the counting relays illustrated in Figs. 12 and 13 are successively energized during the transmission of impulses to the connector portion of the link. At its contacts 833, the relay R830 completes a locking circuit for itself, this locking circuit extending from ground by way of the contacts 833, the resistor 823, the contacts 821 and the winding of R830 to battery. At its contacts 831, the relay R830 completes a circuit for energizing the slow-acting relay R850, this circuit extending from ground by way of the contacts 918', C890, the contacts 831 and the winding of R850 to battery. Shortly after this circuit is completed, the relay R840 operates and, in so doing, closes its contacts 842 to shunt the operated contacts 831 and thus complete an obvious multiple circuit for energizing the relay R850. At its contacts 841, the relay R840 opens a point in the above-traced operating circuit for the pulsing relay R830. The relay R850, in operating, prepares, at its contacts 851, a priming circuit for the line relay R820. At its contacts 852, the relay R850 completes an obvious circuit for energizing the hold relay R860. At its contacts 853, the relay R850 opens a point in the circuit traced hereinafter for energizing the reverting-call relay R940. At its contacts 854, the relay R850 completes a path for impressing ground potential upon the tone apparatus start conductor C895, thereby to energize the tone start relay R400. More specifically, this relay is energized over a circuit which extends from ground by way of the contacts 1037, C894, the contacts 854, the tone start lead C895 and the winding of R400 to battery. When energized over this circuit, the relay R400 operates to initiate the operation of the three associated sets of tone apparatus illustrated in Fig. 4 of the drawings. The manner in which this is accomplished is explained in detail hereinafter.

The hold relay R860, in operating, prepares, at its contacts 866, locking and operating circuits for the relays R810 and R1070. At its contacts 869, the relay R860 completes an obvious path for impressing ground potential upon the release conductor C893, thereby to prepare operating and locking circuits, traced hereinafter, for certain of the other control relays embodied in the link. At its contacts 867, the relay R860 completes a path including the contacts 818 for impressing ground potential upon the timer start lead C889, thereby to initiate the operation of certain of the timing devices embodied in the timing equipment 720*b*. At its contacts 868, the relay R860 prepares a circuit traced hereinafter for energizing the link release relay R900. At its contacts 864, the relay R860 prepares the above-mentioned circuit for transmitting impulses to the relays of the counting chain illustrated in Figs. 12 and 13 of the drawings. At its contacts 863, the relay R860 opens one of the multiple paths included in the normally completed holding circuit for the link distributor relay R700, this circuit now being closed at the engaged contacts 292 of the operated connect relay R290. At its contacts 865, the relay R860 completes the prepared holding circuits for the group and unit relays R210 and R220, respectively. More specifically, the holding circuit for the units relay R220 extends from ground by way of the contacts 948, C882, the contacts 865, C235, the contacts 227 and the winding of R220 to battery. The holding circuit for the group relay R210 extends by way of the grounded lead C235, the contacts 247 and the winding of R210 to battery. At its contacts 861, the relay R860 completes a path for transmitting dial tone signal current over the established connection extending to the calling substation, thereby to inform the calling party that the dialing operation may be started. This path may be traced as extending from the ungrounded terminal of the dial tone generator 435 by way of C1168, the contacts 1121, 1111 and 1141, C845, the condenser 843, the contacts 861, 804 and 813, the conductor 230*b*, and the contacts 273, 222 and 212 to the negative side of the calling line 215. From this point the dial tone current is conducted through the windings of the receiver provided at the calling substation A and back over the positive side of the line 215 to the grounded terminal of the dial tone generator 435.

At its contacts 862, the hold relay R860 completes a path for impressing ground potential upon the private conductor 215c of the calling line 215, this path extending from ground by way of the contacts 852 and 862, C233, and the contacts 275, 223 and 213 to the private conductor 215c. When this private conductor is grounded, the line 215 is marked as busy in the relay contacts of the various connector switches and the cut-off relay R110 is energized in series with the slow-acting lockout relay R105. When energized over this circuit, the two relays R105 and R110 both operate. In operating, the relay R110 disconnects the winding terminals of the line relay R100 from the conductors of the line 215. Thus, the line relay R100 is deenergized and the calling loop circuit is cleared of the impedance represented by the windings of this relay. When thus deenergized, the relay R100 restores to open, at its contacts 102 and 101, the established locking circuits for the operated auxiliary group and unit relays R510 and R550, respectively. At its contacts 103, the relay R100 opens the initially completed path for impressing ground potential upon the private conductor 215d of the calling line 215. At its contacts 103', the relay R100 connects the private conductor 215d to the grounded control conductor 215c, thereby to maintain guarding ground potential upon the private conductor.

The slow-acting lockout relay R105, upon operating, opens, at its contacts 108, a further point in the previously traced circuit for energizing the auxiliary unit relay R550. At its contacts 107, the relay R105 opens another point in the previously traced operating and locking circuits for the auxiliary group relay R510. At its contacts 106, the relay R105 prepares a locking circuit for itself. The relay R510, in releasing, opens, at its contacts 511, the above-traced operating circuit for the relay R210. At its contacts 513 and 514, the relay R510 reprepares the operating circuits for the twenty auxiliary group relays. At its contacts 513', the relay R510 opens a further point in its own locking circuit. At its contacts 515, the relay R510 opens a further point in the above-traced circuit for energizing the relay R550. At the remaining contacts controlled by the relay R510, the prepared operating circuits for the other nine auxiliary unit relays of the common equipment are opened. When the auxiliary unit relay R550 restores, it opens, at its contacts 557, the previously traced operating circuit for the unit relay R220. At its contacts 555, the relay R550 opens a further point in its own locking circuit. At its contacts 554 and 556, the relay R550 reprepares the operating circuits for the ten auxiliary unit relays. At its contacts 552, the relay R550 opens the prepared path for impressing ground potential upon the special service lead C681. At its contacts 551, the relay R550 interrupts the above-traced circuit for energizing the two conect relays R280 and R290 in parallel. The two connect relays R280 and R290 now restore.

The relay R280, in releasing, opens the prepared operating circuit for the twenty group relays of the finder switch. The relay R290, in restoring, opens the prepared operating circuits for the five unit relays and the subgroup relay R270 of the finder switch. At its contacts 298, the relay R290 opens a point in the prepared operating circuit for the control relay R1020. At its contacts 299, the relay R290 opens a point in the prepared operating circuit for the restricted service relay R1480. At its contacts 297, the relay R290 opens the above-traced operating circuit for the relay R610, causing the latter relay to release. At its contacts 292, the relay R290 opens the above-traced multiple holding circuit for the link distributor relay R700. The relay R700 now restores, and at its contacts 702, disconnects the common start lead C573 from the start lead C234 extending to the link illustrated. At its contacts 701, the relay R700 connects the common start lead C573 through the contacts 712 of the second link distributor relay R710 to the start lead individual to the second link, assuming the second link is idle. At its contacts 706, the relay R700 opens a further point in its locking circuit as traced above. At its contacts 707, the relay R700 prepares an operating circuit for itself. At its contacts 705, the relay R700 prepares a point in the chain circuit for energizing the slow-acting reset relay R660. At its contacts 703 and 704, the relay R700 opens the prepared path for short-circuiting its own winding, and prepares a path extending through the contacts 713 for short-circuiting the winding of the second link distributor relay R710. Following the operations just described, the link illustrated is identified as busy in the link distributor relay group, and the relays of this group are set to assign the second link to the use of the next incoming call. Shortly following the release of the relay R700, the slow-acting relay R610 restores and opens, at its contacts 613, the circuit for energizing the metering device 614. At its contacts 611 and 612, the relay R610 reprepares the operating circuits for the auxiliary unit and auxiliary group relays, whereby these relays are conditioned to respond to another call. It will be noted that the operating circuits for these auxiliary relays are held open until all of the other relay operations required incident to the handling of the call in progress are completed, thus positively eliminating the possibility of two calling lines obtaining access to the same link.

As indicated previously, the operation of the common equipment and the finder portion of an assigned link to seize a calling line is different, depending upon the unit designation of the calling line. The preceding explanation is predicated upon the operation of the apparatus to select a calling line included in the first subgroup of lines of a particular ten-line group. Briefly to consider the operation of the apparatus when a call is initiated upon a line, such, for example, as the local battery, ground return line 216 included in the second subgroup of the first ten-line group, it is pointed out that if the line relay R120 individual to this line operates, the previously traced operating circuit for the auxiliary group relay R510 is completed through the contacts 122 and 127. A circuit is also completed for energizing the auxiliary unit relay R560 corresponding to the line 216, this circuit extending from ground by way of the contacts 128 and 121, C148, the contacts 516, the winding of R560, the contacts 566, C577, the contacts 611, C576, the contacts 584, 564, 554 and 574, and corresponding chain-connected contacts of the other six auxiliary unit relays, and the resistor 568 to battery. When energized over this circuit, the relay R560 is locked up in series with the resistor 568 over a circuit including the X contacts 565. At its contacts 564, the relay R560 opens a point in the common portion of the operating circuits for the five auxiliary unit relays. At its contacts 562 the relay R560 prepares a path for impressing

ground potential upon the special service leads C584 and C681. At its contacts 567, the relay R560 prepares a circuit for energizing the unit relay R260 of the first link, assuming that the first link has been selected for use by the link distributor relays. At its contacts 568, the relay R560 prepares the operating circuit for the subgroup relay R270 of the link. At its contacts 561, the relay R560 completes the previously traced circuit for energizing the two connect relays R280 and R290 in parallel. The relay R280, in operating, completes the previously traced operating circuit for the group relay R210. The relay R290, in operating, prepares the operating circuit for the unit and subgroup relays of the finder switch. The relay R290 also performs the other functions described above with reference to the call initiated on the line 215. At its contacts 293, the relay R290 completes the prepared operating circuit for the subgroup relay R270 of the link, this circuit extending from ground by way of the contacts 568, C683, the contacts 293 and the winding of R270 to battery. When energized over this circuit the relay R270 operates and closes its locking contacts 277. At its contacts 271 to 276, inclusive, the relay R270 disconnects the conductors of the link line 230 from the conductors of the link line 228, and connects the conductors of the first-mentioned link line to the conductors of the link line 229 in preparation for the selection of a line in the second subgroup of the selected group of ten lines. At its contacts 278, the relay R270 completes the prepared alternative operating circuit for the unit relay R260, this circuit extending from ground by way of the contacts 278 and 296, C582, the contacts 567, C584', the contacts 294, and the winding of R260 to battery. When energized over this circuit, the relay R260 operates and closes its locking contacts 267. At its contacts 264, 265 and 266, the relay R260 connects the conductors 216a, 216b and 216c of the calling line 216 through to the conductors 230a, 230b and C233 of the link line 230. At its contacts 261 to 263, inclusive, the relay R260 prepares a connection from the line 211 to the conductors of the link line 230, but since the subgroup relay R270 is operated, this connection is held open at the contacts 271, 273 and 275. Thus, it will be apparent that, depending upon the position of the subgroup relay R270, either of two lines may be selected through operation of any one of the five unit relays embodied in the finder switch.

When the connect relay R290 operates, it also functions to complete the operating circuit for the line relay R820, thereby to cause the sequential operation of the relays R830, R840, R850 and R860 in the manner pointed out above. In this case, since the calling line 216 is of the ground return type, the conductor 216a is connected to ground. Accordingly, the relay R825 is short-circuited and does not operate when the calling loop circuit is extended to the connector portion of the link in the manner just explained. The relay R860, in operating, completes the prepared holding circuits for the group relay R210, the unit relay R260, and the subgroup relay R270, these holding circuits commonly extending by way of the grounded hold conductor C235, and branching through the locking contacts 247, 267 and 277, respectively, to the windings of the respective enumerated relays. The relay R860, in operating, also completes a path extending by way of the contacts 852 and 862, C233, and the contacts 276, 266 and 246 for impressing ground potential upon the private conductor 216c of the calling line 216. Thus, the calling line is marked as busy in the contacts of the connector group relays, and the cut-off and lockout relays R130 and R125 are caused to operate. In operating, the relay R130 disconnects the winding of the line relay R120 from the conductor of the line 216. When the relay R120 releases, it functions to initiate the release of the common equipment in the manner explained above, it being pointed out that the holding circuit for the unit relay R560 is interrupted at the contacts 121, when the line relay R120 restores.

Incoming trunk calls

In the arrangement illustrated, the eighth, ninth and tenth groups of lines in the first larger group of one hundred lines each includes groups of inter-office trunks. More specifically, the five trunks extending to the manual office 5 are terminated at the line contacts of the eighth group relay R240 in the finder switch illustrated and at corresponding contacts of the corresponding relays in the other finder switches. These trunks are terminated at the first sets of contacts of the various finder and connector group relays, namely, those designated by the directory numbers 201 to 205, inclusive, and the remaining five sets of contacts of the group, namely, those designated by the directory numbers 206 to 200, inclusive, may be used for substation line termination. The trunks extending to the manual office 6 are terminated in the group relays of the finder and connector switches which correspond to the 290 and 200 series of directory numbers. More specifically, the two toll trunks and the two combined toll and free service trunks extending to the manual office 6 are terminated at the first two sets of contacts of the tenth finder group relay R200 and the corresponding contact sets of the tenth group relays in the other finders and connectors. The two combination toll and free service trunks are also terminated at the first two sets of contacts, i. e., the contact sets having the directory number designations 291 and 292, of the ninth group relay R1490, and the corresponding contact sets of each of the other ninth connector group relays. The purpose achieved by terminating the trunks in this manner is to permit selective control of the marking network associated with the trunk identification and restricted service leads C681 and C584. These leads are controlled by the group relays R530 and R540 and the auxiliary unit relays, and are provided in order to control the trunk identification relay, such, for example, as the relay R1020, and the restricted service relays, such, for example, as the relays R1480 and R1485, of an assigned link. More specifically, the relay R1020 is wired for energization in response to the initiation of calls on trunks and functions to prevent the operation of the conversation timing facilities in the manner described hereinafter. The relays R1485 and R1480, on the other hand, function to prevent the restricted subscribers from obtaining access to the combination toll and free service trunks over the free service route.

In certain installations the switching equipment illustrated in the drawings may be required to handle calls initiated on substation lines of the paystation type. In such case the paystation lines are terminated in the unused contacts of the finder and connector group relays to which the trunks of the system extend. If the paystations associated with these lines are of the well-

known prepay type, a reversal of the polarity of the voltage impressed upon a calling one of the lines is required at the time the call is answered, in order to cause the collection of the deposited coin or coins. This is accomplished in the link illustrated by providing a circuit, including the "L" wiring illustrated in Fig. 2 of the drawings and controlled by the group relay or relays terminating the paystation lines, for energizing the battery reversing relay R800. As contrasted with the paystation lines, it is undesirable to reverse battery over a line serving substations of the local battery type. Accordingly, the local battery lines are not terminated in the contacts of the group relays which are utilized to terminate the paystation lines of the system. If all of the substations served by the lines terminating at the switching equipment illustrated are of the common battery type, the "N" wiring illustrated in Fig. 2 of the drawings is used. With this wiring arrangement, the completion of the circuit for energizing the battery reversing relay R800 is rendered independent of the switching action of the various group relays of the finder switch.

The mode of operation of the common equipment and the finder portion of an assigned link in handling a call initiated on one of the inter-office trunks is substantially similar to the operation of the common equipment and the finder portion of the link illustrated, as described above with reference to calls initiated on the subscribers' lines 215 and 216. Thus, if the central office trunk 30 is seized from an operator's position in the central office 5, the repeater 7 operates in the manner subsequently described to set up a local loop circuit which includes the two windings of the line relay R150. Substantially simultaneously with this operation, ground potential is impressed upon the private conductor 285*d* to mark the trunk 30 as busy in the relay contacts of the connector switches having access thereto. The repeater 7 also operates to complete a circuit for energizing the line relay R150. The latter relay, in operating, opens its contacts 153' to interrupt the series operating circuit for the two relays R155 and R160. At its contacts 153, the line relay R150 completes an obvious path for impressing ground potential upon the conductor 285*e*. At its contacts 152, the relay R150 completes a circuit including the contacts 157 and C146 for energizing the eighth auxiliary group relay R520 in series with the resistor 522'. At its contacts 151, the relay R150 prepares a circuit including the contacts 158 and the conductor C144 for energizing the auxiliary unit relay R550 in series with the resistor 568. The relay R520, in operating, completes a locking circuit for itself; opens the operating circuits for the nineteen other auxiliary group relays; and completes, at its contacts 525, the prepared circuit for energizing the unit relay R550. At its contacts 522, the relay R520 completes an obvious circuit for energizing the group relay R530.

As indicated above, the relay R530 is only energized when calls are initiated on the lines of the eighth line group. This relay, in operating, closes its contacts 531 to prepare the operating circuit for the eighth finder group relay of an assigned link. At its remaining ten sets of make contacts, the relay R530 prepares ten different marking paths for impressing ground potential upon the trunk identification lead C681. These paths are selectively controlled by the ten auxiliary unit relays of the common equipment. By virtue of this arrangement, if any ten-line group is a mixed line group consisting of both trunks and subscribers' lines, the paths may be selectively controlled by the auxiliary unit relays so that ground potential is only impressed upon the trunk identification lead in response to calls initiated on the trunks of the mixed group. This marking arrangement may also be utilized to identify high rate subscribers' lines which are to have service free of timing restrictions. In the case under consideration, with the unit relay R550 operated, the trunk group relay R530, in operating, completes a path extending from ground by way of the contacts 552 and 532 and the cross-connected terminals of the distributing frame 535 for impressing ground potential upon the trunk identification lead C681. The auxiliary unit relay R550, in operating, also completes, at its contacts 551, an obvious path for impressing ground potential upon the common start lead C573. This lead is extended through the contacts of the link distributor relays to the start lead individual to the assigned link. Assuming, for example, that the link illustrated is assigned to the use of the call, the start lead C234 is connected to the common start lead C573 and, accordingly, the two connect relays R280 and R290 are energized in response to the operation of the auxiliary unit relay R550. The relay R280, in operating, completes the prepared operating circuit for the eighth group relay R240, this circuit extending from ground by way of the contacts 531, C571', the contacts 283 and the winding of R240 to battery. The relay R240, in operating, closes its locking contacts 248. At its contacts 249, the relay R240 prepares a busy line verification circuit described more fully hereinafter. As indicated above, depending upon the type of wiring used in association with the group relay R240, this relay may or may not prepare a circuit for energizing the battery reversing relay R800. In the case under consideration, if it is assumed that all of the lines terminating at the line contacts of this group relay require reverse battery for supervision or control purposes, the "L" wire illustrated in Fig. 2 of the drawings may be used, so that the engagement of the contacts 252 incident to operation of the relay R240 serves to prepare a circuit for energizing the battery reversing relay R800. When reverse battery is not required both the "L" and "N" wires are omitted from the circuit.

When the connect relay R290 operates in the manner pointed out above, it completes the circuit for energizing the unit relay R220 and completes the operating circuit for the two line relays R820 and R825, thereby to cause the sequential operation of the relays R830, R840, R850 and R860, in the manner previously explained. The relay R290 also completes a circuit for energizing the relay R1020, this circuit extending by way of the grounded trunk identification lead C681, the contacts 298, C236 and the upper winding of R1020 to battery. In operating, the relay R1020 locks to the grounded release conductor C893 through its contacts 1025. The control operations performed incident to operation of the relay R1020 are described with particularity hereinafter. The relay R860, in operating, connects the holding lead C235 to ground, thereby to complete the prepared holding circuits for the group and unit relays R240 and R220, respectively. In operating, the relay R860 also completes the previously traced path for impressing ground potential upon the control conductor 285*c* of the line 285, thereby to mark the trunk 30 as busy and to energize the relays R155 and R160.

When the cut-off and lockout relays R160 and R155, respectively, of the line circuit 20 operate, the common equipment is released in the exact manner explained above. With the relay R160 in its operated position, the windings of the line relay R150 are disconnected from the link line 285 to clear this line of the impedance represented by the line relay winding. Incident to the release of the common equipment, the two connect relays R280 and R290 are deenergized and restore. After the relay R290 restores, the two line relays R820 and R825 are held operated over a loop circuit extending from these relays through the operating winding of the supervisory relay embodied in the repeater 7. Following the release of the common equipment, the call is extended to the connector portion of the link and may be forwarded to the desired line under the control of the operator handling the call in the central office 5, in the manner described hereinafter.

Operation of the Link Distributor

As indicated above, each time one of the finder-connector links is assigned to the use of a calling line, the link distributor relay corresponding thereto is deenergized and restores. Thus, when the link illustrated is seized, the corresponding distributor relay R700 is caused to restore to extend the control leads C573, C684 and C685 to the contacts of the distributor relay R710 corresponding to the second link. In a similar manner, when the second link is assigned to the use of a calling line, the relay R710 is caused to release to extend the control circuits to the distributor relay corresponding to the third link. This successive assignment of links continues until the last link, namely that corresponding to the distributor relay R730, is assigned to the use of a calling line. In this regard it is pointed out that in the event the second link corresponding to the distributor relay R710 is occupied with a call at the time the first distributor relay R700 releases, the control circuits are extended through the restored contacts of the relay R710 to the distributor relay corresponding to the third link. Further, if this third link is also occupied with a call, the control circuits are extended through the restored contacts of the corresponding distributor relay to the contacts of the distributor relay corresponding to the fourth link. The arrangement of the distributor is such that the relays thereof are not immmediately reoperated in response to the release of the respective associated links. Thus, it will be observed that with the relay R700 in its restored position, no circuit is available for energizing this relay regardless of the position of the hold relay R860. When, however, the last link, corresponding to the distributor relay R730, is assigned for use to cause the release of this distributor relay, a chain circuit is completed for energizing the slow-acting reset relay R660. Under these conditions all of the distributor relays are restored regardless of whether or not the respective associated links are occupied with calls. Accordingly, the circuit for energizing the reset relay R660 may be traced as extending from ground by way of the contacts 734, the chain-connected contacts of the distributor relays other than those illustrated, the contacts 715 and 705, C685, and the winding of R660 to battery. When energized over this circuit, the relay R660 operates to prepare, at its contacts 661, a holding circuit for the all-links-busy relay R670. At its contacts 662, the relay R660 completes the operating circuits for those of the link distributor relays which are associated with idle links. For example, if the link illustrated has been released prior to the operation of the reset relay R660, the operating circuit for the corresponding link distributor relay R700 is completed, this circuit extending from ground by way of the contacts 662, C687, the contacts 707, C232, the contacts 863, C880, the contacts 916, C231, and the winding of R700 to battery. Obviously, if the link illustrated is still occupied with a call, this circuit is held open at the contacts 863, so that the distributor relay R700 is not energized. In a similar manner, if the second link is idle, an operating circuit for the associated distributor relay R710 is completed by way of the grounded conductor C687 and the contacts 717. Similar operating circuits are completed for the other distributor relays which correspond to idle links. In the event the distributor relay R700 is energized over the circuit traced above, this relay operates to complete a locking circuit for itself which extends from ground by way of the resistor 708, the contacts 706, C232, the contacts 863, C880, the contacts 916, C231, and the winding of R700 to battery. At its remaining contacts the relay R700 arranges the associated control circuits so that the link illustrated will be assigned to the use of the next calling line. The other distributor relays which correspond to idle links are similarly locked in their respective operated positions. When the distributor relays which correspond to idle links operate, the chain circuit for energizing the reset relay R660 is broken. The relay R660, accordingly, releases after an interval to open the prepared holding circuit for the relay R670, and to open, at its contacts 662, the respective operating circuits for the distributor relays.

Provisions are made in the link distributing apparatus, whereby in the event an assigned link fails to find and seize a calling line within a reasonable time interval, the assigned link is released and a second link is assigned to the use of the calling line. To this end the common equipment is so arranged that each time a call is initiated upon one of the subscriber's lines, the normally energized slow-to-release relay R630 is deenergized. More specifically, the relay R630 is normally energized over a circuit which extends from ground by way of the contacts 673, the winding of R630, the contacts 622, C576, the contacts 584, 564, 554 and 574, the chain-connected contacts of the other auxiliary unit relays, and the resistor 568 to battery. With the relay R630 energized over this circuit an obvious circuit for energizing the slow-to-release relay R640 is held completed at the contacts 631. With the relay R640 operated, the operating circuit for the overflow meter 632 is prepared at the contacts 641, a multiple circuit for energizing the relay R630 is completed at the contacts 642, and the operating circuit for the slow-acting relay R650 is held open at the contacts 643. When any one of the five auxiliary unit relays is caused to operate in the manner previously explained, the chain portion of the above-traced circuit for energizing the relay R630 is opened at the contacts 554, 564, or the corresponding contacts of one of the other auxiliary unit relays. After an interval determined by the slow-to-release characteristic of the relay R630, this relay restores to open the completed operating circuit for the relay R640. In the event the assigned finder switch successfully operates to seize the calling

line in its intended manner, the line circuit associated with the calling line operates to open the start circuits to the auxiliary group and unit relays, in the manner previously explained, before the relay R640 is released. When these start circuits are opened, the operated one of the auxiliary unit relays is released to recomplete the above-traced operating circuit for the relay R630. This relay, in reoperating, recompletes the operating circuit for the relay R640. Thus, under normal operating conditions the relay R640 is not released during the time interval required for an assigned finder switch to seize the calling line to which it has been assigned.

If, for any reason, the finder portion of an assigned link fails to seize the line to which it is assigned, thereby to cause the reoperation of the relay R630 before the relay R640 is released, then the assigned link is released and a different link is assigned to the use of the calling line. Thus, if the operating circuit for the relay R640 is held open for a sufficiently long interval of time, this relay restores to open, at its contacts 641, the prepared operating circuit for the overflow meter 632, and to open, at the contacts 642, the prepared multiple circuit for energizing the relay R630. At its contacts 643, the relay R640 completes the prepared operating circuit for the slow-acting relay R650, this circuit extending from ground by way of the contacts 674, 624 and 643, and the winding of R650 to battery The relay R650, in operating, opens, at its contacts 651, the prepared path for short-circuiting the winding of the link distributor relay corresponding to the first assigned link. At its contacts 652, the relay R650 completes an obvious circuit for energizing the slow-acting relay R620. The relay R620, in operating, further prepares, at its contacts 621, the path for short-circuiting the winding of the distributor relay corresponding to the first assigned link. At its contacts 624, the relay R620 opens the above-traced circuit for energizing the relay R650. At its contacts 622, the relay R620 opens a point in the normally completed circuit for energizing the relay R630. At its contacts 623, the relay R620 completes an alternative circuit for energizing the relay R630, this alternative circuit extending from ground by way of the contacts 673, the winding of R630, the contacts 623, C579, and the resistor 522 to battery. When thus energized, the relay R630 reoperates to complete the operating circuit for the relay R640. The relay R640, in turn, reoperates to reprepare the circuit for energizing the overflow meter 632, to complete a multiple circuit for energizing the relay R630, and to open, at the contacts 643, a further point in the operating circuit for the relay R650. Substantially concurrently with the reoperation of the relay R640, the relay R650 restores to open, at its contact 652, the operating circuit for the slow-acting relay R620. At its contacts 651, the relay R650 completes the previously mentioned path for short-circuiting the winding of the distributor relay corresponding to the first assigned link.

Assuming, for example, that the link illustrated is the first assigned link and, further, that this link has failed to find the calling line to which it was assigned, the link distributor relay R700 is short-circuited when the relay R650 releases in the manner just explained. The path for short-circuiting this distributor relay extends from the negative terminal of the exchange battery through the resistor 625 and by way of the contacts 621 and 651, C684, the contacts 703, C232, the contacts 292, C231, and the winding of R700 back to the negative terminal of the exchange battery. It is noted that the resistance value of the resistor 625 is relatively small as compared with the resistance value of the resistor 708. More specifically, the resistor 708 has a resistance value of approximately 1,000 ohms, whereas the resistor 625 has a resistance value of only 50 ohms and the winding of the relay R700 is characterized by a resistance of 1,000 ohms. It will be understood, therefore, that when the above-traced path is completed, the relay R700 is effectively short-circuited and caused to release. In releasing, the relay R700, at its contacts 702, disconnects the common start lead C573 from the start lead C234 individual to the link illustrated, whereby the connect relays R280 and R290 are deenergized and restore. At its contacts 701, the relay R700 extends the common start lead to the link start lead individual to the next available idle link. Thus, if the second link is idle, and the relay R710 is operated, the common start lead C573 is connected through the contacts 701 and 712 to the start lead individual to the second link. At its contacts 706, the relay R700, in releasing, opens a point in the common portion of its two locking circuits as traced previously. At its contacts 707, the relay R700 prepares its own operating circuit. At its contacts 703, the relay R700 opens the path short-circuiting its own winding. At its contacts 704, the relay R700 prepares a path for short-circuiting the winding of the distributor relay corresponding to the next idle link, which, in the case assumed, is the second distributor relay R710. At its contacts 705, the relay R700 prepares the above-traced chain circuit for energizing the reset relay R660. Substantially concurrently with the release of the relay R700, the relay R620 restores to open, at its contacts 621, the above-traced path for short-circuiting the winding of the distributor relay R700, and the prepared path for short-circuiting the winding of the distributor relay corresponding to the second assigned link. At its contacts 624, the relay R620 reprepares the operating circuit for the relay R650. At its contacts 622 and 623, the relay R620 opens the above-traced alternative circuit for energizing the relay R630, and reprepares the initially traced operating circuit for the last-mentioned relay. It will be understood that since one of the auxiliary unit relays illustrated in Fig. 5 of the drawings is at this time still operated, the initially traced operating circuit for the relay R630 is open at the contacts 554, 564, or the corresponding contacts of an operated one of the other auxiliary unit relays. Accordingly, the second timing period is started in response to the release of the relay R620.

When the common start lead C573 is disconnected from the link start lead C234 through the release of the link distributor relay R700, in the manner just explained, the two connect relays R280 and R290 restore to open the operating circuits for the selected group and unit relays of the finder switch illustrated, and to open the completed operating circuit for the line relays R820 and R825. Thus, the relays R820, R825, R830, R840, R850 and R860 are caused sequentially to restore in an obvious manner. At its contacts 297, the relay R290, in releasing, disconnects the conductor C682 from ground, thereby momentarily to deenergize the relay R610. Since, however, ground poten-

tial is impressed upon this conductor through operation of the connect relays embodied in the second assigned link substantially concurrently with the release of the two relays R280 and R290, the relay R610 is held energized and does not restore. The application of ground potential to the link start lead extending to the second assigned link results in the operation of the finder portion of this link to seize the calling line, assuming that the second assigned link is not also defective. If the calling line is seized, the operated ones of the auxiliary group and unit relays illustrated in Fig. 5 of the drawings, are caused to restore so that the operating circuit for the relay R630 is recompleted before the relay R640 is released. Thus, the normal operation of the distributor equipment is resumed. If, however, the second assigned link is also defective or, for some reason, fails to seize the calling line to cause the operation of the line circuit associated therewith, the cycle of operation of the distributor equipment as described above, is repeated so that the second assigned link is released and a third link is assigned to the use of the calling line. More specifically, the cyclic operation of the distributor equipment continues until the finder portion of one of the assigned links is successful in its operation to seize the calling line, and thus cause the release of the operated ones of the auxiliary group and unit relays illustrated in Fig. 5 of the drawings.

In the event all of the links embodied in the exchange are busy at the time the relay R730 corresponding to the last link is released to complete the above-traced chain circuit for energizing the relay R660, none of the distributor relays are immediately energized, although the operating circuits for all of these relays are prepared. Accordingly, the relay R660 remains in its operated position until one of the links is released. With the apparatus in this condition, if a call is initiated upon one of the lines terminating at the exchange, the auxiliary unit relay, illustrated in Fig. 5, which corresponds to the calling line operates to impress ground potential upon the common start lead C573, thereby to complete the operating circuit for the all-links-busy relay R670. This circuit extends by way of the grounded lead C573, the contacts 701, 711, 731 and the other chain-connected contacts controlled by the distributor relays, C686 and the winding of R670 to battery. When thus energized, the relay R670 locks to ground through the contacts 671 and 661. At its contacts 672, the relay R670 completes a circuit extending by way of the grounded conductor C686 and the contacts 641 for energizing the overflow meter 632, whereby the all-busy condition of the links is registered. At its contacts 674, the relay R670 opens a point in the previously traced circuit for energizing the call metering device 614, and a point in the operating circuit for the relay R650. At its contacts 673, the relay R670 opens a point in the multiple operating circuit for the relay R630. Shortly following the initiation of the call, the relays R630 and R640 are caused sequentially to restore in the order named and in the manner previously explained. The relay R640, in releasing, prepares the operating circuit for the relay R650, and opens, at its contacts 641, the circuit for energizing the overflow meter 632. The relay R670 remains in its operated position until the all-busy condition of the links is terminated and one of the links is released. If the call under consideration is abandoned before one of the links is released, the operated ones of the auxiliary group and unit relays are caused to restore in a manner clearly apparent from the preceding explanation so that ground potential is removed from the common start lead C573 and the operating circuit for the relay R630 is reprepared. Also, the operating circuit for the all-links-busy relay R670 is opened, but this relay remains energized over its locking circuit as traced above. Further, the relay R630 is not caused to operate since its operating circuit is open at the contacts 642 and 673. Accordingly, other calls initiated prior to the release of one of the links to terminate the all-links-busy condition are prevented from causing further operation of the overflow meter 632. It will be apparent from the foregoing description that with the relay R660 operated, the operating circuits for all of the link distributor relays are prepared. Accordingly, when one of the links is released, the link distributor relay corresponding thereto is immediately energized. Thus, if all of the links are busy and the link illustrated is the first link to be released, the operating circuit for the associated distributor relay R700 is completed in response to the release of the hold relay R860 individual to this link. The relay R700, in reoperating, opens its operating circuit and locks to ground in the manner previously explained. At its contacts 702, the relay R700 connects the common start lead to the link start lead C234 so that if a call is waiting the assignment of a link, the connect relays R280 and R290 are immediately energized to cause the operation of the finder switch illustrated, in the manner explained above. At its contacts 705, the relay R700 opens the above-traced operating circuit for the relay R660. At its contacts 703, the relay R700 prepares the previously traced path for short-circuiting its own winding. After a time interval determined by the slow-to-release characteristic of the relay R660, this relay restores to open, at its contacts 661, the locking circuit for the relay R670 and to open, at its contacts 662, the prepared operating circuits for the link distributor relays. The relay R670 now releases to open, at its contacts 672, the prepared operating circuit for the overflow meter 632, and to reprepare, at its contacts 673, the operating circuit for the relay R630. At its contacts 674, the relay R670 completes the previously traced operating circuit for the relay R650. Due to the slow-to-release characteristic of the relay R660 and the slow-to-operate characteristic of the relay R650, the operation of the finder switch illustrated, to seize the calling line and thus cause the operation of the line circuit associated therewith to release the operated auxiliary group and unit relays, is completed before the relay R650 can operate. Accordingly, the relays R630 and R640 are caused sequentially to reoperate before the relay R650 operates in response to the release of the relay R670. Thus, the two relays R620 and R650 are prevented from completing the path for short-circuiting the relay R700. In the event these two relays are operated prior to operation of the relay R640, the completion of the path for short-circuiting the winding of the distributor relay R700 is without effect, since, under any circumstances, the finder switch illustrated will complete its operation to seize the calling line before the relay R700 is short-circuited. Accordingly, the short-circuiting path will be opened at the contacts 292 and 863 of the relays R290 and R860, respectively, before the relay R650 is caused to restore in response to release of the relay R620.

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Thus, even though these two relays may operate, such operation is, in the case under consideration, without effect.

SELECTING A CALLED SUBSCRIBER'S LINE

Continuing now with the operation of the link to route a connection to a called one of the lines terminating in the connector portion thereof, it is pointed out above that, when the relay R860 operates, a path is completed for transmitting dial tone current through the receiver provided at the calling substation. The calling subscriber upon thus receiving the dial tone signal is informed that the dialing operation may be started. During impulsing, the relay R830 responds to each dialed impulse and repeats the impulse to the relays R1100 and R1150 and the impulse-counting relays illustrated in Figs. 12 and 13 of the drawings. More specifically, when the subscriber's loop circuit is opened at the calling substation at the beginning of the first impulse of the first digit, the line relays R820 and R825 restore. The release of the relay R825 is without effect. The relay R820, in restoring, opens its contacts 821 to interrupt the previously traced operating and locking circuits for the pulsing relay R830. At its contacts 822, the relay R820 prepares a priming circuit for itself. The relay R830, in releasing, opens, at its contacts 833, a further point in the above-traced locking circuit for itself. At its contacts 831, the relay R830 opens a point in the previously traced operating circuit for the slow-acting relay R850. At its contacts 832, the relay R830 opens the operating circuit for the relay R840. The relay R840 now restores to complete the above-mentioned priming circuit for the line relay R820, this circuit extending from ground by way of the contacts 918', C890, the contacts 841, 822 and 851, the resistor 831' and the winding of R820 to battery. The resistance value of the resistor 831' is so proportioned that the relay R820 does not reoperate when the circuit just traced is completed, but is rendered exceedingly fast to operate when the calling subscriber's loop circuit is subsequently recompleted. At its contacts 842, the relay R840, in restoring, opens the previously traced locking circuit for the relay R850. The latter relay, due to its slow-to-release characteristic, remains operated during impulsing.

At the end of the open-circuit period of the first impulse when the subscriber's loop circuit is again completed, the line relay R820 reoperates and again completes the operating circuit for the pulsing relay R830. At its contacts 822, the relay R820 opens the above-traced priming circuit for itself. The relay R830, upon operating, recompletes its locking circuit, recompletes the locking circuit for the slow-acting relay R850, and recompletes the operating circuit for the relay R840. The relay R840, upon operating, again completes the multiple locking circuit for the relay R850. During each succeeding impulse dialed at the calling substation, the three relays R820, R830 and R840 respond in the exact manner just described.

As indicated above, each time the relay R830 restores it completes the pulsing circuit extending to the relays R1100, R1150 and the relays of the counting chain illustrated in Figs. 12 and 13 of the drawings. Thus, when the relay R830 restores at the beginning of the open-circuit period of the first impulse, the relays R1100 and R1150 are energized in parallel with the first counting relay R1240. The circuit for energizing these relays extends from ground by way of the contacts 834, 815 and 864, C881 and the contacts 1056 to the conductor C1081 where it divides, one branch extending through the lower winding of R1100 to battery, a second branch extending through the winding of R1150 to battery, and the third branch extending by way of the contacts 1113, C777, the contacts 754, 764, and 774, C782 and the winding of R1240 to battery. When thus energized, the relay R1150 operates to complete, at its contacts 1152, an obvious circuit for energizing the slow-to-release relay R1160 in parallel with the upper winding of the relay R1100. At its contacts 1151, the relay R1150 completes a path including the conductor C844 for shunting the repeater winding 835 and the winding of the line relay R825 from the established loop circuit extending to the calling substation, thereby to reduce the resistance of this circuit and correspondingly to enhance the energization of the relay R820 during impulsing. The relay R1160, in operating, completes a multiple path including the 750 ohm resistor 1147 in shunt with the series path including the repeater winding 835 and the winding of the relay R825. The relay R1100, upon operating, opens, at its contacts 1101, a point in the common portion of the circuits for energizing the ringing control relay R960 and the counting chain release relay R870. These contacts are also included in additional control circuits referred to with particularity hereinafter. At its remaining contacts 1102, 1103 and 1104, the relay R1100 opens points in the common portions of the operating circuits for the respective group and unit relays of the connector portion of the link and other control circuits subsequently described in detail. Due to the slow-to-release characteristic of the relay R1150, this relay and the associated relays R1100 and R1160 all remain operated during impulsing.

Operation of the counting chain

The relay R1240, upon operating at the beginning of the first impulse, completes, at its contacts 1246, a locking circuit for itself and, in so doing, closes a path for short-circuiting the winding of the control relay R770. This locking circuit extends by way of the grounded release conductor C893, the contacts 871, C897, the contacts 766, the winding of R770, C783, the contacts 1246 and the winding of R1240 to battery. It will be observed that so long as the pulsing relay R830 occupies its restored position, both winding terminals of the relay R770 are connected to ground and, accordingly, this relay is short-circuited. At its contacts 1245, the relay R1240 prepares a circuit for energizing the second counting relay R1250. At its contacts 1244, the relay R1240 prepares a circuit, traced hereinafter, for energizing the ringing relay R1010 in accordance with the coded ground pulses impressed upon the first ringing interrupter lead C1249. At its contacts 1243, the relay R1240 prepares a circuit for energizing the group relay R1510 embodied in the connector portion of the link and terminating the first group of ten lines. At its contacts 1242, the relay R1240 prepares a circuit for energizing the units relay R1450 embodied in the connector portion of the link and corresponding to the first line of each ten-line subgroup. At its contacts 1241, the relay R1240 prepares a circuit, traced hereinafter, for energizing the verification relay R1140 in series with the counting chain release relay R870.

At the end of the open-circuit period of the first impulse, the pulsing relay R830 restores in the

manner explained above and, in so doing, opens its contacts 834 to interrupt the path short-circuiting the winding of the control relay R770. The relay R770 is thus energized in series with the first counting relay R1240 and operates to open, at its contacts 776, a point in the operating circuit for the relay R750. At its contacts 774, the relay R770 opens a further point in the above-traced operating circuit for the first counting relay R1240. At its contacts 775, the relay R770 further prepares the operating circuit for the second counting relay R1250. At its contacts 773, the relay R770 prepares a point in the common portion of certain operating circuits described hereinafter. At its contacts 772, the relay R770 prepares a path for impressing ground potential upon the ringing interrupter start lead C789. At its contacts 771, the relay R770 prepares a path for impressing ground potential upon the ringing generator start conductor C1167.

At the beginning of the open-circuit period of the second impulse when the pulsing relay R830 again restores, the operating circuit for the second counting relay R1250 is completed, this circuit extending from ground by way of the contacts 834, 815 and 864, C881, the contacts 1056, C1081, the contacts 1113, C777, the contacts 754, 764 and 775, C781, the contacts 1245 and the winding of R1250 to battery. When thus energized, the relay R1250 operates and locks to ground over a path including the contacts 1256, C784, the winding of R760, the contacts 756, C897, the contacts 871 and the grounded release conductor C893. At its contacts 1255, the relay R1250 prepares the operating circuit for the third counting relay R1260. At its remaining contacts, the relay R1250 performs additional control operations apparent from the above explanation regarding the operation of the first counting relay R1240. At the end of the open-circuit period of the second impulse when the pulsing relay R830 again operates, the path short-circuiting the winding of the second control relay R760 is interrupted, permitting this relay to be energized in series with the second counting relay R1250. The relay R760 now operates to open, at its contacts 766, the above-traced series locking circuit for the two relays R770 and R1240, causing both of these relays to restore. At its contacts 764, the relay R760 opens a further point in the operating circuit for the second counting relay R1250. At its contacts 765, the relay R760 further prepares the operating circuit for the third counting relay R1260. At its contacts 761, 762 and 763, the relay R760 completes obvious paths individually shunting the contacts 771, 772 and 773 of the relay R770.

At the beginning of the open-circuit period of the third impulse when the pulsing relay R830 again restores, the operating circuit for the third counting relay R1260 is completed, this circuit extending by way of the grounded pulsing lead C777, the contacts 754 and 765, C780, the contacts 1255 and the winding of R1260 to battery. The relay R1260, upon operating, locks to the grounded release conductor C893 over a path including the contacts 1266, C785, the contacts 776, the winding of R750, C897 and the contacts 871. When this path is completed, the relay R750 is obviously short-circuited. At its contacts 1265, the relay R1260 prepares the operating circuit for the fourth counting relay R1270. The remaining circuit-switching operations performed by the third counting relay R1260 are of no consequence at the present point in the operation of the system.

At the end of the open-circuit period of the third impulse when the pulsing relay R830 again operates, the path short-circuiting the winding of the relay R750 is opened, permitting this control relay to be energized in series with the third counting relay R1260. The relay R750 now operates to open, at its contacts 756, the series-locking circuit for the two relays R760 and R1250, causing both of these relays to restore. At its contacts 754 and 755, the relay R750 opens a further point in the operating circuit for the third counting relay R1260 and further prepares the operating circuit for the fourth counting relay R1270. At its remaining contacts 751, 752 and 753, the relay R750 completes obvious paths individually shunting the contacts 761, 762 and 763 of the relay R760.

At the beginning of the open-circuit period of the fourth impulse when the pulsing relay R830 again restores, the prepared operating circuit for the fourth counting relay R1270 is completed, this circuit extending by way of the grounded pulsing lead C777, the contacts 755, C779, the contacts 1265 and the winding of R1270 to battery. When thus energized, the relay R1270 locks to the grounded release conductor C893 over a path including the contacts 1276, C733, the winding of R770, the contacts 766, C897 and the contacts 871. When this path is completed, the winding of the relay R770 is obviously short-circuited. At its contacts 1275, the relay R1270 prepares the operating circuit for the fifth counting relay R1280. The remaining circuit-switching operations performed by the relay R1270 are of no effect at this time. At the end of the open-circuit period of the fourth impulse when the relay R830 again operates, the path short-circuiting the winding of the relay R770 is interrupted, permitting this control relay to be energized in series with the fourth counting relay R1270. The relay R770 now operates to open, at its contacts 776, the above-traced series locking circuit for the two relays R750 and R1260, causing both of these relays to restore. At its contacts 774 and 775, the relay R770 opens a point in the operating circuit for the first counting relay R1240 and further prepares the operating circuit for the fifth counting relay R1280. The relay R750, in releasing, opens its contacts 755 and closes its contacts 754, thereby to open a further point in the operating circuit for the fourth counting relay R1270 and further to prepare the operating circuit for the fifth counting relay R1280. It is believed that the manner in which the remaining counting relays R1280, R1290, R1300, R1310, R1320 and R1330 respond to additional impulses transmitted thereto through operation of the pulsing relay R830 will be clearly apparent from the preceding explanation. Thus it will be noted that the relays R1290, R1300, R1310, R1320 and R1330 sequentially respond to the sixth, seventh, eighth, ninth and tenth impulses of a digit, in the order named. It will also be noted that the relays R1280 and R1310 lock to ground over the lead C784 in series with the control relay R760; the relays R1290 and R1320 lock to ground over the lead C785 in series with the third control relay R750; and the relays R1300 and R1330 lock to ground over the lead C783 in series with the first control relay R770. The three enumerated control relays operate sequentially in response to succeeding impulses, successively to prepare the operating circuits to the various counting relays, and to release the previously operated counting relays and their associated control relays.

The directory numbering arrangement

In order to facilitate an understanding of the manner in which the different types of lines are seized through the connector portion of the link, and the manner in which the various control operations performed incident to the seizure of these lines are carried out, it is desirable briefly to consider the directory numbering arrangement utilized in the system. A four-digit directory numbering arrangement is used for selecting the called subscribers' lines and for selectively signaling the substations associated therewith. The first digit of a directory number dialed at a calling telephone station is used for several different purposes. Thus, if a first digit comprising one impulse is inadvertently dialed at a substation served by the switching equipment illustrated, the digit or impulse is absorbed. On the other hand, if a first digit comprising one impulse is dialed at a calling operator's position in the central office 5, for example, and the single impulse thereof is transmitted to the connector portion of the link illustrated, it is used as a prefix digit for conditioning the connector portion of the link to establish a dry talking circuit to a busy called line. If a first digit comprising either two, four or five impulses is dialed at a calling telephone station, the first group of one hundred lines, namely, the 200-line group, is selected thereby. A first digit of two or three impulses also indicates that ten-party code ringing is to be utilized in signaling over a desired subscriber's line. A first digit of four impulses, on the other hand, indicates that twenty-party code ringing is to be used in signaling over a called subscriber's line and, further, that the code corresponding to the desired substation is included in the first ten codes of the available twenty codes. A first digit of five impulses also indicates that twenty-party code ringing is to be used in signaling over a called subscriber's line, but further indicates that the code corresponding to the desired substation is included in the second group of ten codes of the available twenty codes. A first digit comprising three impulses is also utilized to select the subscribers' lines included in the second 100-line group, namely, the lines having the "300" series of directory numbers assigned thereto. In all cases, the selective signaling of the substations associated with the multiparty lines of this group is accomplished by using the ten-party code ringing facilities as contrasted with the twenty-party code ringing facilities available. This is accomplished by terminating the multiparty subscriber's line serving less than ten substations in the second group of one hundred lines.

In the arrangement illustrated, wherein inter-office communication facilities are provided between the manual offices 5 and 6 and the exchange embodying the switching equipment illustrated, two inter-office trunk groups are provided, the trunk group extending to the manual office 5 being terminated in the contacts of the eighth connector group relay R1580 and forming a part of the first 100-line group. This group of inter-office trunks may be selected by any calling subscriber by dialing a single digit comprising eight impulses. The group of trunks extending to the manual office 6, on the other hand, are of two types, i. e., toll and combined toll and free service. As indicated above, the two toll trunks are terminated at the first and second sets of contacts of the tenth group relay R1400. The two combination toll and free service trunks are terminated in the third and fourth contact sets of the tenth group relay R1400 and also in the first and second contact sets of the ninth group relay R1490. This group of trunks also forms a part of the first group of 100 lines, any one of the four trunks being seizable from any substation by dialing a single digit comprising ten impulses, and the combination trunks being seizable from certain unrestricted substations by dialing a single digit comprising nine impulses. In the arrangement illustrated, if a first digit comprising six or seven impulses is dialed at a calling telephone station, the impulses are absorbed.

The second and third digits of a directory number designating a desired subscriber's substation are utilized respectively to control the connector group and unit relays, so that a connection to the line serving the desired substation is effected. The fourth digit of the directory number is utilized for ringing code selection, i. e., to select the particular ringing code corresponding to the desired substation.

Absorbing unused first digits

Briefly to consider the manner in which the unused first digits are absorbed, it will be recalled from the preceding explanation that, if a first digit of one impulse is dialed at a calling substation such, for example, as the substation A, the first counting relay R1240 is locked energized in series with the first control relay R770 and the pulsing relay R830 remains operated at the end of the digit. Accordingly, the previously traced operating circuits for the relays R1100 and R1150 are held open. Shortly following the end of the digit, therefore, the relays R1150, R1100 and R1160 sequentially restore in the order named. The relays R1150 and R1160, in releasing, open the two previously traced paths for short-circuiting the repeater winding 835 in series with the winding of the line relay R825. The relay R1100, in restoring, completes a circuit for energizing the lower winding of the relay R1140 in series with the counting chain release relay R870, this circuit extending by way of the grounded release conductor C893, the contacts 773, C786, the contacts 1101, 1117, 1128 and 1104, C1221, the contacts 1241, C1214, the lower winding of R1140, C887 and the winding of R870 to battery. The remaining circuit-switching operations performed incident to the release of the relay R1100 are without effect at this time. Also, the operation of the verification relay R1140 is of no consequence at this time. The relay R870, in operating, opens, at its contacts 871, the previously traced series-locking circuit for the two relays R770 and R1240, causing both of these relays to restore. When these two relays restore, two points are opened, at the contacts 773 and 1241, in the above-traced circuit for energizing the relay R870 in series with the lower winding of the relay R1140. Thus, the two latter relays are caused to release, and the equipment is restored to the condition which prevailed before the first digit of one impulse was dialed.

The manner in which the counting chain is released when first digits comprising six and seven impulses are inadvertently dialed is substantially similar to the release of this equipment when a first digit of one impulse is inadvertently dialed at a calling substation. Thus, if the digit 6, for example, is dialed at a calling substation, the counting relay R1290 is locked energized in series with the third control relay R750 at the

end of the digit. Accordingly, when the relay R1100 restores shortly following the end of the digit, the relay R870 is energized over a circuit which extends from ground by way of the contacts 869, the release conductor C893, the contacts 753, C786, the contacts 1101, 1117 and 1128, C1222, the contacts 1291, C887 and the winding of R870 to battery. In the case where a first digit comprising seven impulses is dialed, the circuit completed at the end of the digit for energizing the counting chain release relay R870 is slightly different. More particularly, with the seventh counting relay R1300 operated at the end of a dialed first digit, the circuit for energizing the relay R870 extends by way of the grounded release conductor C893, the contacts 773, C786, the contacts 1101, 1117, 1128 and 1104, C1221, the contacts 1301, C887 and the winding of R870 to battery. When energized over any one of these circuits, the relay R870 opens its contacts 871 to interrupt the common portion of the previously traced locking circuits for the ten counting relays and their associated control relays, causing the two operated ones of these relays to release. Thus, it will be apparent that, with the arrangement illustrated when first digits comprising one, six or seven impulses are inadvertently dialed, the counting chain is automatically released and the control equipment of the link is restored to the condition which prevailed prior to the dialing of the digit.

Selecting a called subscriber's line in the 200-line group

As indicated above, a subscriber's line, such, for example, as the line 219, included in the first group of one hundred lines, may be selected by dialing, at the calling telephone station, a first digit comprising two, four or five impulses followed by the group and units digits respectively designating the ten-line subgroup including the called line and the particular line of this subgroup. Assuming, for example, that the multiparty subscriber's line 219 is desired by a calling subscriber and, further, that this line is arranged for ten-party code ringing, a first digit comprising two impulses is dialed at the calling substation. Accordingly, the counting relay R1250 is locked energized in series with its associated control relay R760 at the end of the digit. When the relays R1150, R1160 and R1160 sequentially restore shortly after the digit is ended, the prepared operating circuit for the relay R1200 is completed. This circuit extends by way of the grounded release conductor C893, the contacts 763, C786, the contacts 1101, 1117 and 1128, C1222, the contacts 1251 and the upper winding of R1200 to battery. The remaining circuit-switching operations performed incident to the release of the relay R1100 are without effect at this time.

The relay R1200, upon operating, prepares, at its contacts 1204, a circuit for energizing the relay R1210. At its contacts 1203, the relay R1200 prepares a circuit for energizing the relay R1350. At its contacts 1201, the relay R1200 prepares a circuit for energizing the ring pickup relay R960 in accordance with the battery pulses impressed upon the first pickup lead C1215 by the ringing interrupter 1395. At its contacts 1202, the relay R1200 completes a circuit including the grounded lead C1222 and the conductor C1217 for energizing the group select relay R1360 individual to the first group of one hundred lines. The relay R1360, in operating, prepares, at its contacts 1362, an alternative circuit for energizing the ring pickup relay R960 in accordance with the battery pulses impressed upon the first pickup lead C1215. At its contacts 1363, the relay R1360 completes a locking circuit for itself and the relay R1200. This locking circuit extends by way of the grounded release conductor C893 and the winding of R1120 to the conductor C1080 where it divides, one branch extending through the contacts 1363 and the winding of R1360 to battery, and the other branch extending by way of the contacts 1163, C1217, the contacts 1202 and the upper winding of R1200 to battery. When this locking circuit is completed, both winding terminals of the relay R1120 are connected to ground and, accordingly, this relay is short-circuited. At its break contacts 1364' to 1368', inclusive, the relay R1360 opens points in the operating circuits for five of the connector group relays terminating fifty of the lines included in the second group of one hundred lines. At its make contacts 1364 to 1368, inclusive, the relay R1360 prepares the operating circuits for five of the connector group relays terminating fifty of the lines included in the first group of one hundred lines. In this regard it will be apparent that, with the other group select relay R1350 occupying its restored position, the operating circuits for the remaining five connector group relays terminating lines included in the first group of one hundred lines are all prepared. With this latter group select relay restored, the operating circuits for the five remaining connector group relays terminating lines of the second group of one hundred lines are held open at the contacts 1353 to 1357, inclusive. Thus, with the relay R1360 operated and the relay R1350 restored, the connector switch is conditioned to select a line included in the first group of one hundred lines.

At its contacts 1361, the relay R1360 completes an alternative circuit for energizing the counting chain release relay R870, this circuit extending from ground by way of the contacts 1361, C1086, the contacts 1126, C887 and the winding of R870 to battery. When thus energized, the relay R870 operates to open, at its contacts 871, the previously traced locking circuit for the second counting relay R1250 and its associated control relay R760, causing both of these relays to restore. Thus, the impulse-counting equipment of the connector switch is fully restored to normal. During the release of the relay R1250, the operating circuit for the relay R1200 is opened at the contacts 1251. Further, with the two relays R1250 and R760 deenergized, the previously described path for short-circuiting the winding of the transfer relay R1120 is opened at the contacts 763 and 1251. When this path is opened, the relay R1120 is energized in series with the parallel connected relays R1200 and R1360. In operating, the relay R1120 opens, at its contacts 1121, the previously traced path for transmitting dial tone signal current over the calling end of the connection. Thus, the dial tone signal is terminated. At its contacts 1122, the relay R1120 completes an obvious shunt path across the restored contacts 1113 of the relay R1110, these contacts being commonly included in the above-described circuit for transmitting impulses to the relays of the counting chain. At its contacts 1123, the relay R1120 opens the path normally short-circuiting the winding of the slow-to-operate idle test relay R1070. At its contacts 1124, the relay R1120 shunts the restored contacts 1114

to prepare a multiple point in the locking circuit for the verification relay R1140. At its contacts 1125, the relay R1120 opens a point in the circuit, traced hereinafter, for energizing the switching-through relay R810. At its contacts 1125', the relay R1120 opens a point in the common portion of the circuits, traced hereinafter, over which the unit relays of the connector switch are selectively energized in setting up an interoffice trunk call. At its contacts 1126', the relay R1120 prepares another of the operating circuits for the counting chain release relay R870. At its contacts 1126, the relay R1120 opens another point in the previously traced operating circuits for the two relays R1200 and R1360. At its contacts 1127, the relay R1120 prepares a point in the common portion of the operating circuits of the twenty group relays embodied in the connector portion of the link.

At its contacts 1126, the relay R1120 opens the previously traced alternative operating circuit for the counting chain release relay, causing the latter relay to restore. Following the release of the relay R870, the control equipment of the link is conditioned to respond to the impulses comprising the second digit of the directory number designating the desired substation associated with the called line 219.

Before proceeding with the explanation relating to the final selection of the called line, it is in order to point out the mode of operation of the apparatus when directory numbers having first digits comprising four and five impulses, respectively, are dialed. In this regard it will be recalled from the previous explanation that, if a first digit of four impulses is dialed at the calling substation, the fourth counting relay R1270 is locked energized in series with its associated control relay R770 at the end of the digit. Accordingly, when the relays R1150, R1100 and R1160 restore shortly following the end of the digit, the group select relay R1360 is directly energized. In this case, the circuit for energizing the relay R1360 extends by way of the grounded release conductor C893, the contacts 773, C786, the contacts 1101, 1117 and 1128, C1222, the contacts 1271, C1217 and the winding of R1360 to battery. The relay R1360, in operating, performs the functions described above, among which are the short-circuiting of the transfer relay R1120 and the completion of the operating circuit for the counting chain release relay R870. The latter relay, in operating, opens the locking circuit for the two relays R770 and R1270, whereby the impulse-counting equipment is released. In response to the release of the relays R770 and R1270, the path short-circuiting the winding of the transfer relay R1120 is opened at the contacts 1271 and 773, permitting this relay to be energized in series with the group select relay R1360. The relay R1120, in operating, opens, at its contacts 1126, the completed circuit for energizing the counting chain release relay R870, causing the latter relay to release. Thus, the control apparatus of the link is conditioned to respond to the impulses of the second digit. It will be apparent from the above explanation that, when a first digit comprising four impulses is dialed at the calling substation, the relay R1360 is alone operated, whereas in the case of a first digit comprising two impulses, both this relay and the relay R1200 are locked energized at the end of the digit.

In the event a first digit comprising five impulses is dialed at the calling substation, the fifth counting relay R1280 is locked energized in series with its associated control relay R760 at the conclusion of the digit. Accordingly, when the relays R1150, R1100 and R1160 sequentially restore at the end of the digit, a circuit is completed for energizing the relay R1210, this circuit extending by way of the grounded release conductor C893, the contacts 763, C786, the contacts 1101, 1117, 1128 and 1104, C1221, the contacts 1281 and the winding of R1210 to battery. In operating, the relay R1210 prepares, at its contacts 1212, a circuit for energizing the ring pickup relay R960 in accordance with the battery impulses impressed upon the second pickup lead C1227 by the ringing interrupter 1395. At its contacts 1211, the relay R1210 opens a point in one of the previously mentioned circuits for energizing the ring pickup relay R960 in accordance with the battery pulses impressed upon the first pickup lead C1215 by the ringing interrupter 1395. At its contacts 1213, the relay R1210 completes a circuit including the grounded conductor C1221 and the conductor C1217 for energizing the group select relay R1360. The relay R1360, upon operating, closes its contacts 1363 to complete the previously traced locking circuit for itself. A branch of this locking circuit extends by way of C1217 and the contacts 1213 to maintain the relay R1210 energized. When these holding circuits are completed, the transfer relay R1120 is short-circuited in the manner explained above. At its contacts 1361, the relay R1360 completes the previously traced operating circuit for the counting chain release relay R870, whereby the relays R1280 and R760 are caused to restore. These relays, in releasing, open the path short-circuiting the winding of the relay R1120, permitting this relay to be energized in series with the parallel connected relays R1210 and R1360. In restoring, the relay R760 also opens the circuit for energizing the counting chain release relay R870, whereby the latter relay is deenergized and restores. Following the release of the relay R870, the control apparatus of the link is conditioned to respond to the impulses comprising the second digit of the directory number designating the desired substation. From the above explanation it will be apparent that, in the case where a first digit comprising five impulses is dialed at the calling substation, the relays R1210 and R1360 are locked energized at the end of the digit, as distinguished from the other two case considered above.

Continuing now with the operation of the control apparatus to select the desired line 219, it will be understood that the counting relays respond to the impulses of the second digit in the exact manner previously explained. It will also be understood that, since the called line is the ninth line of the first subgroup of lines in the first group of one hundred lines, the second and third digits dialed at the calling substation will respectively comprise one and nine impulses. During the dialing of the second digit, the relays R1110, R1150 and R1160 are caused to reoperate in the manner previously described. At the end of the second digit, the first counting relay R1240 is locked energized in series with its associated control relay R770. When the relays R1150, R1100 and R1160 sequentially restore at the end of the second digit, the operating circuit for the group relay R1510, having contacts terminating the conductors of the called line 219, is completed at the contacts 1101 and 1103 of the relay R1100. This circuit extends from ground by way of the

contacts 869, the release conductor C893, the contacts 773, C786, the contacts 1101, 1117, 1127 and 1103, C1226, the contacts 1243, C1248, the contacts 1353', C1248' and the winding of R1510 to battery. When energized over this circuit, the relay R1510 operates to complete, at its contacts 1511, a path including the conductor C1164 and the grounded release conductor C893 for short-circuiting the winding of the transfer relay R1110. At its contacts 1513, the relay R1510 prepares a circuit for energizing one of the unit relays embodied in the connector portion of the link. At its contacts 1512, the relay R1510 completes another of the operating circuits for the counting chain release relay R870, this circuit extending by way of the grounded release conductor C893, the contacts 1512, C1166, the contacts 1126' and 1115, C887 and the winding of R870 to battery. At its remaining contacts, the relay R1510 connects the ten lines associated therewith to the ten link lines respectively extending to the make contacts of the ten unit relays R1430, R1440, R1450, R1460, R1470, etc.

When energized over the circuit just traced, the counting chain release relay R870 operates to open, at its contacts 871, the series-locking circuit for the two relays R770 and R1240, causing both of these relays to restore. Upon restoring, the relays R770 and R1240 open, at their contacts 773 and 1243, respectively, two points in the previously traced operating circuit for the relay R1510 and, in so doing, interrupt the path short-circuiting the winding of the transfer relay R1110. The relay R1110 is thus energized in series with the connector group relay R1510 over a circuit which extends by way of the grounded release conductor C893, the winding of R1110, C1164, the contacts 1511 and the winding of R1510 to battery. Upon operating, the relay R1110 opens, at its contacts 1111, a further point in the previously traced path for transmitting dial tone current over the calling end of the connection. At its contacts 1112, the relay R1110 prepares a path for transmitting busy tone current over the calling end of the connection. At its contacts 1113, the relay R1110 opens the path shunting the operated make contacts 1122 of the transfer relay R1120. At its contacts 1114, the relay R1110 opens the path shunting the operated make contacts 1124 of the relay R1120. At its contacts 1117, the relay R1110 opens a further point in the above-traced operating circuit for the connector group relay R1510. At its contacts 1116, the relay R1110 prepares a point in the common portion of the operating circuits for the ten unit relays embodied in the connector portion of the link. At its contacts 1115, the relay R1110 opens the completed circuit for energizing the counting chain release relay R870, causing the latter relay to restore. Following the release of the relay R870, the control apparatus of the link is conditioned to respond to the impulses comprising the third digit of the directory number designating the desired substation.

From the above explanation it will be understood that the numerical value of the second digit dialed at the calling substation determines the subgroup of lines which is to be selected and, hence, the connector group relay which is to be energized. More specifically, the operating circuits for the five connector group relays terminating the first fifty lines of the first 100-line group commonly include the portion of the operating circuit for the connector group relay R1510 which is traced above as extending from the grounded release conductor C893 to the lead C1226. From this point, the operating circuits for the first five connector relays branch through the contacts 1243, 1253, 1263, 1273 and 1283 to the conductors C1248, C1258, C1268, C1278 and C1288, respectively. From these conductors the circuits are carried through the break contacts 1353' to 1357', inclusive, to the operating leads individual to the five connector group relays under consideration. The operating circuits for the other five connector group relays terminating the remaining fifty lines of the first 100-line group are slightly different. These latter circuits commonly include a portion which extends from the grounded release conductor C893 by way of the contacts 753, 763 or 773, C786, the contacts 1101, 1117 and 1127, and the lead C1225. From this lead, these operating circuits branch through the contacts 1293, 1303, 1313, 1323 and 1333 of the sixth to tenth counting relays R1290, R1300, R1310, R1320 and R1330, respectively, to the conductors C1298, C1308, C1318, C1328 and C1338, respectively. From these conductors, the circuits are carried through the operated make contacts 1364 to 1368, inclusive, of the group select relay R1360 to the operating leads individual to the five connector group relays under consideration. Thus, it will be apparent that, depending upon the setting of the impulse-counting chain at the end of the second digit, any one of the selected ten connector group relays may be energized.

As indicated above, the impulses of the third digit are utilized to select the particular desired line from the selected ten-line subgroup. In the case under consideration, wherein the line 219 is to be selected, it will be understood that the ninth counting relay R1320 is locked energized in series with its associated control relay R750 at the end of the third digit. When the relays R1150, R1100 and R1160 restore shortly following the end of this digit, the operating circuit for the ninth unit relay R1460 is completed at the contacts 1101 and 1102. This circuit extends by way of the grounded release conductor C893, the contacts 753, C786, the contacts 1101, 1116, 1137 and 1102, C1223, the contacts 1322, C1327 and the winding of R1460 to battery. The relay R1460, upon operating, locks to ground over a path including the contacts 1462, C1163, the winding of R1130 and the grounded release conductor C893. When this path is completed, the relay R1130 is obviously short-circuited. At its contacts 1461, the relay R1460 completes another of the operating circuits for the counting chain release relay R870. This circuit extends from ground by way of the contacts 869, the release conductor C893, the contacts 1461, C1165, the contacts 1135, C887 and the winding of R870 to battery. When energized over this circuit, the relay R870 operates to open the previously traced locking circuit for the two relays R750 and R1320. When thus deenergized, the two relays R750 and R1320 restore to open, at their contacts 753 and 1322, respectively, two points in the path short-circuiting the winding of the relay R1130. When this path is broken, the relay R1130 is energized in series with the unit relay R1460 over the locking path traced above. Upon operating, the relay R1130 opens its contacts 1135 to interrupt the operating circuit for the counting chain release relay R870, causing the latter relay to restore. At its contacts 1137, the relay R1130 opens a further point in the above-traced operating circuit for the unit relay R1460. At its contacts 1136, the relay R1130

prepares the operating circuit for the relay R1050. At its contacts 1133, the relay R1130 prepares the operating circuit for the relay R1000. At its contacts 1134, the relay R1130 prepares a circuit for energizing the switching-through relay R810. At its contacts 1131, the relay R1130 opens a point in the operating circuit for the busy test relay R1040. At its contacts 1132, the relay R1130 prepares a circuit, traced hereinafter, for energizing the slow-to-operate idle test relay R1070.

From the above explanation it will be understood that the numerical value of the third digit dialed at the calling substation or operator's position determines the particular line of the selected subgroup which is to be selected and, hence, the connector unit relay which is to be energized. More specifically, the operating circuits for the ten unit relays commonly include the release conductor C893, the contacts 753, 763 or 773 of the counting chain control relays, C786, the contacts 1101, the contacts 1116 and the contacts 1137. From this point, the respective operating circuits for the ten unit relays are divided into two groups. Thus, the five unit relays representing the even-numbered lines are energized over circuits which commonly extend through the contacts 1137 by way of C1224 to the contacts 1252, 1272, 1292, 1312 and 1332, respectively. From this point the circuits respectively extend by way of the conductors C1257, C1277, C1297, C1317 and C1337 to the windings of the unit relays representing the unit digits 2, 4, 6, 8 and 0. The unit relays designating the odd-numbered lines, on the other hand, are energized over operating circuits which extend from the contacts 1137 by way of the contacts 1102 and the conductor C1223 to the contacts 1242, 1262, 1282, 1302 and 1322. From these points the circuits respectively extend over the conductors C1247, C1267, C1287, C1307 and C1327 to the windings of the unit relays designating the lines 1, 3, 5, 7 and 9, respectively. From the above explanation it will be apparent that the particular unit relay which is energized depends entirely upon which of the counting relays is operated at the end of the third digit dialed at the calling substation or operator's position. It will further be noted that these relays all lock to the grounded release conductor C893 over a path including the conductor C1163 and the winding of the transfer relay R1130. Accordingly, the transfer relay is in every case locked energized in series with the selected one of the unit relays. It will further be apparent that these relays include the contacts 1451, 1461, 1471, etc., which are connected in multiple in the above-traced alternative operating circuit for the counting chain release relay R870. Accordingly, this relay is energized in response to operation of any one of the ten unit relays shortly following the end of the third digit.

Busy test

As indicated in the above explanation, the transfer relay R1130, upon operating, opens a point in the operating circuit for the busy test relay R1040 and prepares a circuit for energizing the idle test relay R1070. A short interval occurs between the operation of the unit relay R1460 and the operation of this transfer relay. During this interval the called subscriber's line 219 is tested to determine the idle or busy condition thereof. In this regard it will be understood from the previous description that, if the called line 219 is busy, the private conductor 219c thereof is connected to ground, whereas, if the line is idle, negative battery potential is impressed upon this conductor over a path including the winding of the cut-off relay embodied in the line circuit 25. Assuming that the line 219 is busy at the time it is selected, the relay R1460, upon operating, completes the prepared operating circuit for the busy test relay R1040, this circuit extending by way of the grounded private conductor 219c, the contacts 1516, C1483, the contacts 1465, C1162, the contacts 1131, C1076 and the lower winding of R1040 to battery. In operating, the relay R1040 locks to ground over a path including the contacts 1044, C1075, the contacts 1144, C986, the contacts 942 and the grounded release conductor C893. At its contacts 1041 and 1043, the relay R1040 prepares a dry talking circuit to the selected line 219. At its contacts 1046, the relay R1040 opens a point in the operating circuit for the slow-to-operate idle test relay R1070. At its contacts 1047, the relay R1040 opens a point in the operating circuit for the switching-through relay R810. At its contacts 1048, the relay R1040 prepares a circuit for energizing the reverting call relay R940. At its contacts 1042, the relay R1040 completes a path for transmitting busy tone signal current over the calling end of the connection. This path extends from the busy tone current lead C1089 by way of the contacts 1042, C1073, the contacts 1112 and 1141, C845, the condenser 843 and the contacts 861, 804 and 813 to the negative side of the calling line. From this point the busy tone current is transmitted over the negative side of the calling line, through the receiver provided at the calling station, back over the positive side of the calling line through the contacts 811 and 802, the winding 835 and the winding of the relay R825 to the grounded terminal of the busy tone generator. The current transmitted over this circuit is reproduced by the receiver provided at the calling station to inform the calling subscriber or operator that the desired line is busy. Following operation of the busy test relay R1040 to perform the functions described above, no further operation of the apparatus occurs until the connection is released. The manner in which the switching equipment is restored to normal when the call is abandoned at the calling telephone station is explained in detail in a following portion of the specification.

Idle test

In the event the called line 219 is idle at the time it is selected in the manner pointed out above, the lower winding of the busy test relay R1040 is short-circuited over the test circuit and, accordingly, this relay does not operate. Shortly following the selection of the called line, the transfer relay R1130 operates to complete the above-mentioned circuit for energizing the slow-to-operate control relay R1070. This circuit extends from ground by way of the contacts 866 and 817, C885, the winding of R1070, C1083, the contacts 1046, C1082, the contacts 1132, C1162, the contacts 1465, C1483, the contacts 1516, the private conductor 219c of the called line 219, and the winding of the cut-off relay embodied in the line circuit 25 to battery. When thus energized, the relay R1070 and the cut-off relay of the line circuit 25 both operate. The latter relay, in operating, disconnects the windings of its associated line relay, not shown, from the conductors of the line 219, thereby to clear this line of the impedance represented by the line relay windings. Further, the application of ground potential to the private conductor 219c serves to mark

the line 219 as busy in the relay contacts of the other connector switches. The relay R1070, upon operating, closes its contacts 1071 to complete a circuit including the grounded release conductor C893 for energizing the line-switching relay R1030. In operating, the relay R1030 locks through its X contacts 1033 to the grounded release conductor C893 and completes, at its contacts 1034, an obvious path for short-circuiting the winding of the slow-to-operate control relay R1070, causing the latter relay to restore. At its contacts 1035, the relay R1030 prepares a point in the common portion of the three available operating circuits for the ring pickup relay R960. At its contacts 1037, the relay R1030 opens a point in the above-traced path for grounding the tone apparatus start conductor C895. At its contacts 1036, the relay R1030 prepares a circuit for impressing ground potential upon the ringing code interrupter start lead C789. At its contacts 1031 and 1032, the relay R1030 connects the line terminals of the repeating coil windings 837 and 838 by way of the link line conductors C847 and C849 and the operated line contacts of the unit and group relays R1460 and R1410 to the talking conductors of the line 219.

By virtue of the above described arrangement whereby the repeating coil 834 is connected to the line 219, it is possible for an operator in the central office 5, for example, in setting up a delayed call connection, to seize the desired line and delay the ringing of the called substation until the ringing code-selecting digit is dialed. During this interval, if a subscriber served by the called line removes his receiver, the operator will receive answer supervision due to the action of the relay R800 which functions to reverse battery over the calling end of the connection. Thus, if, during the interval between the dialing of the third and fourth digits, a subscriber at the substation C, for example, removes his receiver from its supporting hook or cradle, a loop circuit is established which extends from ground by way of the winding of the balancing coil 824, the repeater winding 837, C846, the contacts 951, C892, the contacts 1011 and 1031, C847, the contacts 1463, C1481, the contacts 1514, the positive side of the called line 219, the bridge across the conductors of the line 219 at the substation C, the negative side of the line 219, the contacts 1515, C1482, the contacts 1464, C849, the contacts 1032 and 1013, C983, the contacts 953, C848, the winding 838, C872 and the winding of R920 to battery. When energized over this circuit, the relay R920 operates to complete, at its contacts 921, an obvious circuit for energizing the relay R930. At its contacts 922, the relay R920 completes a circuit including the grounded conductor C237 and the contacts 826 for energizing the battery-reversing relay R800. In this regard it will be recalled from the preceding explanation that, in handling calls involving calling trunk lines and calling subscribers' lines arranged for common battery loop operation, the line relay R825 is energized in series with the line relay R820 and, accordingly, occupies its operated position. On the other hand, when calls are initiated on subscribers' lines of the ground return type, the line relay R825 is short-circuited and, accordingly, the operating circuit for the battery-reversing relay R800 is held open at the contacts 826. It will also be understood that, if the "L" wiring illustrated in Fig. 2 of the drawings is used and the calling line is included in a subgroup of lines terminating at a finder group relay not having the "L" wiring arrangement, the lead C237 is open-circuited. Accordingly, the battery reversing relay R800 will not be energized in response to operation of the back bridge relay R920, regardless of the position of the line relay R825. In the case under consideration, the operation of the relay R930 is without effect. The relay R800, upon operating, locks to ground over a path including the contacts 805, C884, the contacts 922 and the grounded conductor C237. At its contacts 801 to 804, inclusive, the relay R800 reverses the direction of current flow over the calling end of the connection. This current reversal is utilized in the two-way repeater 7 for the purpose of causing the operation of a supervisory relay embodied therein, with the result that the direction of current flow over the loop circuit established between this repeater and the trunk circuit terminating the trunk 30 in the central office 5 is reversed. A supervisory relay is also incorporated in this trunk circuit, which relay functions to energize a signal lamp provided at the calling operator's position. Thus, the arrangement of the finder-connector link is such that, if a call is routed from an operator's position to a subscriber's line and a second call is initiated on this line before the called substation is signaled, the calling operator will receive an answer signal, and a communication connection will be established between the calling operator's position and the substation at which the second call is initiated.

Selecting the ringing code

As pointed out previously, the fourth digit dialed at the calling substation is utilized for the purpose of selecting the code of the ringing current corresponding to the desired substation. In this regard it will be apparent that the impulse-counting equipment and, more particularly, the counting chain illustrated in Figs. 12 and 13 of the drawings, operates in the exact manner previously described in response to the impulses of the fourth digit.

The numerical value of the fourth digit not only determines the code of the ringing current but, in addition, is utilized to select the side of the called line over which ringing current will subsequently be transmitted. With respect to those lines arranged for twenty-party code ringing, the bridged type of ringing is used in all cases. When using this type of ringing, the numerical value of the fourth digit determines which code of the selected subgroup of ten codes will be used in signaling over the called line, the subgroup of codes having been previously selected in response to the impulses of the first digit. On the other hand, if the called subscriber's line is arranged for ten-party code ringing, either the bridged or divided type of ringing may be used. If the line is arranged for bridged ringing, the numerical value of the fourth or code-selecting digit is of no consequence aside from the determination of the ringing code. On the other hand, if the called line is arranged for divided ringing, the fourth digit is also utilized to determine the side of the line over which the ringing current will subsequently be projected. More specifically, if a fourth digit comprising from one to five impulses is dialed at the calling substation, the ringing control apparatus is conditioned to transmit ringing current over the negative side of the selected line. If a fourth digit comprising from six to ten impulses is dialed, the ringing control equipment is conditioned to transmit ringing current over the positive side of the selected line.

If it be assumed, for example, that the substation C is desired by the calling party; that the line 219 is arranged for ten-party divided ringing; that the ringer provided at the called substation C is connected between the positive side of the line 219 and ground; and that the ringing code assigned to this substation corresponds to the code of the voltage pulses impressed upon the ringing interrupter lead C1299, a fourth digit comprising six impulses will necessarily be dialed at the calling telephone station. It will be recalled that under the assumptions made, a first digit of two impulses is dialed at the calling substation so that at the conclusion of this digit the relay R1200 is locked operated for the duration of the call. At the end of the fourth digit, the relay R1290 is locked energized in series with its associated control relay R750. When the relay R1290 operates, it completes the prepared operating circuit for the transfer relay R1000, this circuit extending by way of the grounded release conductor C893, the contacts 1291' and 1204, C1219, the contacts 1133, C1077 and the winding of R1000 to battery. When thus energized, the relay R1000 operates and locks to the grounded release conductor C893 over a path including the contacts 1005. At its contacts 1001 to 1004, inclusive, the relay R1000 arranges the ringing circuit for the transmission of ringing current over the positive side of the selected line.

When the relays R1150, R1100 and R1160 sequentially restore shortly following the end of the digit, a circuit is completed at the contacts 1101 for energizing the relay R1050. This circuit extends by way of the grounded release conductor C893, the contacts 753, C786, the contacts 1101, 1116 and 1136, C1079, the contacts 1054 and the winding of R1050 to battery. In operating, the relay R1050 locks to the grounded release conductor C893 through its contacts 1053 and then opens a point to its operating circuit at its contacts 1054. At its contacts 1051 and 1052, the relay R1050 completes obvious paths in shunt with the resistors 1038 and 1039, respectively. At its contacts 1056, the relay R1050 opens a point in the above-traced circuit for delivering current pulses to the relays R1100 and R1150, and the relays of the counting chain illustrated in Figs. 12 and 13 of the drawings. At its contacts 1057', the relay R1050 opens one of the completed multiple paths over which ground potential is impressed upon the ringing generator start conductor C1167. At its contacts 1058, the relay R1050 prepares a locking circuit for the reverting call relay R940. At its contacts 1058', the relay R1050 connects the leads C1228 and C1229 together, thereby to associate the ten ringing interrupter leads with the ringing control relay R1010. At its contacts 1059, the relay R1050 completes a path for impressing ground potential upon the ringing interrupter start lead C789, this path extending from ground by way of the contacts 1036 and 1059, C778 and the contacts 752 to the start lead C789. When this lead is grounded, operation of the ringing interrupter 1395 is initiated, providing this unit, which is common to the exchange, is not already in operation. At its contacts 1055, the relay R1050 prepares an alternative locking circuit for the hold relay R860. At its contacts 1057, the relay R1050 prepares another point in the common portion of the three operating circuits for the ringing control relay R960. Following operation of the relay R1050, the transmission of coded ringing current over the called line 219 is started.

As pointed out in the general description of the apparatus, the ringing interrupter 1395 is of the well-known all-relay type and functions to impress differently coded ground pulses upon the ten interrupter lead C1249, C1259, C1269, etc., during each cycle of operation thereof. At the beginning of each cycle of its operation, the interrupter 1395 impresses a negative battery pulse upon each of the two pick-up leads C1215 and C1227. In the case under consideration, the relay R960 is energized in response to the first negative battery pulse impressed upon the first pickup lead C1215 following energization of the relay R1050. More specifically, the relay R960 is energized over a circuit which extends from the grounded release conductor C893 by way of the contacts 753, C786, the contacts 1057, C997, the contacts 924, the upper winding of R960, C992, the contacts 1035, C991, the contacts 963, C998 and the contacts 1201 to the negative terminal of the exchange battery as connected to the pickup lead C1215 through the contacts of the coding relays embodied in the ringing interrupter 1395. When thus energized, the relay R960 operates and completes a locking circuit for itself, this locking circuit extending by way of the grounded release conductor C893, the contacts 753, C786, the contacts 1057, C997, the contacts 924, the upper winding of R960, C992, the contacts 1035, C991, the contacts 962 and 917, and the hold lead C883 to the negative terminal of the exchange battery as connected to the hold lead C883 through the contacts of the coding relays included in the interrupter 1395. After this circuit is completed, the relay R960 opens its contacts 963 to interrupt its operating circuit as traced above. At its contacts 965, the relay R960 prepares an alternative path for grounding the tone apparatus start conductor C895. At its contacts 961, the relay R960 prepares an auxiliary path for transmitting dial tone current over the calling end of the connection. At its contacts 964, the relay R960 further prepares the operating circuit for the ringing relay R1010.

Following the operation of the pickup relay R960, the ringing relay R1010 operates each time ground potential is impressed upon the selected ringing interrupter lead. In the case under consideration, this relay is energized each time the interrupter lead C1299 is grounded by the coding relays of the ringing interrupter 1395. The circuit for energizing the relay R1010 extends by way of the grounded lead C1299, the contacts 1294, C1228, the contacts 1058', the winding of R1010, C996 and the contacts 964 to battery. It will be apparent that nine similar circuits are prepared following operation of the relay R960, which circuits individually include the make contacts 1244, 1254, 1264, etc., of the nine other counting relays. Accordingly, the operation of the relay R1010 is determined in accordance with the one of the counting relays which remains operated at the end of the fourth digit. In this regard it is pointed out that the odd-numbered interrupter leads C1249, C1269, C1289, etc., are arranged to deliver ground pulses to the ringing relay R1010 over a circuit commonly including the conductor C1229, whereas the even-numbered interrupter leads C1259, C1279, C1299, and so on, are arranged to deliver ground pulses to the ringing control relay over the lead C1228.

In the case under consideration, the relay R1010 functions to transmit ringing current over the positive side of the called line 219 each time it operates. The path traversed by the ringing cur-

rent extends from one terminal of the ringing current generator by way of the winding of the slow-to-operate relay R980, C984, the contacts 1002, 1012 and 1031, C847, the contacts 1463, C1481, the contacts 1514, the positive side of the line 219 and through the windings of the ringer provided at the substation C to ground. From this point, the ringing current is transmitted over a ground return path and through the exchange battery to the opposite terminal of the ringing current generator. Portions of the ringing current are by-passed through the ringers bridged between the positive side of the line 219 and ground, and provided at other substations served by this line. The coded character of the signals produced by these ringers indicates, however, that only the substation C is being called.

In order more fully to explain the different types of ringing which may be used, it is pointed out that if the fourth or code-selecting digit comprises less than six impulses, the previously traced operating circuit for the relay R1000 is not completed and, accordingly, this relay occupies its restored position during the ringing operation. With the relay R1000 deenergized, ringing current is transmitted over the negative side of the selected line. Thus, if the code designating the called substation C corresponds to the ground pulses impressed upon the ringing interrupter lead C1269, the counting relay R1260 will be operated at the end of the code-selecting digit so that the ringing relay R1010 is energized in accordance with the ground pulses impressed upon the lead C1269. In this case, the ringing current traverses a circuit which extends from one terminal of the ringing current generator through the winding of the relay R980 and by way of C984, the contacts 1003, 1014, and 1032, C849, the contacts 1464, C1482, the contacts 1515, the negative side of the line 219 and through the windings of the ringers bridged between this side of the line 219 and ground. From this point the ringing current is transmitted over a ground return path and through the exchange battery to the other terminal of the ringing current generator. From the foregoing explanation it will be understood that, depending upon the number of impulses of the fourth digit, the relay R1000 will be energized or deenergized to determine the side of the line over which ringing current is projected.

It will be recalled from the preceding explanation that, if a called subscriber's line is arranged for twenty-party code ringing, a first digit comprising four or five impulses is dialed and, depending upon the numerical value of the digit, one of two groups of ringing codes is selected. Thus, if a first digit of four impulses is dialed, the relay R1360 is operated and the relay R1210 is restored. On the other hand, if a first digit of five impulses is dialed, both the relays R1210 and R1360 are operated. It will be observed that in neither case is the relay R1200 operated. Accordingly, the operating circuit for the relay R1000 is held open at the contacts 1204, and this relay has no function when the twenty-party type of code ringing is used. With the relay R1210 in its restored position, the pickup relay R960 is, at the beginning of a ringing operation, energized over a circuit which extends from the grounded release conductor C893 by way of the contacts 753, 763 or 773, C786, the contacts 1057, C997, the contacts 924, the upper winding of R960, C992, the contacts 1035, C991, the contacts 963, C998, the contacts 1211, C1216 and the contacts 1362 to the first pickup lead C1215. When thus energized, the pickup relay R960 operates to perform the functions described above. Following the operation of this relay, the ringing relay R1010 operates in accordance with the ground pulses impressed upon the selected one of the interrupter leads C1247, C1257, C1267, etc., to complete a circuit for transmitting ringing current through the windings of the ringers bridged across the called line. Thus, if the line 219 is arranged for this type of ringing, the ringing current transverses a circuit which may be traced as extending from the ungrounded terminal of the ringing current generator by way of the winding of R980, C984, the contacts 1003, 1014 and 1032, C849, the contacts 1464, C1482, the contacts 1515, the negative side of the line 219, the ringers bridged across the conductors of this line, the positive side of the line, the contacts 1514, C1481, the contacts 1463, C847, the contacts 1031, 1012 and 1001, and the exchange battery to the other terminal of the ringing current generator. The coded character of the signals, produced by the ringers bridged across the line 219 and provided at the substations served by this line, indicates which substation is being called.

As pointed out in the general description of the system, the arrangement of the ringing interrupter 1395 is such that the two groups of ringing codes are substantially similar. More specifically, the codes of the second group are differentiated from those of the first group by the addition of a short ring at the beginning of each ringing or code cycle. This is accomplished by wiring the interrupter in a well-known manner so that the hold lead C883 is disconnected from ground at the end of each code cycle, and by arranging the coding relays so that the battery pickup pulse is not impressed upon the first pick-up lead C1215 until after the periods of each ringing code during which the short or preliminary ring, ground pulses are concurrently applied to the ten ringing interrupter leads. Thus, the pickup relay R960 is, in all cases, deenergized to open, at its contacts 964, the operating circuit for the ringing relay R1010 at the end of each code cycle, and is reenergized by the application of a battery pulse to the pickup lead C1215 or C1227 in use at an appropriate point in the next succeeding code cycle. By eliminating the short or preliminary ring battery pulses from the first pickup lead C1215, the short rings are not included in the codes of the first group. In the case under consideration, wherein a ringing code of the first group is selected, it will be understood that the called substation is signaled by using a code from which the short or preliminary ring is eliminated.

If, however, the code designating a desired substation is included in the second group of ten codes, the relays R1210 and R1360 are both locked energized at the end of the first digit of five impulses dialed at the calling substation. Accordingly, the pickup relay R960 is, during the ringing operation, energized over a circuit including the second pickup lead C1227. More particularly, the operating circuit for the relay R960 extends from the grounded release conductor C893 by way of the contacts 753, 763 or 773, C786, the contacts 1057, C997, the contacts 924, the upper winding of R960, C992, the contacts 1035, C991, the contacts 963, C998, the contacts 1212, the second pickup lead C1227 and through the contacts of the coding relays embodied in the ringing interrupter 1395 to the negative terminal of the exchange battery. When thus ener-

gized, the relay R960 operates and locks to the negative terminal of the exchange battery over the previously traced path including the hold lead C883. With the circuit arranged in this manner, the relay R960 is deenergized in response to removal of battery potential from the locking lead C883 at the end of each code cycle, and is subsequently reenergized at the beginning of the next succeeding cycle through the application of another pickup pulse to the second pickup lead C1227. It will be noted that each time the relay R960 restores, it opens, at its contacts 964, the operating circuit for the relay R1010 so that the latter relay will not be energized by ground pulses applied to a selected one of the ringing interrupter leads. In this case, however, the pickup pulse applied to the second pickup lead C1227 at the beginning of each code cycle precedes the interval during which the short ring ground pulses are concurrently impressed upon the ten ringing interrupter leads. Accordingly, the pickup relay R960 is energized and operates to prepare the circuit for energizing the ringing relay R1010 before the preliminary or short ring period of each code cycle starts. The manner in which ringing current is transmitted over the called line each time the relay R1010 operates, in response to a ground pulse applied to the selected ringing interrupter lead, is exactly the same as described above with reference to the signaling of a called substation designated by a code of the first ten-code group.

Regardless of the type of ringing employed in signaling a particular station, or the code of the signaling current used, a portion of the ringing current is transmitted back over the calling end of the connection so that the usual ring-back tone signal is produced by the receiver provided at the calling telephone station. Thus, each time the ringing relay R1010 operates, it completes a path which extends from the ungrounded terminal of the ringing current generator by way of the contacts 1015, C985, the condenser 926, C873 and the contacts 804 and 813 to the negative side of the loop circuit including the calling line. From this point, the ringing current is transmitted through the receiver provided at the calling station back over the positive side of the calling loop circuit and through the exchange battery to the other terminal of the ringing current generator. The resulting operation of the receiver provided at the calling station serves to inform the calling party or operator that the called substation is being rung. Each time the ringing relay R1010 operates, it also functions to complete, at its contacts 1016, a circuit including the conductor C987 for energizing the slow-to-release relay R950. The relay R950, upon operating, prepares, at its contacts 952, a path for connecting the positive side of the called line 219 to ground. At its contacts 954, the relay R950 prepares a path including the resistor 927 for connecting the negative side of the line to the negative terminal of the exchange battery. The purpose of this arrangement is to provide a low resistance path including the exchange battery and the resistor 927 for draining the called line of any charge accumulated thereon during the preceding ringing interval. Thus, each time the ringing relay R1010 restores at the end of a ringing period, it completes, at its contacts 1011 and 1013, the two paths mentioned above, whereby the exchange battery is connected in series with the resistor 927 across the two conductors of the called line to provide a low resistance path for dissipating any accumulated charge on this line. In releasing, the relay R1010 also opens the above-traced operating circuit for the slow-to-release relay R950. The latter relay, accordingly, restores after a short interval determined by its release period. It is during this interval that the line is drained of any accumulated charge.

The call is answered

The desired conversational circuit between the calling and called substations is completed when the call is answered at the called substation associated with the selected line 219. More specifically, the ringing operation is terminated and the desired conversational circuit is completed instantly following the answering of the call at the called substation. Thus, if the call is answered at the substation C, for example, a direct current bridge is connected across the conductors of this line so that the relay R980 is energized over a circuit substantially identical with the bridged ringing circuit traced above. When thus energized, the slow-to-operate relay R980 operates to complete a circuit including the contacts 981 and the conductor C990 for energizing the slow-to-operate relay R1060. The relay R1060, in operating, locks to the grounded release conductor C893 through its contacts 1061, and, at its contacts 1062, completes another circuit for energizing the counting chain release relay R870. This latter circuit extends from the grounded release conductor C893 by way of the contacts 751, 761 or 771, C896', the contacts 1062, C887 and the winding of R870 to battery. When thus energized, the relay R870 operates to open, at its contacts 871, the established series-locking circuit for the operated one of the counting relays and its associated control relay, causing both of these relays to restore. The operated counting relay, in releasing, disconnects the selected ringing interrupter lead from the parallel-connected conductors C1228 and C1229, thereby to open a point in the operating circuit for the ringing control relay R1010. Thus, the relay R1010 is deenergized and restores to deenergize the relays R980 and R950. In releasing, the operated one of the three counting chain control relays R750, R760 and R770 opens, at its upper make contacts, the completed path for impressing ground potential upon the ringing generator start lead C1167 and, in so doing, interrupts the above-traced operating circuit for the counting chain release relay R870. Thus, the relay R870 is deenergized and restores. The relay R1010, upon restoring, completes the previously traced circuit for energizing the back-bridge relay R920 in series with the line balancing coil 824.

The relay R920, upon operating, completes, at its contacts 922, the previously traced circuit for energizing the battery-reversing relay R800, assuming that the calling line is of the metallic type arranged for loop operation. In this regard it will be recalled from the above explanation that, in the event the calling line is of the ground return type, the relay R825 occupies its restored position and, accordingly, the operating circuit for the battery-reversing relay R800 is held open at the contacts 826 for the duration of the call. In the event the relay R800 is energized in response to operation of the back-bridge relay R920, it functions to reverse the direction of current flow over the calling loop circuit in the manner set forth above.

At its contacts 924, the relay R920 opens a point in the common portion of the previously

traced operating circuits for the pickup relay R960. At its contacts 923, the relay R920 prepares a circuit for energizing the counting chain release relay R870. At its contacts 921, the relay R920 completes a circuit including the grounded release conductor C893 for energizing the relay R930. The operation of this relay is without effect on a call of the character under consideration.

Following the relay operations just described, the desired conversational circuit between the calling and called substations is completed by way of the link illustrated. In this regard it will be noted that talking battery is impressed upon the calling end of the connection through the windings of the line relays R820 and R825. Talking battery is impressed upon the called end of the connection through the winding of the balancing coil 824 and the windings of the back-bridge relay R920.

Release

The release of a connection established in the manner set forth above is primarily under the control of the calling party. Thus, if the called party is the first to restore his receiver to its supporting hook or cradle, the loop circuit extending to the called substation is interrupted with the result that the two relays R920 and R930 are sequentially deenergized and restore. In releasing, the back-bridge relay R920 also functions to open, at its contacts 922, the operating and locking circuits for the battery-reversing relay R800, causing the latter relay to release, if operated. The relay R800, in releasing, reverses the direction of current flow over the conductors of the calling line. In the event the call under consideration is a central office trunk call routed by way of the trunk 30, for example, this current reversal may be utilized for the purpose of causing the energization of a supervisory signal lamp provided at the position of the operator handling the call in the central office 5, whereby the operator is informed that the connection is ready to be released. In this regard it will be apparent that the called subscriber may recall the operator in the central office 5 in a well-known manner by operating the switchhook provided at the called substation up and down a number of times to cause the repeated operation and release of the three relays R920, R930 and R800, whereby a flashing recall signal is produced by the supervisory signal lamp provided at the position of the operator handling the call in the central office 5. When this signal is received, the operator may enter the connection and converse with the called subscriber for the purpose of ascertaining the service desired. As contrasted with the flashing recall signal, the release of the connection at the called substation results in the continuous energization of the supervisory signal lamp provided at the position of the operator handling the call in the central office 5. Following the release of the relays R920 and R930, and the relay R800, if operated, no further operation of the apparatus occurs until the connection is cleared out at the calling telephone station.

When the calling loop circuit is interrupted at a calling substation or in the repeater 7, for example, the relays R820, R830, R840, R850 and R860 are deenergized and sequentially restore in the order named and in the manner previously explained. The relay R825, if operated, is also deenergized and restores in response to interruption of the calling loop circuit. The relay R860, in restoring, opens, at its contacts 865, a point in the common portion of the previously traced locking circuits for the relays embodied in the finder portion of the link. Thus, the operated finder unit and group relays are deenergized and restored. Since the subgroup relay R270 is also arranged to be locked energized over a circuit including the locking lead C235, this relay, if operated, is also deenergized and restores in response to the release of the hold relay R860. Thus, the finder end of the link is fully restored to normal. During the release of this portion of the link, the private conductor of the calling line, such, for example, as the conductor 215c of the line 215, is disconnected from ground. The path for impressing ground potential upon this conductor is initially opened at the contacts 852 in response to the release of the relay R850. When this conductor is thus open-circuited, the cut-off and lock-out relays, such, for example, as the relays R110 and R105, of the line circuit associated with the calling line, are deenergized and restore in an obvious manner. Further, the removal of ground potential from the private conductor of the calling line permits negative battery potential to be impressed upon this conductor through the windings of the cut-off and lock-out relays embodied in the line circuit associated with the calling line, whereby the line is marked as idle in the relay contacts of the various connector switches.

The relay R860, upon restoring, also closes its contacts 863 to reprepare the previously traced operating circuit for the link distributor relay R700 corresponding to the link illustrated. Thus, the link is marked as idle in the distributor illustrated in Fig. 7 of the drawings.

At its contacts 869, the relay R860 disconnects the release conductor C893 from ground. In response to this operation, all of the relays which are locked up over holding circuits including the release conductor are deenergized and restore. Thus, if the call is successfully completed in the manner explained above, the relays R1030, R1060, R1110, R1120, R1130, R1510 and R1460 are all deenergized in response to the removal of ground potential from the release conductor C893. Further, the operated ones of the relays R1200, R1210, R1350 and R1360 are obviously deenergized when the release conductor C893 is disconnected from ground. When these relays are all released, the link illustrated is fully restored to normal.

It will be understood from the above explanation that in the event the connection is cleared out at the calling telephone station prior to the release thereof at the called substation, the back-bridge relay R920 is deenergized and restores when the relays R1030, R1460 and R1510 restore to open the loop circuit extending to the called substation.

The manner in which a connection routed to a busy called subscriber's line is released under the control of the calling party is substantially similar to the release of the connection as described above. In this case, the busy test relay R1040 is operated at the time the call is abandoned. This relay is deenergized and restores in response to the release of the hold relay R860 to disconnect holding ground potential from the release conductor C893.

In the event a call is abandoned before it is completely set up, or is abandoned after the ringing operation is started but before the call is answered, the impulse-counting equipment illus-

trated in Figs. 7, 12 and 13 of the drawings, is released in the manner previously explained in response to the removal of ground potential from the release conductor C893.

During the release of the connector end of the link, the relays R1130, R860, R1510 and R1460 function to open points in the previously traced path for impressing ground potential upon the private conductor 219c of the called line 219. When this conductor is disconnected from ground, the cut-off and lock-out relays embodied in the line circuit 25 are deenergized and restore in a manner clearly apparent from the preceding explanation with reference to the line circuits 10 and 15. Following the release of these relays, negative battery potential is impressed upon the private conductor 219c of the line 219 to mark this line as idle in the relay contacts of the various connector switches having access thereto. Thus, all of the equipment involved in setting up the connection is fully restored to normal.

Selecting a called subscriber's line in the "300"-line group

As indicated above, if a subscriber's line in the "300" group of one hundred lines is to be selected, a first digit of three impulses is dialed at the calling telephone station. Accordingly, at the end of the digit the third counting relay R1260 is locked energized in series with the third control relay R750. When the relays R1150, R1100 and R1160 restore shortly following the end of the digit, an alternative circuit is completed for energizing the control relay R1200. This circuit extends by way of the grounded release conductor C893, the contacts 753, C786, the contacts 1101, 1117, 1128 and 1104, C1221, the contacts 1261 and the lower winding of R1200 to battery. When thus energized, the relay R1200 operates to complete a circuit including the contacts 1203 and C1218 for energizing the relay R1350. At its contacts 1204, the relay R1200 prepares the operating circuit for the relay R1000. At its contacts 1202, the relay R1200 prepares the circuit for energizing the relay R1360. At its contacts 1201, the relay R1200 prepares the above-traced circuit for energizing the ringing control relay R960 in accordance with the negative battery pulses impressed upon the first pickup lead C1215 by the ringing interrupter 1395.

The relay R1350, in operating, completes, at its contacts 1352, a holding circuit for itself and the relay R1200. This circuit extends by way of the grounded release conductor C893 and the winding of R1120 to C1080 where it divides, one branch extending through the contacts 1352 and the winding of R1350 to battery, and the second branch extending by way of the contacts 1352, C1218, the contacts 1203 and the lower winding of R1200 to battery. When this circuit is completed, ground potential is impressed upon both winding terminals of the transfer relay R1120 and, accordingly, this relay is short-circuited. At its contacts 1353 to 1357, inclusive, the relay R1350 prepares the operating circuits individually extending to the five group relays terminating the five subgroups of lines assigned the directory numbers 310 to 360, inclusive. At its break contacts 1353' to 1357', the relay R1350 opens the normally prepared operating circuits for the five group relays terminating the five subgroups of lines assigned the directory numbers 210 to 260, inclusive. In this regard it will be noted that the five group relays terminating the lines forming the other five ten-line subgroups and assigned numbers in the "300" directory number series, are prepared at the break contacts 1364' to 1368', inclusive, of the restored relay R1360. Further, the operating circuits for the other five group relays terminating lines assigned the directory numbers 261 to 200, inclusive, are held open at the restored make contacts 1364 to 1368, inclusive, of the restored relay R1360. Thus, the group relay operating circuits are conditioned for the energization of one of the ten connector group relays terminating the subscribers' lines assigned directory numbers in the "300" number series.

The relay R1350, in operating, also closes its contacts 1351 to complete an alternative circuit for energizing the counting chain release relay R870, this circuit extending from ground by way of the contacts 1351, C1086, the contacts 1126, C887 and the winding of R870 to battery. When thus energized, the relay R870 operates to open, at its contacts 871, the previously traced locking circuit for the series-connected relays R750 and R1260, causing both of these relays to restore. Thus, the impulse-counting equipment is conditioned to respond to the impulses of a second digit. Upon restoring, the relay R1260 opens, at its contacts 1261, the above-traced operating circuit for the relay R1200. The relay R750, upon restoring, opens, at its contacts 753, the previously described path short-circuiting the winding of the relay R1120, permitting the latter relay to be energized in series with the parallel-connected relays R1350 to R1200. When thus energized, the relay R1120 operates to open, at its contacts 1126, the above-traced alternative operating circuit for the counting chain release relay R870. The relay R870 is thus deenergized and restores. In operating, the relay R1120 performs the other functions described previously in connection with the selection of the line 219.

Following the operation of the relay R1120, the control apparatus of the link is conditioned to respond to the impulses comprising the second digit of the directory number designating the desired substation. If it be assumed, for example, that the desired line is the eighth line of the fourth subgroup of lines in the larger group of one hundred lines having assigned directory numbers in the "300" series, the second and third digits dialed at the calling telephone station will comprise four and eight impulses, respectively. The manner in which these impulses are utilized to control the relays of the counting chain illustrated in Figs. 12 and 13 of the drawings, is exactly the same as described previously. In this regard it will also be understood that the three relays R1150, R1100 and R1160 operate at the beginning of the first impulse of the second digit and remain operated until shortly after the digit is ended. In the case assumed, the fourth counting relay R1270 is locked energized in series with its associated control relay R770 at the end of the second digit. Accordingly, when the relays R1150, R1100 and R1160 sequentially restore shortly following the end of the digit, a circuit is completed for energizing the connector group relay which terminates the ten lines forming the fourth subgroup of the selected 100-line group. This circuit may partially be traced as extending from ground by way of the contacts 869, the release conductor C893, the contacts 773, C786, the contacts 1101, 1117, 1127 and 1103, C1226, the contacts 1273, C1278, the contacts 1356, C1278' and the winding of the indicated connector group relay to battery. It will be

understood that if the desired line is included in another of the ten-line subgroups of the second group of one hundred lines, the corresponding group relay is operated in accordance with the setting of the counting relay chain. Thus, the five connector group relays terminating the first five subgroups of lines in this 100-line group are energized over circuits commonly including the portion of the above-traced circuit which extends to the conductor C1226. From this point the various group relay operating circuits branch through the contacts 1243, 1253, 1263, 1273 and 1283 of the counting relays, over the leads C1248, C1258, C1268, C1278 and C1288, and through the contacts 1353, 1354, 1355, 1356 and 1357 to the operating leads of the indicated group relays. The circuits for energizing the connector group relays terminating the other five subgroups of lines in the second 100-line group are slightly different. These latter circuits commonly include a portion which may be traced as extending from the grounded release conductor C893 by way of the contacts 753, 863 or 773, C786, the contacts 1101, 1117 and 1127, and the lead C1225. From this lead the operating circuits for the last-mentioned connector group relays branch through the contacts 1293, 1303, 1313, 1323 and 1333 to the leads C1298, C1308, C1318, C1328 and C1338. From these leads the operating circuits are individually carried through the break contacts 1364' to 1368', inclusive, of the restored relay R1360 to the operating windings of the indicated group relays. From the above explanation it will be apparent that depending upon the setting of the counting relay chain at the end of the second digit dialed at a calling substation or at an operator's position in the central office 5, the connector group relay terminating any line assigned a directory number of the "300" series may be energized.

Continuing now with the specific case under consideration, when the connector group relay terminating the fourth subgroup of lines of the second 100-line group operates, it functions in the manner previously explained to impress ground potential upon the conductor C1166 and thus energizes the counting chain release relay R870. This relay, in operating, restores the impulse-counting equipment to normal, following which it is itself released, all in the manner described above. During these operations the relay R1110 is locked energized in series with the operated connector group relay in the manner described above.

From this point on, the manner in which the called line is selected from the selected subgroup of ten lines; the called line is tested to determine the idle or busy condition thereof; the desired ringing code is selected; the desired substation is signaled; and the connection is released, is exactly the same as described previously with reference to the call routed to the subscriber's line 219.

Busy Line Verification

Provisions are made whereby the operators in the central offices 5 and 6 having access to the switching equipment illustrated in the drawings over the two-way trunks connecting the two offices with this switching equipment, may establish talking circuits to busy lines. The purpose of this arrangement is to enable the central office operators to ascertain whether or not a desired line is actually busy. If desired, the arrangement for this purpose may also be used for toll offering purposes. The manner in which a call of this character may be routed through the finder portion of the link illustrated to the connector portion of the link, has already been considered. From this explanation it will be recalled that when the connect relay R290 operates, a circuit is completed for energizing the relay R1020. Assuming that the call is initiated on the trunk 30, this circuit, when completed, extends from ground by way of the contacts 552 and 532, the trunk identification lead C681, the contacts 298, C236 and the upper winding of R1020 to battery. When thus energized, the relay R1020 operates to prepare a locking circuit for itself which includes the contacts 1025 and the release conductor C893. This locking circuit is completed shortly thereafter in response to operation of the hold relay R860 to impress ground potential upon the release conductor C893. In operating, the relay R1020 prepares, at its contacts 1024, an alternative circuit for energizing the battery-reversing relay R800. At its contacts 1021, the relay R1020 opens a point in one of the operating circuits for the link release relay R900. At its contacts 1022, the relay R1020 opens a point in one of the locking circuits for the relay R850. At its contacts 1025, the relay R1020 also prepares a locking circuit for the verification relay R1140.

In order to obtain access to the desired busy line, it is necessary for the calling operator to dial a prefix digit comprising one impulse before dialing the remaining digits constituting the directory number assigned to the desired line. The manner in which the control equipment responds to the single impulse of this prefix digit is exactly the same as set forth previously. At the end of the digit, the first counting relay R1240 is locked energized in series with its associated control relay R770. When the relay R1150, R1100 and R1160 restore shortly following the end of this digit, a circuit is completed for energizing the lower winding of the verification relay R1140 in series with the counting release relay R870. This circuit extends by way of the grounded release conductor C893, the contacts 773, C786, the contacts 1101, 1117, 1128 and 1104, C1221, the contacts 1241, C1214, the lower winding of R1140, C887 and the winding of R870 to battery. When thus energized, the relay R1140 operates to complete, at its X contacts 1146, the prepared locking circuit for itself. This circuit extends by way of the grounded release conductor C893, the contacts 1025, C238, the contacts 249, C239, the contacts 1114 and 1146, and the upper winding of R1140 to battery. At its contacts 1141, the relay R1140 opens a point in the previously traced path for impressing busy tone signal voltage upon the calling end of the connection. At its contacts 1142 and 1143, the relay R1140 prepares the previously mentioned dry talking circuit to the desired line. At its contacts 1144, the relay R1140 opens a point in the previously traced locking circuit for the busy test relay R1040. At its contacts 1145, the relay R1140 prepares an alternative locking circuit for the busy test relay R1040.

The relay R870 also operates when energized in series with the lower winding of the verification relay R1140. Upon operating, the relay R870 opens the established series-locking circuit for the two relays R770 and R1240 in the manner previously explained, causing both of these relays to restore. These relays, in releasing, open, at the contacts 773 and 1241, two points in the above-traced circuit for energizing the relays

R1140 and R870 in series. Thus, the relay R870 is deenergized and restores. Following the release of this relay, the control equipment of the link is conditioned to respond to the impulses comprising the first digit of the directory number assigned to the desired subscriber's line. The manner in which this line is selected in response to the next three digits dialed at the calling operator's position is exactly the same as described above with reference to the call routed to the line 219. From this explanation it will be recalled that during the dialing of the third digit of the called subscriber's directory number, the relays R1100, R1150 and R1160 are operated. Assuming that the line 219 is the desired busy line, a circuit is completed for energizing the busy test relay R1040 in response to the operation of the relay R1460 which occurs shortly following the dialing of the third digit of the directory number designating this line. This circuit extends by way of the grounded private conductor 219c, the contacts 1516, C1483, the contacts 1465, C1162, the contacts 1131, C1076 and the lower winding of R1040 to battery. When thus energized, the relay R1040 locks to the grounded private conductor 219c over a path including the contacts 1044, C1075, the contacts 1145, C1162, the contacts 1465, C1483 and the contacts 1516. Shortly after this locking path is completed, the transfer relay R1130 operates to open its contacts 1131 and thus interrupt the operating circuit for the busy test relay. The relay R1130 also performs the other functions assigned thereto and described above with reference to the call routed to the line 219.

The relay R1040, upon operating, closes its contacts 1041 and 1043 to connect the line terminals of the repeating coil windings 837 and 838 to the talking conductors of the selected line 219 over paths including the resistors 1038 and 1039, and the condensers 1038' and 1039'. At its contacts 1042, the relay R1040 prepares the previously traced circuit for transmitting busy tone current over the calling end of the connection, this circuit now being held open at the disengaged contacts 1141 of the operated verification relay R1140. At its contacts 1047, the relay R1040 opens a point in the operating circuit for the switching-through relay R810. At its contacts 1048, the relay R1040 prepares a circuit for energizing the reverting call relay R940. At its contacts 1046, the relay R1040 opens a point in the previously traced operating circuit for the relay R1070.

When the fourth digit of the directory number assigned to the line 219 is dialed at the calling operator's position, the control equipment of the link responds in the exact manner described above. Shortly following the end of the digit, the relays R1150, R1160 and R1100 restore. The relay R1100, in releasing, completes the previously traced operating circuit for the relay R1050. In operating, the relay R1050 locks to the grounded release conductor C893 and performs the other switching operations previously explained. At its contacts 1051 and 1052, the relay R1050 completes obvious paths for short-circuiting the two resistors 1038 and 1039. When these resistors are excluded from the paths connecting the line terminals of the repeating coil windings 837 and 838 with the talking conductors of the line 219, a communication connection is established between the calling operator's position in the central office 5 and the busy called line. With this connection established, the operator may monitor the called line to determine whether or not it is actually in use. This arrangement permits the operator to locate faulty lines which are in fact not in use although a permanent calling condition is present thereon. If the called line is actually in use and the operator so desires, she may break in upon the conversation being held over this line, to inform the parties conversing over the connection that she requires the use of the line in order to complete a toll connection. It will be observed that the condensers 1038' and 1039' are included in the portion of the connection which extends from the repeating coil 834 to the conductors of the called line 219. Accordingly, the previously established connection involving the line 219 may be cleared out without interference occasioned by the completed dry talking circuit extending through the link illustrated.

If the previously established connection involving the line 219 is released before the verification connection just described is cleared out at the calling operator's position in the central office 5, the relay R1040 is deenergized and restores in response to the removal of ground potential from the private conductor 219c. Upon restoring, the relay R1040 opens, at its contacts 1041 and 1043, two points in the dry talking circuit described above. At its contacts 1042, the relay R1040 opens a point in the previously traced path for transmitting busy tone current over the calling end of the connection. At its contacts 1044, the relay R1040 opens another point in its locking circuit. At its contacts 1046, the relay R1040 completes the previously traced circuit for energizing the relay R1070 in series with the operated cut-off relay embodied in the line circuit 25. Thus, this cut-off relay is prevented from releasing. At its contacts 1048, the relay R1040 opens a point in the prepared operating circuit for the reverting call relay R940.

When energized in series with the cut-off relay of the line circuit 25, the relay R1070 operates to complete the operating circuit for the line-switching relay R1030. The relay R1030, in operating, short-circuits the relay R1070 and initiates the ringing operation to signal the desired substation in the exact manner previously explained. The manner in which the called substation is signaled, the call is answered, and the connection is released under the control of the calling operator in the central office 5, is exactly the same as set forth above.

In the event the connection is cleared out at the calling operator's position in the central office 5 before the previously established connection involving the line 219 is released under the control of the parties conversing thereover, or before a permanent condition present on this line is cleared, the finder-connector link is restored to normal in a manner which will be clearly apparent from the preceding explanation. In this regard it is pointed out that the verification relay R1140 is deenergized and restores in response to the release of the hold relay R860 to remove ground potential from the release conductor C893.

Reverting Calls

The arrangement of the finder-connector links is such that reverting call connections are established by the well-known directory number dialing method. Thus, if a call intended for the substation D, for example, is initiated at the substation C, also served by the line 219, and the link illustrated is assigned to the use of the call, the

connection is extended to the connector portion of the link in the manner previously explained with reference to the calls initiated on the lines 215 and 216. The manner in which the connector portion of the link responds to the impulses of the digits comprising the directory number assigned to the called substation D is exactly the same as explained above. In this regard it will be recalled that, at the end of the third digit, the line selected through the connector portion of the link, in this case the calling line 219, is tested to determine the idle or busy condition thereof. Obviously, this line tests busy due to the operated condition of the line circuit 25. Accordingly, the busy test relay R1040 is energized and operates at the end of the third digit to perform the previously explained functions assigned thereto. One of these functions, it will be recalled, is that of transmitting the usual busy tone signal to the calling subscriber.

After dialing the fourth or ringing code-selecting digit, the calling subscriber restores the receiver provided at the calling substation to its supporting hook or cradle, thereby to open the established loop circuit extending through the finder portion of the link to the line relays R820 and R825. These two relays are thus deenergized and restore. The relay R820, in restoring, initiates the sequential release of the three relays R830, R840 and R850 in the manner previously explained. The relay R860, however, is held energized over a locking circuit which may be traced as extending from ground by way of the contacts 834, 815 and 864, C881, the contacts 1055, 1023 and 1045, C1082, the contacts 1132, C1162, the contacts 1465, C1483, the contacts 1516, the private conductor 219c, the contacts of the line relay embodied in the line circuit 25, the control conductor of the line 219, the operated contacts of the finder group and unit relays, the conductor 229c, the contacts 276, C233, the contacts 862 and the winding of R860 to battery. With the hold relay R860 operated, the link is prevented from releasing, for reasons clearly apparent from the preceding explanation.

The relay R850, upon restoring, completes a circuit for energizing the reverting call relay R940, this circuit extending by way of the grounded conductor C233, the contacts 853, C898, the upper winding of R940, C993 and the contacts 1048 to battery. When thus energized, the relay R940 closes its X contacts 949 to complete a locking circuit for itself. This locking circuit extends from ground by way of the contacts 918' and 949, C995, the contacts 1058, C994, the contacts 973 and the lower winding of R940 to battery. At its contacts 949', the relay R940 prepares an alternative locking circuit for itself. At its contacts 941, the relay R940 prepares a path for transmitting a reverting call tone signal current over the connection to inform the answering party as to the character of the call answered. At its contacts 942, the relay R940 opens the previously traced locking circuit for the busy test relay R1040, causing the latter relay to restore. At its contacts 943, the relay R940 prepares a locking circuit for the relay R930. At its contacts 944, the relay R940 prepares the operating circuit for the relay R970. At its contacts 945, the relay R940 prepares a path for impressing ground potential upon the timer start lead C878. At its contacts 946, the relay R940 completes a multiple locking circuit for the hold relay R860, this circuit extending from ground by way of the contacts 946, C233, the contacts 862 and the winding of R860 to battery. At its contacts 947, the relay R940 prepares a path for impressing ground potential upon the tone start lead C879. At its contacts 948, the relay R940 opens the previously traced locking circuits for the operated finder group, subgroup and unit relays, thereby to cause the release of the finder portion of the link in the manner previously explained.

The busy test relay R1040, upon restoring, disconnects the busy tone current source from the line 219, thereby to terminate the busy signal being transmitted over this line. At its contacts 1045, the relay R1040 opens the previously traced path for impressing ground potential upon the private conductor 219c of the line 219. When this path is opened, the relay R1070 is energized with the cut-off and lockout relays of the line circuit 25 over a circuit which extends from ground by way of the contacts 866 and 817, C885, the winding of R1070, C1083, the contacts 1046, C1082, the contacts 1132, C1162, the contacts 1465, C1483, the contacts 1516, the conductor 219c, the restored contacts of the line relay embodied in the line circuit 25, and the windings of the cut-off and lockout relays of this line circuit to battery. When thus energized, the relay R1070 operates to complete, at its contacts 1071, the previously traced operating circuit for the line-switching relay R1030. The relay R1030, upon operating, locks to the grounded release conductor C893 and, at its contacts 1034, short-circuits the winding of the relay R1070. When this short-circuiting path is completed, the relay R1070 is deenergized and restores. In addition, ground potential is again impressed directly upon the private conductor 219c of the called line 219 to maintain the energization of the cut-off and lockout relays in the line circuit 25, and to maintain the busy marking of the line 219 in the various connector switches having access thereto. The relay R1030, upon operating, also prepares, at its contacts 1035, the previously traced operating circuits for the pickup relay R960, and completes, at its contacts 1036, the previously traced path for impressing ground potential upon the ringing interrupter start lead C789. Thus, the relay R1030, in operating, initiates the ringing operation in the manner previously described.

When the call is answered at the called substation D, the ringing operation is arrested, the impulse counting chain is released, and a loop circuit is completed by way of the line 219 for energizing the back-bridge relay R920, all in the manner previously explained. Upon operating, the relay R920 completes the operating circuit for the relay R930. The relay R930, upon operating, locks to ground over a path including the contacts 932 and 943, and the grounded release conductor C893. At its contacts 933, the relay R930 further prepares the operating circuit for the relay R970. At its contacts 935, the relay R930 opens a point in one of the operating circuits for the link release relay R900. At its contacts 937, the relay R930 completes the above-mentioned path including the contacts 947 for impressing ground potential upon the tone apparatus start lead C879, whereby operation of the reverting call signal current generator 475 is initiated in the manner subsequently described. This apparatus, in operating, functions to impress an alternating voltage of a predetermined frequency upon the reverting call tone lead C907. This voltage is impressed through the condenser 925 and the engaged contacts 931 and 941 upon the nega-

tive side of the loop circuit extending to the answering substation, and is reproduced by the receiver provided at this substation to inform the answering party that the answered call is of the revertive type. The purpose of this arrangement is to prevent the answering party from receiving the impression, upon answering the call, that the answered call has been abandoned.

The relay R930, in operating, also completes the above-mentioned path including the contacts 934 and 945 for impressing ground potential upon the timer start lead C878. When this lead is grounded, operation of the timing device 720*a* is initiated. A predetermined time interval thereafter, this device functions to transmit a ground pulse over the time pulse lead C876, and to impress ground potential upon the holding lead C891. When the lead C876 is connected to ground, a circuit including this lead and the contacts 933 and 944 is completed for energizing the upper winding of the relay R970. When thus energized, the relay R970 locks to the grounded release conductor C893 over a path including its contacts 971. Thus, the relay R970 is held operated after the pulse impressed upon the time pulse lead C876 by the timing device 720*a* is terminated. At its contacts 972, the relay R970 completes an alternative locking circuit for the reverting call R940, this circuit extending by way of the grounded time cut-off lead C891, the contacts 949', the contacts 972 and the lower winding of R940 to battery. After this circuit is completed, the relay R970 opens its contacts 973 to interrupt the initially completed locking circuit for the relay R940. A short time interval following operation of the relay R970, the timing device 720*a* operates to disconnect the time cut-off lead C891 from ground and thus deenergize the reverting call relay R940. The relay R940, upon restoring, opens its contacts 946 to deenergize the hold relay R860. When the latter relay restores, the release conductor C893 is disconnected from ground to deenergize all of the operated relays in the connector portion of the link, thus causing the link to release. It will be understood that during the release of the link, the above-traced path for impressing the reverting call signal voltage upon the line 219 is interrupted at a number of points. The hold relay R860, upon restoring, also opens, at its contacts 866, the previously traced path for impressing ground potential upon the private conductor 219*c* of the line 219.

When the private conductor 219*c* is disconnected from ground, the line circuit 25 functions to lock the line 219 out of service for the duration of the call, and to impress guarding ground potential upon the private conductor 219*c* for the purpose of guarding the line 219 against seizure by the connector switches having access thereto. The manner in which this is accomplished may best be explained by reference to the line circuit 10 associated with the subscriber's line 215. It will be noted from an inspection of this line circuit that when the conductors 215*c* and 215*d* are disconnected from ground, the relays R105 and R110 are deenergized. The relay R110 immediately restores to reconnect the windings of the line relay R100 across the conductors of the associated line. In the case under consideration, when the line relay of the line circuit 25 associated with the line 219 is thus reconnected to the line 219 it is again energized. From an inspection of the line circuit 10, it will be understood that when this occurs a locking circuit is completed for the associated lockout relay. Accordingly, the line lockout relay of the line circuit 25 remains in its operated position. With this relay operated, ground potential is again impressed upon the private conductor 219*c* through the winding of the associated cut-off relay, and the marking leads extending to the common equipment illustrated in Figs. 5 and 6 of the drawings are disconnected from ground.

The desired conversational circuit between the calling and called substations C and D associated with the line 219 is completed when the calling subscriber again removes the receiver provided at the calling substation from its supporting hook or cradle. In the event this line is arranged for common battery operation, current for energizing the transmitters respectively provided at the calling and called substations is supplied to the line 219 through the windings of the line relay embodied in the line circuit 25.

When the connection is cleared out at both the calling and called substations, the loop circuit established by way of the line 219 is interrupted. In response to this operation, the line relay of the line circuit 25 is deenergized and restores to open the established locking circuit for its associated lockout relay. Thus, the line circuit 25 is released and guarding ground potential is removed from the private conductor 219*c* to render the line 219 accessible to the connector switches having access thereto.

Call Interception

In considering the operation of the call intercepting circuit 1605 illustrated in Fig. 16 of the drawings, it may be assumed that the substation D normally served by the line 219 has been taken out of service and that this substation, when connected to the line 219, is provided with a ringer which is connected between the negative side of the line and ground in series with a condenser. It may also be assumed that the other substation C served by the line 219 is provided with a ringer which is bridged between the positive side of the line and ground. In order to intercept calls intended for the disconnected substation D, the alternating current relay R1600 is provided. This relay is connected between the negative side of the line 219 and ground in series with the condenser 1602. In this regard it will be appreciated that the "M" wiring is utilized in this case.

With the relay R1600 wired in the manner pointed out in the preceding paragraph, if a call intended for the disconnected substation D is routed through the link illustrated to the line 219, and ringing current is projected over the negative side of this line, in the manner explained above, the relay R1600 is energized at the beginning of the first ringing interval in a circuit including the condenser 1602 and operates to complete a circuit for energizing the associated switching relay R1610. This circuit extends from ground by way of the chain-connected contacts 1641, 1631, 1621, 1611 and 1601, and the upper winding of R1610 to battery. When thus energized, the relay R1610 locks to the grounded private conductor 219*c* over a path including its preliminary make contacts 1613. After this locking circuit is completed the relay R1610 opens its contacts 1611 to interrupt the operating circuit for the relay R1610 as well as the operating circuits for the other switching relays R1620, R1630, etc., individual to the other lines arranged for

call interception and served by the intercepting circuit 1605. Following the operation of the relay R1610 at the beginning of the first ringing interval, any further operation of the alternating current relay R1600 is without effect. At its contacts 1612, the relay R1610 completes an obvious circuit for energizing the common switching relay R1640. At its contacts 1614 and 1615, the relay R1610 prepares a path for bridging the ring-trip resistor 1673 across the positive and negative conductors of the line 219. The relay R1640, in operating, closes its contacts 1643 to complete the last-mentioned path, whereby the ring cut-off relay R980 and the back-bridge relay R920 are caused sequentially to operate in the manner previously explained. From this explanation it will be recalled that following the operation of the back-bridge relay a communication channel is established through the link between the calling line and the line 219.

The relay R1640, in operating, also opens its contacts 1641 further to interrupt the common portion of the operating circuits for the switching relays R1610, R1620, R1630, etc. At its contacts 1642, the relay R1640 completes an obvious circuit for energizing the timing relay R1650. The latter relay is of the pendulum type and is equipped with a weighted contact spring 1652. Accordingly, when the relay R1650 is energized to attract its armature 1651 vibration of the contact spring 1652 is initiated, whereby this spring and the armature 1651 are only intermittently engaged. After a predetermined time interval the vibration of the contact spring 1652 is arrested and this spring settles into resting engagement with the armature 1651. When this occurs the slow-to-operate relay R1660 is sufficiently energized to operate. In operating, the relay R1660 closes its contacts 1661 to complete an obvious circuit for energizing the metering device 1664, whereby the presence of the intercepted call is registered. At its contacts 1663, the relay R1660 prepares a path for transmitting signaling current over the established communication connection extending to the calling substation. At its contacts 1662, the relay R1660 completes an obvious circuit for energizing the two series-connected windings of the slow-acting relay R1670. The relay R1670 operates after an interval and closes its contacts 1671 to short-circuit its upper winding. When this winding is short-circuited the relay R1670 restores so that its two windings are again energized in series. Thus the relay R1670 functions in the manner of a buzzer. Each time this relay operates it closes its contacts 1672 to complete an obvious path for short-circuiting the resistor 1676 in series with the exchange battery. This short-circuiting path is obviously opened each time the relay R1670 restores. It will thus be apparent that positive and negative potentials are alternately applied to the lower electrode of the condenser 1674 through the radio frequency choke coil 1675. The periodic change in the potential of the lower electrode of the condenser 1674 causes an undulating current to be transmitted over the established communication connection which is reproduced by the receiver provided at the calling substation. The tone of the signal thus produced at the calling substation serves to inform the calling party that the desired substation is out of service.

The release of the call intercepting circuit 1605 is under the control of the calling subscriber. More specifically, when the call is abandoned at the calling substation the illustrated finder-connector link is released in the exact manner previously described. During the release of this link the private conductor 219c of the line 219 is disconnected from ground to cause the deenergization and release of the switching relay R1610. This relay, in restoring, opens its contacts 1612 to cause the sequential release of the relays R1640, R1650, R1660 and R1670, in an obvious manner. The relay R1660, in restoring, opens its contacts 1661 to deenergize the metering device 1664. Thus the intercepting circuit is fully restored to normal.

It will be understood from the above explanation that in any case where one of the switching relays R1610, R1620, R1630, etc., individually associated with the lines arranged for call intercepting service, is energized, the other relays of similar character are locked out. Thus the circuit is only capable of handling one call at a time, and means are provided for positively guarding the circuit against seizure when it is occupied with a call. In the event the relay R1600 and its associated switching relay R1610 are to be used in conjunction with a single party line arranged for bridged ringing, the "N" wiring illustrated in the drawings is used in lieu of the "M" wiring described above. In such case the relay R1600 is energized by ringing current traversing its winding, the condenser 1602, and the two sides of the line 219 in series.

Private Branch Exchange Calls

Calls involving the trunks extending to a private branch exchange are handled by the links in substantially the same manner as calls involving the subscribers' lines. Provisions are made, however, for the automatic preselection of idle P. B. X. trunks. Thus, the trunk preselect relay group diagrammatically illustrated at 1490 is provided for automatically selecting an idle one of the four associated trunks each time a previously selected trunk is seized and thus rendered busy. These preselect relays are arranged selectively to control the unit relays of the link in accordance with the condition of the four associated trunks. More specifically, if a call intended for the private branch exchange terminating this group of trunks is routed through the finder-connector link illustrated, the group of trunks is selected by dialing at the calling telephone station the directory number assigned to the trunk group. During the dialing of the first two digits of this number, the group relay R1510 is caused to operate in the manner previously described. With the arrangement illustrated, the third digit of the directory number designating the P. B. X. trunk group is the digit 1. Accordingly, at the end of this digit, the first counting relay R1240 is locked energized in series with its associated control relay R770. Shortly thereafter, the relays R1150, R1100 and R1160 restore. In restoring, the relay R1100 functions to complete the operating circuit for the connector unit relay which corresponds to the preselected idle trunk. Thus, if the first trunk of the group is idle, the connector unit relay R1450 is energized over a circuit which extends by way of the grounded release conductor C893, the contacts 773, C786, the contacts 1101, 1116, 1137 and 1102, C1223, the contacts 1242, C1247, the contacts 1513, C1484, the contacts of the preselect relays embodied in the relay group 1490, C1491 and the winding of R1450 to battery. The relay R1450, in operating, locks to ground over the previously traced path including the winding of the trans-

fer relay R1130, and completes the previously traced operating circuit for the counting chain release relay R870. At its contacts 1453 to 1455, inclusive, the relay R1450 connects the conductors of the first trunk 211 to the conductors of the link line C487, C849, C1162. From this point on, the manner in which the call is forwarded to the private branch exchange and the connection is released under the control of the calling party is exactly the same as described above with reference to the call routed to the subscriber's line 219.

In the event the first trunk line of the group is busy at the time the above-described call is initiated, the preselect relays of the relay group 1490 occupy positions such that the conductor C1484 is connected through the contacts of these relays to the conductor C1257 which extends to the winding of the second connector unit relay R1430. Accordingly, the unit relay R1430 operates to connect the second trunk of the group to the conductors of the link line C847, C849, C1162. Similarly, if the first two trunks of the group are busy at the time the call is initiated, the lead C1484 is connected through the contacts of the trunk preselect relays 1490 to the conductor C1267 which extends to the winding of the third connector unit relay R1440. Accordingly, the unit relay R1440 is energized and operates to connect the third trunk of the group to the link line C847, C849, C1162. Finally, if the first three trunks of the group are all busy, the lead C1484 is connected through the contacts of the trunk preselect relays 1490 to the lead C1494 which extends to the winding of the fourth unit relay. This relay, in operating, connects the conductors of the fourth trunk to the link line C847, C849, C1162 in a manner which will readily be understood from the above explanation. As indicated previously, the arrangement of the trunk preselect relays is such that if the first trunk becomes idle, it is utilized in routing the next P. B. X. call to the private branch exchange in preference to the second, third, and fourth trunks which may also be idle at the time the first trunk is released.

The trunk preselect relays 1490 are controlled over the private conductors of the associated trunks. Thus, when ground potential is impressed upon the private conductor 211c of the first trunk 211, the corresponding trunk preselect relays operate to open the connection between the lead C1484 and the lead C1247', and to establish a connection between the lead C1484 and the lead C1257, providing the second trunk is idle. In the event the second trunk is also busy, the lead C1484 is connected through the contacts of the trunk preselect relays to the third connector unit relay operating lead C1267, and so on. By virtue of this arrangement, the trunk preselect relays are controlled automatically to prevent seizure of busy corresponding trunks regardless of whether the calls present on the corresponding trunks are incoming or outgoing calls. In this regard it will be understood from the preceding explanation that each line is marked busy through the application of ground potential to the private conductor thereof, regardless of whether the line is seized through the connector switch of one of the links or is seized in the distant P. B. X.

Release on Permanents and Conversation Timing

As indicated previously, provisions are made in the finder-connector links for automatically releasing any operated one thereof when it is seized over a faulty line having a permanent calling condition thereon, or a partially established connection is held for an unreasonable time interval. Thus, it is pointed out above that when a call is routed to the connector portion of the link illustrated, the hold relay R860 functions to impress ground potential upon the timer start lead C889 over a path including the contacts 867 and 818. In operating, the relay R860 also closes its contacts 868 to prepare a circuit for energizing the link release relay R900. When ground potential is impressed upon the start lead C889, operation of the timing device 720b is initiated. Thereafter, the timing device 720b operates at regular intervals to impress ground potential upon the lead C892. When this lead is first grounded following operation of the hold relay R860, the circuit for energizing the relay R900 is completed, this circuit extending by way of the grounded lead C892, the contacts 868 and 819, C877, the contacts 935 and 915, and the lower winding of R900 to battery. A parallel branch of this circuit may extend by way of the conductor C877, the contacts 1021 and the conductor C988. Upon operating, the relay R900 locks to ground over a path including the contacts 903 and 913, C897 and the contacts 871 and 869. Thus, the relay R900 is held operated after the ground pulse impressed upon the lead C892 by the timing device 720b terminates. At its contacts 906, the relay R900 opens a point in an alternative operating circuit for the relay R960. At its contacts 901, the relay R900 opens a point in an alternative path for transmitting dial tone signal current over the calling end of the connection. At its contacts 902, the relay R900 prepares a circuit for energizing the relay R910. At its contacts 904, the relay R900 prepares an alternative path for impressing ground potential upon the release conductor C893. At its contacts 905, the relay R900 opens a point in an alternative holding circuit for the relay R850. Assuming that no further operation of the connector portion of the link occurs following operation of the hold relay R860, no further operation of the relay equipment embodied therein occurs for a predetermined time interval. At the expiration of this interval, the timing device 720b functions to impress ground potential upon the time pulse lead C874, thereby to energize the relay R910 over a circuit including this conductor and the contacts 902. When thus energized, the relay R910 locks to ground over a path including the contacts 914 and the grounded release conductor C893. At its contacts 911, the relay R900 prepares a point in the above-mentioned alternative circuit for transmitting dial tone current over the calling end of the connection. At its contacts 915, the relay R910 opens a point in the previously traced operating circuit for the relay R900. At its contacts 912, the relay R910 completes an alternative locking circuit for the relay R900, this alternative circuit including the grounded time pulse lead C875 and the contacts 912 and 903. In this regard, it is noted that the timing device 720b normally maintains ground potential upon the time pulse lead C875 but functions to disconnect this lead from ground at regularly spaced intervals. Following the completion of this alternative circuit, the relay R910 opens its contacts 913 to interrupt the initially completed locking circuit for the relay R900. At its contacts 916, the relay R910 opens a further point in the previously traced operating circuit for the link

distributor relay R700, thereby further to insure the busy marking of the link illustrated in the link distributor. At its contacts 917, the relay R910 opens a point in the previously traced locking circuit for the pickup relay R960. At its contacts 918', the relay R910 opens the previously traced holding circuit for the relay R850. The relays R850 and R860 are thus sequentially deenergized and restore. Upon restoring, the hold relay R860 initiates the release of the link in the manner previously described. During the release of the link equipment, the relay R910 is deenergized in response to the removal of ground potential from the release conductor C893. Under the conditions assumed, a calling condition is still present on the line responsible for seizure of the link. Accordingly, the line and lockout relays of the line circuit associated with this line are held energized to lock the line out of service in the manner described previously with reference to the reverting call connection established between the substations C and D served by the line 219.

The above description pertaining to the forcible release of the link only applies when the link is seized and no dial pulses are transmitted thereto. In the event the dialing operation is started following operation of the relay R900 but prior to operation of the relay R910, the timing operation in progress is arrested and is started anew at the end of each digit dialed. Thus, the counting chain release relay R870 operates to open, at its contacts 871, the previously traced locking circuit for the relay R900 shortly following the end of each series of impulses transmitted to the connector portion of the link. The relay R900 is thus deenergized and restores so that a second timing period is started. This arrangement insures that the link will be forcibly released in the event the directory number designating a particular substation is partially dialed at a calling substation and the call is abandoned without a release of the connection at the calling substation. In this regard it will be noted that if the central office trunk digit comprising eight, nine or ten impulses is dialed at a calling substation and the switching-through relay R810 operates in the manner previously explained, the contacts 818 are opened to disconnect the timer start lead C889 from ground and the contacts 819 are opened to prevent further energization of the relay R900. The counting chain release relay R870 also operates shortly following the end of a digit of this character to open the holding circuit for the relay R900 and thus cause the release of the latter relay, if operated. It will be apparent, therefore, that when the link illustrated is occupied with a central office trunk call, the apparatus for forcibly releasing the link is rendered inactive.

In the event a timing operation is in progress at the time a call routed by way of the link is answered at the called substation, the relay R900 will occupy its operated position for reasons apparent from the above explanation. When, however, the call is answered at the called substation, the back-bridge relay R920 operates to complete, at its contacts 921, the previously traced operating circuit for the relay R930. The relays R1060 and R920 complete the previously traced operating circuit for the counting chain release relay R870. The latter relay, upon operating, opens its contacts 871 to interrupt the established locking circuit for the relay R900, causing the latter relay to release. Thus, the timing operation in progress is terminated. With the arrangement illustrated, a second timing operation is immediately started in order to time the duration of the call.

In the event a connection is established by way of the link, the called party releases the connection but the calling party fails to release the connection, the timing equipment functions automatically to release the link after a predetermined time interval. Thus, when the called subscriber restores the receiver provided at the called substation to its supporting hook or cradle to terminate the conversation, the loop circuit extending to the called substation is interrupted to deenergize the back-bridge relay R920. The relay R920, upon restoring, opens the operating circuit for the relay R930. When the relay R930 restores, it closes its contacts 935 to reprepare the operating circuit for the timing relay R900. Thus, a timing operation is started which results in the forcible release of the link in the event the calling party fails to restore the receiver provided at the calling substation to its supporting hook or cradle.

Conversation timing

The two timing or link release relays R900 and R910 are also utilized for the purpose of timing the duration of established connections routed by way of the link illustrated, and for releasing the link after a connection routed by way thereof has been established for a predetermined time interval. This feature of the link circuit is optional and may be omitted, if desired, by deleting the "S" wiring arrangement comprising the conductors C988 and C877, and the contacts 1021 of the relay R1020.

Assuming that the "S" wiring is used, the timing of a call routed by way of the link is started when the call is answered at the called substation to cause the operation of the back-bridge relay R920 and the operation of the relays R930 and R870. The counting chain release relay R870, upon momentarily operating in response to the answering of the call, opens its contacts 871 to deenergize the relay R900, assuming that a timing operation is in progress. Thus, the relay R900 is normalized incident to the completion of the desired talking circuit. Thereafter, this relay and the relay R910 are sequentially operated in response to the ground pulses applied at spaced intervals to the time pulse leads C877 and C874, respectively. In this regard it will be understood that the operating circuit for the relay R900 extends, following operation of the relay R930, by way of the "S" wiring arrangement comprising the conductors C877 and C988, and the contacts 1021. It will further be apparent that if the call in progress is a central office trunk call or was originated at a nonrestricted substation, such that the relay R1020 is operated in the link, this circuit will be held open at the contacts 1021. Thus, conversation timing is limited to calls originating at the restricted substations directly served by the switching equipment illustrated.

When the relay R910 operates in response to the ground pulse applied to the time pulse lead C874 by the timing device 720b, it establishes, at its contacts 912, the previously traced alternative locking circuit for the relay R900. At its contacts 918, the relay R910 completes an alternative locking circuit for the relay R850, this circuit extending by way of the grounded release conductor C893, the contacts 1022, C989, the con-

tacts 936, 904 and 918, C890, the contacts 831 and 842 in parallel and the winding of R850 to battery. After this circuit is completed, the relay R910 opens its contacts 918' to interrupt the initially completed holding circuit for the relay R850. After a predetermined time interval, the timing device 720b functions in the manner pointed out above to remove ground potential from the time pulse lead C875, thereby to deenergize the relay R900. Upon restoring, the relay R900 prepares the previously mentioned alternative path for impressing dial tone voltage upon the connection. At its contacts 906, the relay R900 prepares the above-mentioned alternative operating circuit for the pickup relay R960. At its contacts 904 and 905, the relay R900 transfers the holding circuit for the relay R850 from the release conductor C893 to the normally grounded release lead C888. This lead is normally connected to ground through the contacts of the timing device 720b. Shortly after the release of the relay R900, the timing device 720b functions to impress a ground pulse upon the lead C892', thereby to energize the relay R960 over a circuit including this lead, the contacts 906 and 919, and the lower winding of R960. The relay R960, upon operating, connects the tone start lead C895 to ground over a path including the conductor C894 and the contacts 854, 919' and 965. At its contacts 961, the relay R960 completes the above-mentioned path for impressing dial tone signal voltage upon the established connection, this path extending from the ungrounded terminal of the dial tone generator 435 by way of the lead C1168, the contacts 961, 911 and 901, the conductor C845, the condenser 843 and the contacts 861 to the negative side of the established connection. From this point, the dial tone current is conducted through the receivers respectively provided at the calling and called substations, whereby the usual dial tone signal is reproduced thereby. The parties conversing over the established connection are thus informed that the allotted conversation time has expired and that the connection will shortly be forcibly released. Immediately after the termination of this signal, which occurs when the timing device 720b operates to disconnect ground from the lead C892' and thus deenergize the relay R960, the timing device 720b functions to disconnect the holding lead C888 from ground and thus open the above-traced alternative holding circuit for the relay R850. When deenergized in this manner, the relay R850 restores to open the circuit for energizing the hold relay R860. The relay R860, upon restoring, initiates the release of the link in the manner previously explained. During the release of the link, ground potential is removed from the private conductors of the calling and called lines, with the result that the line and lockout relays of the line circuits respectively associated therewith are locked operated. Thus, the calling and called lines are effectively locked out of service until the receivers respectively provided at the calling and called substations associated therewith are restored to their respective supporting hooks or cradles.

Calls to the Manual Offices

As indicated previously, a call may be routed to the central office 5 from a calling one of the substations served by the illustrated automatic switching equipment, in response to the dialing of a single digit comprising eight impulses at the calling substation. Idle ones of the trunks extending to the central office are automatically preselected through operation of the preselect relay group 1495. This relay group is identical in arrangement with the P. B. X. trunk preselect relay group 1490 except that the capacity thereof is enlarged to accommodate five trunks.

Briefly to consider the manner in which a trunk call to the manual office 5 is handled, it may be assumed that a call of this character is initiated at the substation A, for example, and that the link illustrated is assigned to the use of the call. The manner in which the link operates in response to initiation of the call is substantially the same as described above with respect to the call routed to the line 219.

Following seizure of the link in the manner just described, and when the single central office trunk digit comprising eight impulses is dialed at the calling substation A, the impulse-counting chain responds in the manner previously described. At the end of the digit, the eighth counting relay R1310 is locked energized in series with its associated control relay R760. When the relays R1150, R1100 and R1160 restore shortly following the end of the digit, the prepared operating circuit for the connector group relay R1580 is completed. This operating circuit extends by way of the grounded release conductor C893, the contacts 763, C786, the contacts 1101, 1117 and 1128, C1222, the contacts 1311, C1318' and the winding of R1580 to battery. Upon operating, the relay R1580 connects the conductors of the ten associated trunks to the ten link lines of the connector switch and completes, at its contacts 1582, a path including the conductor C1164 and the grounded release conductor C893 for short-circuiting the winding of the transfer relay R1110. At its contacts 1583, the relay R1580 prepares one of the previously traced operating circuits for the counting chain release relay R870, but this circuit is now open at the restored contacts 1126' of the transfer relay R1120. At its contacts 1581, the relay R1580 completes a circuit for energizing the connector unit relay which corresponds to the trunk preselected for the use of the call by the trunk preselect relay group 1495. Thus, if the first trunk of the central office trunk group is idle, the lead C1486 is connected through the contacts of the trunk preselect relays to the operating lead C1247' extending to the unit relay R1450 corresponding to the first trunk of the group. On the other hand, if the first trunk is busy at the time the call is initiated and the second trunk of this group is idle, the lead C1486 is connected through the contacts of the trunk preselect relays 1495 to the operating lead extending to the connector unit relay corresponding to the second trunk of the group. More generally stated, the lead C1486 is connected through the contacts of the trunk preselect relays 1495 to the operating lead of the connector unit relay which corresponds to the preselected idle trunk. Assuming that the first trunk of the group is idle, the connector unit relay R1450 is energized over a circuit which may be traced as extending by way of the grounded release conductor C893, the contacts 773, C786, the contacts 1101 and 1125', C1085, the contacts 1311', the conductor C1344, the contacts 1581, C1486, the contacts of the trunk preselect relays 1495, C1247', and the winding of R1450 to battery. In operating, the relay R1450 closes its contacts 1453, 1454 and 1455 to connect the conductors of the first trunk 281 to the link line conductors C1162, C849 and C847. At its contacts 1452, the relay R1450 locks to the

grounded release conductor C893 over a path including the conductor C1163 and, in so doing, short-circuits the transfer relay R1130. At its contacts 1451, the relay R1450 completes a circuit for energizing the counting chain release relay R870, this circuit extending by way of the grounded release conductor C893, the contacts 1451, C1165, the contacts 1135, C887 and the winding of R870 to battery. When thus energized, the relay R870 functions to release the operated relays R760 and R1310 of the counting chain in the manner previously explained. During the release of these relays, the paths short-circuiting the transfer relays R1110 and R1130 are opened at the contacts 1311 and 1311', respectively, permitting these two transfer relays to be energized in series with the connector group and unit relays R1580 and R1450, respectively. The relay R1130, upon operating, opens its contacts 1135 to interrupt the above-traced operating circuit for the counting chain release relay R870, causing the latter relay to restore. At its contacts 1134, the relay R1130 completes a circuit for energizing the switching-through relay R810, this circuit extending from ground by way of the contacts 852 and 862, C233, the contacts 1134 and 1125, C1084, the contacts 1047, C886 and the winding of R810 to battery. At its contacts 1132, the relay R1130 completes a path for impressing ground potential upon the private conductor of the selected central office trunk 281, this path extending from ground by way of the contacts 866 and 817, C885, the contacts 1123, C1083, the contacts 1046, C1082, the contacts 1132, C1162, the contacts 1455, C1489 and the contacts 1587 to the private conductor 281c. The relay R810, upon operating, opens its contacts 818 to disconnect the timer start conductor C889 from ground, and opens its contacts 815, further to interrupt the previously traced pulsing circuit, thereby to prevent further impulses from being transmitted to the impulse-counting equipment and the associated control relays R1100, R1150 and R1180. At its contacts 819, the relay R810 opens a point in the operating circuit for the link release relay R900. At its contacts 812 and 814, the relay R810 connects the link line conductors 230a and 230b to the link line conductors C847 and C849, whereby the calling loop circuit is extended through the connector end of the link to the repeater associated with the central office trunk 281. At its contacts 811 and 813, the relay R810 opens two points in the circuit for energizing the line relays R820 and R825, thereby to cause the sequential release of these relays and the relays R830, R840 and R850. At its contacts 817, the relay R810 opens a point in the previously traced operating circuit for the relay R1070. At its contacts 816, the relay R810 completes an alternative path for impressing ground potential upon the private conductor 281c of the selected central office trunk 281. This path extends from ground by way of the contacts 852 and 862, C233, the contacts 1134 and 1125, C1084, the contacts 1047, C886, the contacts 816, C885, the contacts 1123, C1083, the contacts 1046, C1082, the contacts 1132, C1162, the contacts 1455, C1489 and the contacts 1587 to the private conductor 281c of the trunk 281. After this alternative path is completed, the relay R810 opens its contacts 817 to interrupt the initially completed path for grounding the private conductor 281c.

When the calling loop circuit is extended to the repeater associated with the trunk 201, and ground potential is impressed upon the private conductor of this trunk in the manner just explained, the repeater operates in the manner described hereinafter to extend the call to the central office 5 and to complete a multiple path for impressing ground potential upon the private conductor 281c of the trunk 281. More specifically, when the indicated repeater is seized, the line and hold relays embodied therein operate to connect the private conductor 281c to ground, thus establishing multiple holding circuits for the switch-through relay R810 and the hold relay R860. These holding circuits commonly extend by way of the grounded private conductor 281c, the contacts 1587, C1489, the contacts 1455, C1162, the contacts 1132, C1082, the contacts 1046, C1083, the contacts 1123, C885 to the contacts 816 where they divide, one circuit extending through the winding of R810 to battery, and the other circuit extending by way of C886, the contacts 1047, C1084, the contacts 1125 and 1134, C233, the contacts 862 and the winding of R860 to battery. Due to the completion of these holding circuits, the relays R810 and R860 are held operated following the release of the relays R820, R830, R840 and R850. With the hold relay R860 operated, ground potential is maintained upon the release conductor C893 to prevent the transfer relays R1110 and R1130 and the connector group and unit relays from releasing.

When the private conductor 281c of the trunk 281 is connected to ground, the trunk preselect relays 1495 operate to connect the lead C1486 to the connector unit relay operating lead which corresponds to the next idle central office trunk. Thus, if the second, third, and fourth central office trunks are all busy at the time ground potential is impressed upon the private conductor 281c, the lead C1486 is connected through the contacts of the trunk preselect relays to the operating lead individual to the fifth unit relay of the connector switch. In a similar manner, the common trunk select leads of the other links are, through operation of the trunk preselect relays 1495, connected to the operating leads individual to the corresponding fifth connector unit relays. Thus, the fifth central office trunk 30 and the associated repeater 7 are selected for use in setting up the next central office trunk call. In this regard, it will be apparent that, when a trunk is seized in the central office, the repeater associated therewith functions to impress ground potential upon the associated private conductor so that the trunk preselect relays 1495 operate to select another of the trunks for use in setting up the next succeeding trunk call. The release of the connection is entirely under the control of the operator handling the call at the central office 5. Thus, when the connection is cleared out at the operator's position in the manual office 5, the repeater associated with the trunk 281 is released. During the release of the control equipment embodied in this repeater, the private conductor 281c of the trunk 281 is disconnected from ground, thereby to deenergize the switching-through relay R810 and the hold relay R860. The hold relay, upon restoring, disconnects the release conductor C893 from ground to initiate the release of the connector portion of the link in the manner described above. This relay also disconnects the finder hold lead C235 from ground, whereby the finder portion of the link is released in the manner previously explained. In addition, the hold relay functions to mark the link as idle in the link

distributor and to remove ground potential from the control conductor extending to the line circuit associated with the calling line. In response to the latter operation, the cut-off and lockout relays embodied in the line circuit associated with the calling line are deenergized and restore in the previously described manner. Thus, the connection is fully released and the apparatus utilized therein is conditioned for further use.

Operation of the repeater 7

Assuming that the repeater **7** is seized through the link illustrated, in setting up the trunk call connection described above, the calling loop circuit is switched through to the repeating coil **2205** in response to operation of the switch-through relay **R810**. At this time, the line relay **R2320** is energized in the calling loop circuit which has been extended to include the positive conductor **C2274**, the winding **2208**, **C2275**, the contacts **2302** and **2311**, the impedance coil **2315**, the contacts **2313** and **2304**, **C2276**, the winding **2209** and the negative line conductor **C2277**. When thus energized the relay **R2320** closes its contacts **2321** to complete an obvious circuit for energizing the hold relay **R2330**. At its contacts **2322**, the relay **R2320** prepares a circuit for energizing the battery reversing relay **R2235**.

The slow-acting relay **R2330**, in operating, closes its contacts **2332** to complete a path including the contacts **2393** and the lower winding of the tone relay **R2340** for impressing ground potential upon the test conductor **285*d*** extending to the preselect relays **1495** and the connector portion of the link, whereby the trunk **30** is marked busy in the preselect relays and the above-described locking circuits are completed to prevent the release of the link. At its contacts **2334**, the relay **R2330** prepares a locking circuit for itself and completes a path including the contacts **2382** for impressing ground potential upon the ringing apparatus start conductor **C1167**. At its contacts **2336**, the relay **R2330** prepares a locking circuit for the relay **R2325**. At its contacts **2333**, the relay **R2330** completes a circuit for energizing the slow-to-operate relay **R2200**, this circuit extending from ground by way of the contacts **2333**, **C2283**, the contacts **2215** and the winding of **R2200** to battery. At its contacts **2335**, the relay **R2330** completes an obvious circuit for energizing the relay **R2360**. The relay **R2340** operates when its lower winding is included in the above-traced path for impressing ground potential upon the test conductor **285*d***. In operating, the relay **R2340** opens its contacts **2341**, thereby to prevent the operation of the relay **R2325** when the call is answered in the manual office **5**.

The relay **R2360**, upon operating, closes its contacts **2361** to complete a path for transmitting the usual ring-back tone signal to the calling substation. This path may partially be traced as extending from the ungrounded terminal of the ringing current generator by way of the condenser **2377**, the contacts **2361** and **2351**, **C2281**, the contacts **2271**, and the negative line conductor **C2277**. From this line conductor the ringing current is transmitted over the calling end of the connection and through the receiver provided at the calling substation. The reproduction of this current informs the calling subscriber that the called manual office is being signaled. At its contacts **2362**, the relay **R2360** opens one of the alternative paths for impressing ground potential upon the test conductor **285*d***. At its contacts **2363**, the relay **R2360** completes an obvious path for impressing ground potential upon the timing apparatus start lead **C889**, whereby the operation of the timing device **720*b*** is initiated in the event this device is not already in operation. At its contacts **2364**, the relay **R2360** prepares the operating circuit for the release relay **R2390**. At its contacts **2365**, the relay **R2360** prepares a circuit for energizing the relay **R2370**. At its contacts **2366**, the relay **R2360** opens a point in the operating circuit for the relay **R2300**. At its contacts **2367**, the relay **R2360** prepares a locking circuit for the relay **R2270**.

The slow-to-operate relay **R2200**, in operating, closes its contacts **2201** to complete an obvious circuit for energizing the slow-to-release relay **R2220**. The latter relay now operates to complete, at its contacts **2226**, an obvious circuit for energizing the slow-to-release relay **R2230**. At its contacts **2225**, the relay **R2220** completes a path including the resistor **2202** and the contacts **2212** for transmitting ringing current through the upper winding of the relay **R2210**. At its contacts **2227**, the relay **R2220** completes the prepared operating circuit for the relay **R2235**, this circuit extending from ground by way of the contacts **2322**, **C2288**, the contacts **2227** and the winding of **R2235** to battery. At its contacts **2221** to **2224**, inclusive, the relay **R2220** disconnects the conductors of the trunk **30** from the terminals of the repeating coil **2205** and prepares a circuit for transmitting ringing current over this trunk. The relay **R2230**, in operating, closes its contacts **2232** and **2234** to prepare a low resistance path for draining the trunk **30** of its accumulated capacity charge at the end of the signaling operation. At its contacts **2231** and **2233**, the relay **R2230** further opens the connection between the trunk **30** and the repeating coil **2205**. The relay **R2235**, in operating, opens its contacts **2237** and **2239** and closes its contacts **2236** and **2238**, thereby to reverse the connections between the conductors of the trunk **30** and the terminals of the repeating coil **2205** so that an off-hook supervisory signal will be produced at the position of the operator answering the call in the central office **5** when the call is answered.

The relay **R2210** operates to close its preliminary make contacts **2214** and thus complete a circuit for energizing its lower winding when its upper winding is traversed by ringing current in the manner explained above. The circuit for energizing the lower winding of the relay **R2210** extends from ground by way of the contacts **2333**, **C2283**, the contacts **2214** and the lower winding of **R2210** to battery. After this circuit is completed the relay **R2210** fully operates and opens its contacts **2215** to deenergize the relay **R2200**. At its contacts **2212**, the relay **R2210** interrupts the path over which ringing current is transmitted through its upper winding. At its contacts **2216**, the relay **R2210** completes an obvious holding circuit for the battery reversing relay **R2235**. At its contacts **2211** and **2213**, the relay **R2210** completes the prepared circuit for transmitting ringing current through the winding of the drop provided at the operator's switchboard in the manual office **5**. This circuit extends from the ungrounded terminal of the ringing current generator by way of the resistor **2202**, the contacts **2225**, **2213** and **2224**, the negative conductor of the trunk **30**, the winding of the drop provided at the operator's switchboard in the manual office **5**, the positive conductor of the trunk **30**, the contacts **2222** and **2211**, and the

exchange battery to the opposite terminal of the ringing current generator. Shortly after the relay R2210 operates to complete this circuit, the relay R2220 restores and opens its contacts 2226 to deenergize the relay R2230. At its contacts 2222 and 2224, the relay R2220 interrupts the circuit traversed by the ringing current. At its contacts 2221 and 2223, the relay R2220 connects the conductors of the trunk 30 together over a path including the contacts 2232 and 2234, whereby the accumulated charge on the trunk is dissipated. At its contacts 2227, the relay R2220 also opens the initially completed operating circuit for the relay R2235. The relay R2230 restores shortly following the release of the relay R2220. Upon restoring, the relay R2230 opens its contacts 2232 and 2234 to interrupt the above-described discharge path, and closes its contacts 2231 and 2233 to reconnect the conductors of the trunk 30 to the terminals of the repeating coil 2205. Following the relay operations just described no further operation of the repeater 7 occurs until the call is answered at the operator's switchboard in the manual office 5.

From the foregoing explanation it will be understood that a splash of ringing current is transmitted over the trunk 30 to signal the operator attending the answering operator's position in the distant manual office 5, and that at the conclusion of this signal the trunk 30 is drained of accumulated charges to prevent the premature operation of the line relay R2260. It will also be understood that after the repeater 7 is seized and the distant manual office is signaled, the relays R2210, R2235, R2320, R2330 and R2360 are operated.

When the call is answered at the operator's switchboard in the manual office 5, the line relay R2260 is energized in the established answering loop circuit, and closes its contacts 2262 to complete a circuit including the conductor C2285 for energizing the slow-acting hold relay R2350. At its contacts 2263, the relay R2260 opens the prepared operating circuit for the relay R2270. The relay R2350, in operating, opens its contacts 2351 to interrupt the above-traced ring-back tone signaling circuit and thus terminate the ring-back tone signal. At its contacts 2352, the relay R2350 prepares an alternative path for impressing ground potential upon the test conductor 285*d*. At its contacts 2354, the relay R2350 prepares the operating circuit for the relay R2270. At its contacts 2353, the relay R2350 completes a circuit including the contacts 2365 and 2386 for energizing the relay R2370. The relay R2370 now operates and closes its contacts 2372 to complete an obvious path for impressing ground potential upon the tone start lead C895. At its contacts 2373, the relay R2370 opens the prepared operating circuit for the release relay R2390. At its contacts 2371, the relay R2370 completes the paystation tone signaling circuit. At its contacts 2376, the relay R2370 prepares the operating circuit for the relay R2325, this circuit being held open at the contacts 2341 for the duration of the call under consideration.

In the event the call in progress was initiated at a substation of the paystation type, paystation tone signaling current is transmitted through the lower winding of the relay R2340 over a path including the test conductor 285*d* and the contacts 2332 and 2393, in the usual manner. This current causes an induced voltage to be developed in the upper winding of the relay R2340 which is impressed upon the terminals of the repeating coil 2205 through the contacts 2371 and the condenser 2355. The paystation tone signaling current is thus transmitted through the receiver of the operator's headset in use at the manual office 5 to signal the operator that the assessed charges are to be paid by coin deposit. The termination of the signal is under the control of the timing relay R2370. More specifically, this relay is equipped with a weighted contact spring 2374 which is set in vibration when struck by the armature 2375. A predetermined time interval following the energization of the relay R2370, the contact spring 2374 settles into resting engagement with the armature 2375. At this time the slow-to-operate relay R2380 is sufficiently energized to operate. In operating, the relay R2380 opens its contacts 2389 further to interrupt the prepared operating circuit for the relay R2325. At its contacts 2381, the relay R2380 short-circuits the lower winding of the relay R2340, thereby to terminate the paystation tone signal and to deenergize the relay R2340. At its contacts 2382, the relay R2380 disconnects the ringing apparatus start lead C1167 from ground. At its contacts 2383, the relay R2380 completes the prepared locking circuit for the relay R2330. At its contacts 2384, the relay R2380 further interrupts the prepared operating circuit for the release relay R2390. At its contacts 2385, the relay R2380 locks to ground over a path including the contacts 2365 and 2353. At its contacts 2386, the relay R2380 deenergizes the relay R2370. At its contacts 2387, the relay R2380 opens the prepared locking circuit for the relay R2270. At its contacts 2388, the relay R2380 prepares a locking circuit for the relay R2325. At its contacts 2389', the relay R2380 prepares the operating circuit for the relay R2270.

The relay R2370, in releasing, opens its contacts 2371 to interrupt the path over which the upper winding of R2340 is bridged across the trunk conductors C2274 and C2277. At its contacts 2372, the relay R2370 disconnects the tone apparatus start lead C895 from ground. At its contacts 2373, the relay R2370 reprepares the operating circuit for the release relay R2390. At the contact spring 2374 and the armature 2375, the relay R2370 interrupts the operating circuit for the relay R2380. At its contacts 2376, the relay R2370 opens another point in the operating circuit for the relay R2325. The relay R2340, in releasing, closes its contacts 2341 to reprepare the operating circuit for the relay R2325.

If the operator handling the call in the manual office 5 desires to recall the paystation tone signal, she may do so by momentarily withdrawing the answer plug of her cord circuit from the jack terminating the trunk 30 at the operator's switchboard. In response to this operation the answering loop circuit is interrupted to cause the deenergization and release of the line relay R2260. This relay, upon restoring, opens the operating circuit for the relay R2350, and closes its contacts 2263 to complete the prepared operating circuit for the relay R2270, the latter circuit extending from ground by way of the contacts 2263, C2289, the contacts 2389' and 2354, C2291 and the winding of R2270 to battery. The relay R2270, in operating, closes its contacts 2273 to prepare a locking circuit for itself, and opens its contacts 2271 further to interrupt the previously traced path for transmitting the ring-back tone signal to the calling substation. The relay R2350, in releasing, opens its contacts 2354

to deenergize the relay R2270 and opens its contacts 2353 to interrupt the locking circuit for the relay R2380. The relay R2380 now restores and closes its contacts 2387 to complete the prepared locking circuit for the relay R2270, this circuit extending from ground by way of the contacts 2387 and 2367, C2287, the contacts 2273 and the winding of R2270 to battery. In releasing, the relay R2380 also opens its contacts 2381 to interrupt the path short-circuiting the lower winding of the relay R2340, whereby the latter relay reoperates. When the operator again inserts the answer plug of her cord circuit in the jack terminating the trunk 30 at the operator's switchboard in the manual office 5, the relay R2260 reoperates to cause the sequential operation of the relays R2350, R2370 and R2380, followed by the release of the relays R2370 and R2340, in the exact manner described above. Thus the pay-station tone signal is again transmitted to the answering operator for a short time interval. The relay R2260, in reoperating, also opens its contacts 2263 to cause the deenergization and release of the relay R2270.

After the call is routed to the operator's switchboard in the distant manual office 5, in the manner explained above, it may be extended from this point to the desired called substation in the manner conventionally followed in manual office practice. If the calling subscriber desires to recall the operator handling the call in the manual office 5, he may do so by flashing the switchhook provided at the calling substation, thereby to open and close the calling loop circuit to produce intermittent operation of the relay R2320. The release and reoperation of this relay is followed by the relay R2235. Each time the latter relay restores it reverses the direction of current flow over the loop circuit extending from the manual office 5, whereby an on-hook supervisory signal is produced at the position of the operator handling the call in the manual office 5. Conversely, each time the relay R2235 reoperates the direction of current flow over the answering loop circuit is reversed to produce an off-hook supervisory signal at the operator's position. This flashing of the supervisory lamp associated with the trunk 30 in the manual office 5 informs the answering operator that she is being recalled from the calling substation. It will also be understood that when the calling party disconnects, the two relays R2320 and R2235 are sequentially deenergized and remain in their restored positions so that a sustained on-hook supervisory signal is produced at the operator's switchboard in the manual office. The operator is thus signaled that the calling end of the connection may be released.

In order to clear out the connection the operator handling the call in the manual office withdraws the answer plug of her cord circuit from the jack terminating the trunk 30. In response to this operation the relay R2260 restores to complete the operating circuit for the relay R2270 and to open the operating circuit for the relay R2350. The operation of the relay R2270 is without effect. The relay R2350, in restoring, opens the locking circuit for the relay R2380. The relay R2380 now restores to interrupt the locking circuit for the relay R2330. At its contacts 2385, the relay R2380 further interrupts its own locking circuit. The relay R2330, in releasing, opens its contacts 2335 to interrupt the operating circuit for the relay R2360. At its contacts 2333, the relay R2330 interrupts the locking circuit for the relay R2210. At its contacts 2332, the relay R2330 interrupts the above-traced circuit for energizing the lower winding of the relay R2340. Thus the three relays R2210, R2340 and R2350 are caused to restore at which time the repeater 7 is fully released. At its contacts 2332, the relay R2330 also disconnects the test conductor 285*d* from ground, thereby to cause the release of the finder-connector link and the line circuit associated with the calling line, in the exact manner previously described.

Calls from the Manual Office 5

When the repeater 7 is seized over the trunk 30 from the operator's switchboard in the manual office 5, a calling loop circuit is established which includes the two windings of the line relay R2260, the contacts 2221, 2231, 2237, 2223, 2233 and 2239 and the repeater windings 2206 and 2207. In operating, the relay R2260 closes its contacts 2262 to complete the above-traced operating circuit for the relay R2350. At its contacts 2261, the relay R2260 prepares a loop to the line circuit 20. At its contacts 2263, the relay R2260 opens a point in the above-traced operating circuit for the relay R2270.

The relay R2350, in operating, closes its contacts 2352 to complete a path including the contacts 2362 for impressing ground potential upon the test conductor 285*d*, whereby the trunk 30 is marked busy in the trunk preselect relay group 1495. At its contacts 2353, the relay R2350 completes a circuit including the contacts 2366 for energizing the relay R2300. At its contacts 2354, the relay R2350 prepares the operating circuit for the relay R2270. The relay R2300, upon operating, closes its contacts 2307 to complete a circuit including the conductor C2284 for energizing the slow-to-operate relay R2250 and the lower winding of the electro-polarized relay R2245 in parallel. At its contacts 2308, the relay R2300 prepares a locking circuit for itself. At its contacts 2302 and 2304, the relay R2300 opens two points in the above-traced circuit for energizing the line relay R2320 in series with the impedance coil 2315. At its contacts 2301, 2303, 2305 and 2306, the relay R2300 completes a loop circuit which extends from the repeater 7 to the line circuit 20. More specifically, this circuit extends from ground by way of the upper winding of R150, the contacts 161, the conductor 285*b*, the contacts 2301, C2274, the winding 2208, C2275, the contacts 2303, C2279, the upper winding of R2245, the resistor 2265, C2280, the contacts 2305, C2276, the winding 2209, C2277, the contacts 2306, C2278, the contacts 2261, the conductor 285*a*, the contacts 162, and the lower winding of R150 to battery. The direction of current flow over this loop circuit is such that the electro-polarized relay R2245 does not operate, this relay being so constructed that it operates only when both of its windings are energized with current of aiding polarity. The slow-to-operate relay R2250, in operating, closes its contacts 2253 to prepare the operating circuit for the relay R2270. At its contacts 2254, the relay R2250 prepares the operating circuit for the relay R2240. At its contacts 2251, the relay R2250 completes the prepared locking circuit for the relay R2300 and in so doing impresses ground potential upon the control conductor 285*e*. This locking circuit extends from ground by way of the contacts 2353, C2286, the contacts 2241 and 2251, the conductor 285*e*, the contacts 2308 and the upper winding of R2300 to battery. At its contacts 2252, the relay R2250 closes a multiple path over

which ground potential is impressed upon the test conductor 285*d*, this path extending from ground by way of the contacts 2252, C2282 and the contacts 2362 to the test conductor 285*d*.

The line relay R150, of the line circuit 20, operates when energized in the above-traced loop circuit and initiates the operation of an assigned link to seize the repeater 7 in the manner previously explained. The finder portion of the assigned link, upon seizing the repeater 7, switches the local loop circuit through to the line relays of the link, in the manner explained above. Assuming that the link illustrated is assigned to the call, the upper or operating winding of the polarized relay R2245 is at this time energized in series with the two line relays R820 and R825. Incident to the seizure of the repeater 7, the cut-off and lockout relays R160 and R155 also operate to release the common equipment illustrated in Figs. 5 and 6 of the drawings. In operating, the relay R160 opens its contacts 161 and 162 to disconnect the windings of the line relay R150 from the conductors 285*a* and 285*b*. The relay R150, when thus deenergized, restores and closes its contacts 153 to connect the grounded control conductor 285*e* to the control conductor 285*c* of the line circuit.

In the event all of the links provided in the community exchange are busy at the time the call is extended over the trunk to the repeater 7, an all-links-busy signal is transmitted to the operator handling the call in the manual office 5. Under these circumstances the all-links-busy relay R670 occupies its operated position to prevent the assignment of a link to the use of the calling trunk 30. In this regard it will be noted that a busy tone signal is transmitted from the busy tone current source by way of the lead C1089, the condenser 167 and the contacts 162 to the calling trunk 30, immediately the above-described local loop circuit is completed. Normally, this signal is of such short duration that it may be disregarded by the operator, since the assigned link operates to seize the repeater 7 and cause the operation of the cut-off relay R160 almost instantly the local loop circuit is completed. The cut-off relay R160, in operating, opens its contacts 162 to interrupt the busy tone signaling circuit and thus terminate the busy signal. When an all-links-busy condition exists, however, no link is assigned to the use of the calling trunk 30 and, accordingly, the busy signal persists to inform the calling operator that no links are available in the distant community exchange If desired, the operator may wait for an idle link to become available, or may release the repeater 7 and the trunk 30, in the manner explained above.

Assuming that the call is extended to the connector portion of the illustrated link, the usual dial tone signal is transmitted to the calling operator in the manner previously explained. During the dialing operation the repeater 7 and, more particularly, the line relay R2260, functions to repeat the dialed impulses to the line relay R820 of the link. Thus each time the relay R2260 restores at the beginning of the open-circuit period of an impulse it opens its contacts 2261 to interrupt the loop circuit extending between the repeater 7 and the link. Each time the relay R2260 restores, it also opens its contacts 2262 to deenergize the relay R2350, and closes its contacts 2263 to complete the prepared operating circuit for the relay R2270. This circuit extends from ground by way of the contacts 2263 and 2253, C2290, the contacts 2354, C2291 and the winding of R2270 to battery. The relay R2270 is thus caused to operate at the beginning of each digit dialed at the position of the operator handling the call in the manual office 5 and, due to the slow-to-release characteristic thereof, remains operated until shortly after the digit is ended. The relay R2350, due to its slow-to-release characteristic, also remains operated throughout the dialing operation. The relay R2270, in operating, closes its contacts 2272 to complete a path including the resistor 2264 for excluding the repeating coil winding 2209 and the upper winding of the relay R2245 from the local loop circuit extending between the repeating coil 2205 and the repeating coil 834 of the link. This short-circuiting path is obviously opened at the contacts 2272 when the relay R2270 restores at the end of each digit dialed at the calling operator's position.

The manner in which the link illustrated responds to the impulses repeated thereto by the line relay R2260 to select the called line is exactly the same as described above with reference to the call originated at the substation A. Assuming that the call is routed to a line terminating at the community exchange, the line is tested to determine the idle or busy condition thereof and ringing current of the code designating the desired substation thereon is transmitted thereover, all in the manner described above, assuming that the called line is idle. When the call is answered at the called substation, the relay R800 operates to reverse the direction of current flow through the upper winding of the polarized relay R2245. The relay R2245 now operates and closes its contacts 2246 to complete an obvious circuit for energizing the battery reversing relay R2235. The relay R2235, in operating, reverses the direction of current flow over the trunk 30 so that an off-hook supervisory signal is produced at the position of the operator handling the call in the manual office 5.

After the desired talking circuit is set up in this manner, the operator handling the call in the manual office 5 may retire from the connection and rely upon the supervisory lamps associated therewith to indicate the condition of the connection. In this regard it is pointed out that if the called subscriber desires to recall the operator he may do so by flashing the switchhook provided at the called substation, to cause the intermittent release and reoperation of the three relays R800, R2245 and R2235. Thus a succession of battery reversals over the trunk 30 are produced which result in the production of a flashing recall signal by the supervisory lamp associated with the trunk 30 at the position of the operator handling the call in the manual office 5. Upon receiving this signal the operator may reenter the connection and ascertain the service desired by the called subscriber. When the called subscriber disconnects, the three relays R800, R2245 and R2235 are sequentially released, whereby a sustained on-hook supervisory signal is produced at the operator's position in the manual office 5. Upon receiving this signal the operator is informed that the called end of the connection may be released. To release the connection, the operator withdraws the calling plug of her cord circuit from the jack terminating the trunk in the manual office, thereby to interrupt the loop circuit extending through the windings of the line relay R2260. When thus deenergized the relay R2260 opens its contacts 2261 to interrupt the loop circuit extending to

the link, and opens its contacts 2262 to deenergize the relay R2350. At its contacts 2263, the relay R2260 recompletes the operating circuit for the relay R2270. The relay R2350, upon restoring, opens its contacts 2352 to interrupt one of the paths over which the test conductor 285d is connected to ground, and opens its contacts 2353 to interrupt the operating and locking circuits for the relay R2300. At its contacts 2353, the relay R2350 also disconnects the control conductor 285e from ground and opens the locking circuit for the relay R2300. At its contacts 2354, the relay R2350 interrupts the operating circuit for the relay R2270. Thus the two relays R2300 and R2270 are deenergized and restore. The relay R2300, upon restoring, opens its contacts 2307 to deenergize the relay R2250 and the lower winding of the relay R2245. Following the release of the two last-mentioned relays, the repeater 7 is fully restored to normal. When the control conductor 285e is disconnected from ground and the loop circuit extending from the repeater 7 to the illustrated link is interrupted by the line relay R2260, this link and the line circuit 20 are released in the manner previously explained.

FORCED RELEASE OF THE REPEATER 7

In the event a call is routed by way of the illustrated link, the repeater 7 and the trunk 30 to the operator's switchboard in the manual office 5, and the call is not answered within a reasonable time interval, the timing device 720b, operating in conjunction with the release relay R2390, functions automatically to release the repeater 7 and the link. In this regard, it will be recalled from the above explanation that when the repeater 7 is seized on a call incoming to the manual office 5, the delays R2320, R2330, R2360, R2210 and R2235 are operated after the ringing signal is transmitted over the trunk 30 and before the call is answered. The relay R2360, in operating, closes its contacts 2363 to impress ground potential upon the timer start lead C889, whereby operation of the timing device 720b is initiated. At its contacts 2364, the relay R2360 prepares the operating circuit for the release relay R2390. Assuming that the call is not answered in the manual office 5 within a reasonable time interval, the timing device 720b functions to transmit a ground pulse over the start timing lead C892. When this lead is connected to ground the relay R2390 is energized in a circuit including the contacts 2395, 2384, 2373, and 2364. In operating, the relay R2390 locks to ground over a path including the contacts 2364, 2373, 2384 and 2394 and closes its contacts 2391 to prepare a path for impressing ground potential upon the test conductor 285d. After this locking circuit is completed the relay R2390 opens its contacts 2395 to interrupt its operating circuit. At its contacts 2392, the relay R2390 completes an alternative path for impressing ground potential upon the test conductor 285d, this path extending by way of the normally grounded release lead C888, the contacts 2392, the lower winding of R2340 and the contacts 2332 to the conductor 285d. After this path is completed the relay R2390 disconnects the conductor 285d from ground at the contacts 2393.

A predetermined time interval after the relay R2390 operates, the timing device 720b functions to disconnect the release conductor C888 from ground and thus remove ground potential from the conductor 285d. When the test conductor 285d is disconnected from ground the illustrated link is caused to release in the manner previously explained, and the line circuit associated with the calling line assumes its lockout setting. This line circuit is restored to normal when the calling subscriber abandons the call. Incident to the release of the illustrated link the loop circuit extending between the connector portion of the link and the repeater 7 is opened, thereby to cause the deenergization and release of the relays R2320, R2330, R2360, R2390, R2235 and R2210. Following the release of these relays the repeater 7 is fully restored to normal.

It will be observed, from the above explanation, that if the call is answered at any time between the seizure of the link and the operation of the timing device 720b to disconnect the release lead C888 from ground, the relay R2390 is deenergized and restores to prevent the forcible release of the connection. More specifically, when the call is answered the relays R2350, R2370 and R2380 are caused sequentially to operate and the latter relay remains operated for the duration of the call. These relays, in operating, open their contacts 2373 and 2384, respectively, to interrupt the locking circuit for the relay R2390. When the relay R2390 restores, the test conductor 285d is again connected to ground at the contacts 2393. In releasing, the relay R2390 also closes its contacts 2395 to reprepare its operating circuit. It will also be understood from the above explanation that if the connection is cleared out at the position of the operator handling the call in the manual office 5, to cause the release of the two relays R2350 and R2380 in the manner previously explained, before the connection is released at the calling end thereof, the relay R2390 is again rendered operative forcibly to release the operated switch train. Thus, with the two relays R2370 and R2380 restored, the operating circuit for the relay R2390 is again reprepared. The manner in which this relay, as controlled by the timing device 720b, operates forcibly to release the repeater 7 and the illustrated link under the circumstances last assumed, will be clearly apparent from the above explanation.

If the conductors of the trunk 30 are short-circuited, or a permanent calling condition is otherwise created on this trunk, the relays R2260, R2350, R2300 and R2250 are caused to operate in the exact manner previously described. These relays, in operating, complete a loop circuit which extends from the repeater 7 to the line circuit 20, whereby an idle one of the links provided in the community exchange is seized and the loop circuit is extended to the connector portion thereof. Assuming that the illustrated link is seized, the relays R820, R830, R840, R850 and R860 are operated therein and the control conductor 285e is connected to the control conductor C233 over a path including the contacts 153', the conductor 285c, and the contacts 243, 223 and 275, following the operation of the finder portion of the link to seize the repeater 7. Incident to the operation of the relay R2250 the control conductor 285e is connected to ground over a path including the contacts 2251 and 2241, C2286, and the contacts 2353. This path, when extended to the control conductor C233, provides a locking circuit for the hold relay R860. It will be understood, therefore, that in the absence of some means for interrupting this ground path in the repeater 7, the two link-release relays R900 and R910 are rendered inoperative forcibly to release the link. It is for this reason that the re-

lay R2240 is provided in the repeater 7. With this arrangement, the timing device 720b is rendered operative forcibly to release the link and to lock the repeater 7 out of service.

More specifically, a timing operation is started in the manner previously explained when the link is seized. From this explanation, it will be recalled that the relay R910 operates to interrupt the operating and holding circuits for the relay R850 when a ground pulse is impressed upon the time pulse lead C874. The relay R850, in restoring, opens its contacts 852 to interrupt the operating circuit for the relay R860. Concurrently with this operation the relay R2240 is energized in a circuit including the grounded time pulse lead C874 and the contacts 2254. In operating, the relay R2240 opens its contacts 2241 to disconnect the connected control conductors 285e and C233 from ground in the repeater 7. Thus the relay R860 is deenergized and restores to initiate the release of the link in the manner previously explained. When the control conductor 285e is disconnected from ground the locking circuit for the relay R2300 is also opened, but this relay is held energized over its operating circuit as traced above. The removal of ground potential from the two connected control conductors 285e and C233 also results in the deenergization and release of the line relay R160. This relay, in restoring, closes its contacts 161 and 162 to energize the two windings of the line relay R150 in series with the upper winding of the polarized relay R2245. As indicated above, the direction of current flow over this loop circuit is such that the relay R2245 does not operate. The relay R150, however, operates and closes its contacts 152 to complete the locking circuit for the lockout relay R155. Thus the line circuit 20 assumes its lockout setting wherein the repeater 7 is locked out of service. In this regard, it will be noted that with the relay R2350 operated ground potential is impressed upon the test conductor 285d over a path including the contacts 2352 and 2362, thereby to mark the repeater 7 as busy in the trunk preselect relay group 1495.

When the ground pulse applied to the time pulse lead C874 ends, the relay R2240 is obviously deenergized and restores to again connect the control conductor 285e to ground. The duration of the pulse is, however, sufficient to permit the release of the link and the locking out of the repeater in the manner just explained. Any further operation of the relay R2240 under the control of the timing device 720b is without effect. When the fault present on the trunk 30 is repaired or the permanent calling condition present on this trunk is otherwise removed, the relays R2260, R2350, R2300 and R2250 are deenergized and restore, in a manner clearly apparent from the above explanation. Incident to the release of these relays the loop circuit extending between the repeater 7 and the line circuit 20 is opened to permit the deenergization and sequential release of the two relays R150 and R155. Thus the repeater 7 and the line circuit 20 are restored to normal.

Calls to the Manual Office 6

As indicated previously, the four trunks connecting the community exchange with the manual office 6 are of two types, i. e., toll and combination toll and free service, the two toll trunks being terminated at the contact sets 201 and 202 of each connector switch, and the combination trunks being terminated at the contacts 203, 204, 291 and 292 of each connector switch. These trunks are preselected for use through operation of the relay group 1700 illustrated in Figs. 17 and 17A of the drawings, in the manner more fully described hereinafter. In order to explain how such calls are handled, it may be assumed that the link illustrated and the repeater 8 associated with the combination toll and free service trunk 51 are utilized in extending a call from a restricted substation to the operator's switchboard in the manual office 6.

Toll call

The calling subscriber, upon initiating the toll call at the restricted substation, dials a single digit comprising ten impulses, whereby the connector portion of the link is caused to seize the repeater associated with the previously selected idle trunk, which in the case under consideration is assumed to be the repeater 8. Incident to the seizure of this repeater the calling loop circuit is extended from the calling substation to the repeating coil 2015, so that the line relay R2020 is energized and operates. More specifically, the calling loop circuit is extended to include the positive and negative conductors 203a and 203b, the upper winding of R1800, the repeating coil windings 2016 and 2017, the contacts 2032, 2034, 2026 and 2029, the winding of R2020, the winding of the balancing coil 2012, C1972, and the contacts 1912. The relay R1800 operates when energized in the calling loop circuit, and closes its preliminary make contacts 1804 to prepare a locking circuit for itself. At its contacts 1801, the relay R1800 completes an obvious path for short-circuiting its upper winding, thereby to render itself slow-to-release. At its contacts 1802, the relay R1800 opens a point in the operating circuit for the timing relay R1820. At its contacts 1803, the relay R1800 opens a point in the path traced hereinafter over which ground potential is impressed upon the start lead C889 extending to the timing device 720b. In operating, the relay R2020 closes its contacts 2021 to complete an obvious circuit for energizing the slow-acting hold relay R2000. At its contacts 2022, the relay R2020 prepares an operating circuit for the battery reversing relay R2120.

The hold relay R2000, upon operating, connects the test conductor 203c to ground over a path including the contacts 2002, C1975, the upper winding of R1970, C1979, the contacts 2039, C1845 and the contacts 1813. When this conductor is thus grounded, the relay R1970 is energized and locking circuits are completed for the operated switch-through and hold relays of the link, in the manner previously explained. Also, the application of ground potential to the conductor 203c serves to maintain the repeater 8 marked as busy in the trunk preselect relays. At its contacts 2003, the relay R2000 prepares a locking circuit for itself and completes a path including the conductor C1985 and the contacts 1909 for impressing ground potential upon the ringing apparatus start lead C1167. At its contacts 2005, the relay R2000 prepares a locking circuit for the relay R1820. At its contacts 2006, the relay R2000 prepares a locking circuit for the relay R1940. At its contacts 2007, the relay R2000 completes the operating circuits for the relays R1930 and R2160, and also completes the prepared locking circuit for the relay R1800. This locking circuit extends from ground by way of the contacts 2007, C1855, the contacts 1804 and

the lower winding of R1800 to battery. The circuit for energizing the relay R1930 extends from ground by way of the contacts 2007, C1855 and the winding of R1930 to battery. The circuit for energizing the relay R2160 extends from ground by way of the contacts 2007, C1855, the contacts 2156 and the winding of R2160 to battery.

The relay R1970 operates when its upper winding is energized in the above-traced path over which the test conductor 203c is connected to ground. In operating, this relay opens its contacts 1971 further to interrupt the prepared operating circuit for the relay R1940. The relay R1930, in operating, opens its contacts 1931 to interrupt another of the paths over which ground potential may be impressed upon the test conductor 203c. At its contacts 1932, the relay R1930 opens the prepared operating circuit for the relay R2030. At its contacts 1933, the relay R1930 prepares the operating circuit for the relays R1910 and R1920. At its contacts 1934, the relay R1930 prepares a locking circuit for the relay R2070. At its contacts 1935, the relay R1930 prepares the operating circuit for the release relay R1820. At its contacts 1936, the relay R1930 prepares a path for impressing ground potential upon the timer start lead C889. At its contacts 1937, the relay R1930 completes a path for transmitting ringing current over the calling end of the connection to produce the usual ringback tone signal at the calling substation. This path extends from the ungrounded terminal of the ringing current generator by way of the condenser 1918, the contacts 1937 and 1955, C1990 and the contacts 2073 to the negative line conductor 203b. From this point the ringing current is transmitted over the calling loop circuit, through the receiver provided at the calling substation and back over the positive side of the calling loop circuit to the opposite terminal of the ringing current generator. The resulting ringback tone signal produced by the receiver provided at the calling substation serves to inform the calling party that the manual office 6 is being signaled.

The slow-to-operate signal control relay R2160 operates, after an interval, and closes its contacts 2161 to complete an obvious circuit for energizing the slow-to-release relay R2140. The latter relay, in operating, closes its contacts 2145 to transmit ringing current through the lower winding of the relay R2150, over an obvious circuit. At its contacts 2146, the relay R2140 completes an obvious circuit for energizing the slow-to-release relay R2130. At its contacts 2142 and 2144, the relay R2140 prepares a path for transmitting ringing current over the trunk 51. At its contacts 2147, the relay R2140 completes the prepared operating circuit for the relay R2120, this circuit extending from ground by way of the contacts 2022, C2090, the contacts 2147 and the winding of R2120 to battery. The relay R2120, in operating, reverses the connections between the conductors of the trunk 51 and the terminals of the repeating coil 2015, thereby to condition the battery feed circuit to produce an off-hook supervisory signal at the operator's switchboard in the manual office 6 when the call is answered.

When its lower winding is traversed by ringing current, the relay R2150 locks to ground over a circuit which includes the contacts 2007, C1855, the contacts 2155 and the upper winding of R2150. After this locking circuit is completed, the relay R2150 opens its contacts 2156 to deenergize the relay R2160, and closes its contacts 2154 to complete an obvious multiple circuit for energizing the relay R2120. At its contacts 2151 and 2153, the relay R2150 completes the prepared path for transmitting ringing current over the trunk 51 to energize the drop associated with this trunk at the operator's switchboard in the manual office 6. More specifically, the circuit traversed by the ringing current extends from the ungrounded terminal of the ringing current generator by way of the contacts 2145, 2153 and 2144, the negative side of the trunk 51, the winding of the drop connected across the conductors of the trunk at the operator's switchboard in the manual office 6, the positive conductor of the trunk, the contacts 2142 and 2151, and the exchange battery to the opposite terminal of the ringing current generator. When thus energized, the drop associated with the trunk 51 in the manual office 6 operates to signal the operator that a call is present on the trunk 51 which should be answered.

The relay R2160, upon restoring, opens its contacts 2161 to deenergize the relay R2140. Shortly thereafter the relay R2140 restores and opens its contacts 2146 to deenergize the relay R2130. At its contacts 2142, 2144 and 2145, the relay R2140 opens three points in the above-traced path for transmitting ringing current over the trunk 51. At its contacts 2147, the relay R2140 opens the initially completed operating circuit for the relay R2120. At its contacts 2141 and 2143, the relay R2140 connects the conductors of the trunk 51 together over a low resistance path which includes the operated make contacts 2132 and 2134 of the relay R2130. When this path is completed the accumulated charge on the trunk 51 is dissipated, thus preventing premature operation of the line relay R2110 when the relay R2130 restores. Shortly following the release of the relay R2140, the relay R2130 releases and opens its contacts 2132 and 2134 to interrupt the discharge path just referred to. At its contacts 2131 and 2133, the relay R2130 reconnects the conductors of the trunk 51 to the line terminals of the repeating coil 2015.

When the call is answered at the operator's switchboard in the manual office 6, an answering loop circuit is established which extends from ground by way of the upper winding of R2110, the upper winding of R2170, C2084, the winding 2018, the contacts 2122, 2133 and 2143, the negative side of the trunk 51, the direct current bridge across the conductors of the trunk 51 at the operator's position in the manual office 6, the positive conductor of the trunk 51, the contacts 2141, 2131 and 2124, the repeating coil winding 2019, C2085, the lower winding of R2170 and the lower winding of R2110 to battery. The differentially wound relay R2170 does not operate when this circuit is completed. The relay R2110, in operating, closes its contacts 2112 to complete a circuit including the conductor C1974 for energizing the slow-acting relay R1960. At its contacts 2113, the relay R2110 opens a point in the operating circuit for the relay R2070. The relay R1960, upon operating, closes its contacts 1961 to complete an obvious circuit for energizing the relay R1950. At its contacts 1962, the relay R1960 prepares a locking circuit for the relay R1940. The relay R1950, in operating, closes its contacts 1951 to prepare an alternative path for impressing ground potential upon the test conductor 203c. At its contacts 1953, the relay

R1950 prepares the operating circuit for the relay R2070. At its contacts 1954, the relay R1950 prepares a locking circuit for the relay R1820. At its contacts 1955, the relay R1950 opens the above-traced path for transmitting ringing current over the calling end of the connection, whereby the ring-back tone signal being reproduced by the receiver at the calling substation is terminated. At its contacts 1956, the relay R1950 prepares various operating and locking circuits referred to with particularity hereinafter. At its contacts 1952, the relay R1950 completes a circuit including the contacts 1933 and 1904 for energizing the two relays R1910 and R1920 in parallel.

The relay R1910, in operating, closes its contacts 1911 to bridge the lower winding of the relay R1970 across the trunk conductors 203a and 203b in series with the condenser 1964. In this regard it will be recalled that if the call in progress was initiated at a substation of the paystation type, paystation tone signaling current is transmitted from the line circuit thereof over the test conductor 203c and through the upper winding of the relay R1970. The alternating character of this current causes an induced voltage to be developed in the lower winding of the relay R1970 which is impressed across the trunk conductor 203a and 203b over the bridging path just traced. This voltage causes a corresponding signal current to be transmitted over the trunk 51 and through the receiver of the telephone instrument in use by the operator handling the call in the manual office 6. The operator is thus informed that the call is a paystation call and may handle the same accordingly.

The relay R1910, in operating, also closes its contacts 1913 to complete a circuit including the conductor C1977, for energizing the slow-to-operate relay R2010. At its contacts 1912, the relay R1910 opens the calling loop circuit. At its contacts 1914, the relay R1910 completes an obvious locking circuit for the relay R2000. At its contacts 1915, the relay R1910 opens the prepared operating circuit for the relay R1820. At its contacts 1916, the relay R1910 prepares the operating circuit for the relay R1940. At its contacts 1917, the relay R1910 completes a path for impressing ground potential upon the tone start lead C895, whereby operation of the tone generating equipment is initiated. The relay R2010, upon operating, closes its contacts 2011 to recomplete the calling loop circuit and thus cause the reoperation of the line relay A2020. During the short interval when the relay R2020 is restored the operating circuit for the relay R2120 is opened and the latter relay restores to reverse the direction of current flow over the trunk 51. This momentary current reversal results in the flashing of the supervisory signal lamp associated with the trunk 51 at the operator's switchboard in the manual office 6.

The purpose of arranging the relays R1910 and R2010 so that the calling loop circuit is opened for a short interval when the call is answered in the manual office 6 is to permit the repeater 8 to be used in tandem with a preceding repeater of the character disclosed in Figs. 7 and 8 of Patent No. 2,214,213, granted September 10,1940, to John H. Voss. As explained in this patent, the latter repeater requires a momentary interruption in the answering loop circuit extending thereto in order to repeat a paystation signal over the answering loop circuit. The two relays R1910 and R2010, operating in the manner just explained, constitute facilities for meeting this requirement.

The relay R1920 is of the well-known pendulum type, this relay being equipped with a weighted contact spring 1922 which is set in vibration when the relay R1920 is energized to attract its armature 1921. During the vibration of this contact spring the armature 1921 is only intermittently engaged thereby and, accordingly, the slow-to-operate relay R1900 is insufficiently energized to operate. After a predetermined time interval, vibration of the contact spring 1922 is arrested and this spring settles into resting engagement with the armature 1921, thereby to sustain the energization of the relay R1900. The latter relay operates after an interval and locks up in a circuit which includes the contacts 1903, 1933 and 1952. At its contacts 1901, the relay R1900 completes an obvious path for short-circuiting the upper winding of the relay R1970, whereby this winding is excluded from the path traversed by the paystation tone signal current and the paystation identification signal is terminated. At its contacts 1904, the relay R1900 interrupts the operating circuit for the two relays R1910 and R1920. At its contacts 1905, the relay R1900 opens a point in the prepared locking circuit for the relay R2070. At its contacts 1906, the relay R1900 prepares a locking circuit for the relay R2040. At its contacts 1907, the relay R1900 prepares the operating circuit for the relay R2070. At its contacts 1909, the relay R1900 disconnects the ringing apparatus start lead C1167 from ground. At its contacts 1908, the relay R1900 completes an alternative locking circuit for the relay R2000, this circuit extending from ground by way of the contacts 2003, C1985, the contacts 1908, C1984 and the winding of R2000 to battery. At its contacts 1903', the relay R1900 opens another point in the operating circuit for the relay R1940. At its contacts 1904', the relay R1900 disconnects the tone start lead C895 from ground. At its remaining contacts the relay R1900 performs additional circuit control operations referred to with particularity hereinafter.

The relay R1910, upon restoring, opens its contacts 1911 to interrupt the paystation tone signaling current, and closes its contacts 1912 to recomplete the initially traced calling loop circuit. At its contacts 1913, the relay R1910 interrupts the operating circuit for the relay R2010, causing the latter relay to restore. At its contacts 1914, the relay R1910 opens one of the multiple locking circuits for the relay R2000. At its contacts 1916, the relay R1910 opens another point in the operating circuit for the relay R1940. At its contacts 1917, the relay R1910 opens another point in the path for impressing ground potential upon the tone start lead C895. When the relay R1920 restores, its armature 1921 and the weighted contact spring 1922 are disengaged to interrupt the above-traced operating circuit for the relay R1900. The release of the relay R2010 is without effect.

In the event the answering operator wishes to recall the paystation identification signal, she may do so by momentarily withdrawing the answer plug of her cord circuit from the jack terminating the trunk 51 at the operator's switchboard in the manual office 6. In response to this operation the answering loop circuit is interrupted to cause the deenergization and release of the relay R2110. This relay, in restoring, opens its contacts 2112 to deenergize the relay R1960,

and closes its contacts 2113 to complete the prepared operating circuit for the relay R2070. This circuit extends from ground by way of the contacts 2113, C1983, the contacts 1907 and 1953, C1981 and the winding of R2070 to battery. In operating, the relay R2070 closes its contacts 2071 to prepare a locking circuit for itself and opens its contacts 2073 further to interrupt the above-traced path for transmitting ringing current over the calling end of the connection. Thus the ring-back tone signaling circuit is interrupted to prevent a false signal from being transmitted to the calling substation. The relay R1960, in restoring, opens the operating circuit for the relay R1950. The relay R1950 now restores to interrupt the locking circuit for the relay R1900. The relay R1900 now restores and completes the prepared locking circuit for the relay R2070. This circuit extends by way of the contacts 1905 and 1934, C1980, the contacts 2071 and the winding of R2070 to battery. At its contacts 1904, the relay R1900 reprepares the operating circuit for the two relays R1910 and R1920. At its contacts 1901, the relay R1900 again includes the upper winding of the relay R1970 in the path traversed by the paystation tone signaling current. At its contacts 1904', the relay R1900 again prepares the path for impressing ground potential upon the tone apparatus start lead C895. When the answer plug of the operator's cord circuit in use at the operator's switchboard in the manual office 6 is again inserted in the jack terminating the trunk 51, the relays R2110, R1960, R1950, R1910, R1920 and R1900 are caused sequentially to operate in the order named and in a manner clearly apparent from the preceding explanation. These relays, in reoperating, transmit a splash of paystation tone signal current over the trunk 51, in the exact manner described above, whereby the operator is informed that the calling substation is of the paystation type. The relays R2110 and R1900, in reoperating, open the operating and locking circuits for the relay R2070, whereby the latter relay is deenergized and restores.

After the call is extended to the answering operator's position in the manual office 6, it may be forwarded to the desired substation in the manner conventionally followed in manual office practice. After the desired talking circuit between the calling and called substations is fully completed, the answering operator in the manual office 6 may retire from the connection and rely upon the supervisory signal lamps associated therewith for supervision of the call. In this regard it is pointed out that if the calling party desires to recall the answering operator in the manual office 6, he may do so by flashing the switchhook provided at the calling substation, thereby momentarily to interrupt the calling loop circuit one or more times. The line relay R2020 follows the switchhook operations by restoring each time the calling loop circuit is interrupted, and reoperating each time this loop circuit is recompleted. This relay directly controls the battery reversing relay R2120 and, accordingly, the latter relay also follows the switch operations. Each time the relay R2120 restores it functions to reverse the direction of current flow over the answering loop circuit extending by way of the trunk 51, so that an on-hook supervisory signal is produced at the position of the answering operator in the manual office 6. Conversely, each time the supervisory relay R2120 reoperates, an off-hook supervisory signal is produced at the operator's position. The flashing of the signal lamp provided to produce these signals serves to inform the answering operator that she is being recalled from the calling end of the connection set up by way of the trunk 51. Upon receiving this signal the operator may reenter the connection and ascertain the service desired by the calling subscriber.

From the above explanation, it will be apparent that when the calling party disconnects, the two relays R2020 and R2120 restore to produce an uninterrupted on-hook supervisory signal at the position of the answering operator in the manual office 6 to the sustained deenergization of the two relays R2020 and R2120. In order to release the calling end of the connection the operator withdraws the answer plug of her cord circuit from the jack terminating the trunk 51 at the operator's switchboard, thereby to cause the sequential release of the relays R2110, R1960 and R1950, in a manner clearly apparent from the preceding explanation. The relay R1950, in releasing, closes its contacts 1955 to prepare the above-traced ring-back tone signaling circuit, and opens its contacts 1952 to interrupt the locking circuit for the relay R1900. The relay R1900 now restores and opens its contacts 1908 to interrupt the established locking circuit for the slow-acting hold relay R2000. The relay R2000, upon restoring, opens its contacts 2002 to disconnect the test conductor 203c from ground and thereby identify the trunk 51 as idle in the trunk preselect relays 1700. At its contacts 2007, the relay R2000 disconnects the conductor C1855 from ground, thereby to cause the deenergization and release of the three relays R1800, R1930 and R2150. Following the release of the three last-mentioned relays the repeater 8 is fully restored to normal and is available for use in setting up another connection. When the test conductor 203c is disconnected from ground, the illustrated link and the line circuit individual to the calling line are restored to normal in the manner previously described.

Supervision between the offices 5 and 6

The manner in which the repeaters 7 and 8 operate when utilized in a tandem connection routed from the manual office through the community exchange to the manual office 6, is substantially similar to the mode of operation of these two switching units as described above. In this regard it will be recalled from the preceding explanation that when the trunk 30 is seized from the operator's switchboard in the manual office 5, and switch-directing impulses are transmitted thereover to select the desired line terminating at the community exchange, the relays R2260, R2250, R2300 and R2350 are operated in the repeater 7 at the end of the dialing operation. When the call is extended to the repeater 8 through one of the links provided in the community exchange, such, for example, as the link illustrated, a loop circuit is established between the two repeaters which includes the operating winding of the polarized relay R2245 and the winding of the line relay R2020. The direction of current flow over this loop circuit is such that the electro-polarized relay R2245 does not operate. Accordingly, an off-hook supervisory signal is not produced at the position of the operator handling the call in the manual office 5 incident to the extension of the connection to the repeater 8. Moreover, when the connection is extended to this repeater the two test conductors

285e and 203c, individual to the calling and called trunks, respectively, are connected together through the link over a path which extends from the conductor 285e by way of the break contacts 153' of the restored line relay R150, the control conductor 285c, the contacts 243, 223 and 275, C233, the contacts 1134 and 1125, C1084, the contacts 1047, C886, the contacts 816, C885, the contacts 1123, C1083, the contacts 1046, C1082, the contacts 1132, C1162 and the contacts of the operated group and unit relays in the connector portion of the link to the test conductor 203c. It will be understood that so long as ground potential is impressed upon this path by relays in either of the two repeaters 7 and 8, the two repeaters and the link are prevented from releasing. This permits inter-office supervisory signaling between the two offices 5 and 6 in either direction without a release of the connection.

In this regard it will be noted that when the connection is initially extended to the repeater 8, ground potential is impressed upon the conductor 285e in the repeater 7 over a path which includes the contacts 2251 and 2241, C2286 and the contacts 2353. The other test conductor 203c is connected to ground in the repeater 8 over a path which extends through the contacts 2002, C1975, the upper winding of R1970, C1979, the contacts 2039, C1845 and the contacts 1813. Thus the upper winding of the relay R1970 is short-circuited and this relay remains in its restored position for the duration of the call. Accordingly, when the call is answered at the operator's switchboard in the manual office 6 to cause the sequential operation of the relays R2110, R1960, R1950, R1910, R1920 and R1900, in the manner explained above, a circuit is completed for energizing the relay R1940. This circuit extends from ground by way of the contacts 1971, 1916 and 1903', and the winding of R1940 to battery, and is completed during the interval which elapses between the operation of the relay R1910 and the operation of the slow-to-operate relay R1900.

In operating, the relay R1940 locks to ground over two paths, one of which includes the contacts 1941 and 1962, and the other of which includes the contacts 1941, C1987 and the contacts 2006. At its contacts 1942, the relay R1940 completes the operating circuit for the battery reversing relay R2025, this circuit extending from ground by way of the contacts 1956 and 1942, C1989 and the winding of R2025 to battery. The relay R2025, in operating, closes its contacts 2027 and 2028 and then opens its contacts 2026 and 2029, thereby to reverse the direction of current flow over the loop circuit extending between the two repeaters 7 and 8. In response to this current reversal the polarized relay R2245, included in the repeater 7, operates to complete the operating circuit for the battery reversing relay R2235. The relay R2235, in operating, reverses the direction of current flow over the loop circuit extending between the manual office 5 and the repeater 7, whereby an off-hook supervisory signal is produced at the position of the calling operator in this office.

After a connection, including the two repeaters 7 and 8 is thus set up between the manual offices 5 and 6, if the calling operator in the office 5 desires to signal the answering operator in the manual office 6, she may do so by momentarily opening the loop circuit extending from the manual office 5 to the repeater 7, thereby to cause the momentary release of the relay R2260. This relay, in releasing, opens its contacts 2261 to interrupt the established loop circuit extending between the two repeaters 7 and 8. In releasing, the relay R2260 also opens its contacts 2262 to deenergize the relay R2350, and closes its contacts 2263 to complete the operating circuit for the relay R2270. The relay R2270, in operating, opens its contacts 2271 to interrupt the above-traced ring-back tone signaling circuit. Otherwise the momentary operation of the relay R2270 is without effect. The relay R2350 may or may not release during the period when the relay R2260 is restored. If this relay does release, it opens its contacts 2353 to disconnect the control or test conductor 285e from ground in the repeater 7 and thus interrupts one of the multiple locking circuits for the relay R2300. At this time, however, the connected control or test conductors 285e and 203c are connected to ground in the repeater 8 over a path which extends by way of the contacts 1901, C1979, the contacts 2039, C1845 and the contacts 1813. Accordingly, the two relays R2300 and R2250 and the illustrated link are prevented from releasing. It will be understood that when the loop circuit extending between the manual office 5 and the repeater 7 is recompleted, the relay R2260 reoperates to again complete the loop circuit between the two repeaters 7 and 8, to recomplete the operating circuit for the relay R2350, and to deenergize the relay R2270.

During the interval when the loop circuit extending between the two repeaters 7 and 8 is open, the relay R2020 restores and opens its contacts 2022 to deenergize the battery reversing relay R2120. At its contacts 2021, the relay R2020 opens the operating circuit for the hold relay R2000, but the latter relay is now held energized over its locking circuit as traced above. The relay R2120, in releasing, reverses the direction of current flow over the loop circuit extending between the repeater 8 and the manual office 6, whereby an on-hook supervisory signal is produced at the position of the answering operator in this office. Obviously, when the loop circuit extending between the two repeaters 7 and 8 is recompleted, the relays R2020 and R2120 sequentially reoperate in the order named, so that an off-hook supervisory signal is again produced at the position of the answering operator in the manual office 6. From the above explanation it will be apparent that if the loop circuit extending from the manual office 5 to the repeater 7 is repeatedly opened and closed, the supervisory lamp associated with the trunk 51 in the manual office 6 is intermittently energized to produce a flashing recall signal. This signal serves to inform the answering operator handling the call in the manual office 6 that she is being recalled from the position of the calling operator in the manual office 5. It will also be understood that if the connection is cleared out at the position of the calling operator in the manual office 5 prior to the release thereof in the manual office 6, the relays R2260, R2350, R2020 and R2120 will all restore, whereby the supervisory lamp associated with the trunk 51 in the manual office 6 is controlled to produce a continuous on-hook supervisory signal. This signal indicates to the answering operator that the connection may be released.

When the connection is cleared out at the manual office 6 following the release thereof in the manual office 5, the relays R2110, R1960, R1950 and R1900 are caused sequentially to re-

store in the order named and in the manner explained above. The relay R1900, in restoring, opens its contacts 1908 to interrupt the locking circuit for the relay R2000. When the relay R2000 restores it opens its contacts 2002 to interrupt the path over which ground potential is impressed upon the two connected test or control conductors 285e and 203c. At its contacts 2006, the relay R2000 interrupts the locking circuit for the trunk call supervisory relay R1940. At its contacts 2007, the relay R2000 disconnects the lead C1855 from ground, thereby to cause the deenergization and release of the relays R1800, R1930 and R2150. Following the release of the four relays R1800, R1930, R1940 and R2150, the repeater 8 is fully restored to normal. When the conductors 285e and 203c are disconnected from ground, the illustrated link and the line circuit 20 are restored to normal in a manner clearly apparent from the preceding explanation. The relay R2300 is also deenergized and restores when ground potential is removed from the conductor 285e. This relay, in releasing, opens its contacts 2307 to deenergize the relay R2250 and the lower winding of the relay R2245. Following the release of the relay R2250 the repeater 7 is fully restored to normal.

After the above-described connection including the repeaters 7 and 8 is set up between the manual offices 5 and 6, the answering operator in the manual office 6 may resignal the calling operator in the manual office 5 by opening and then reclosing the calling loop circuit extending from the last-mentioned office to the repeater 8. When this loop circuit is interrupted, the relay R2110 restores to cause the sequential release of the two relays R1960 and R1950 in the manner previously explained. At its contacts 2113, the relay R2110 recompletes the previously traced operating circuit for the relay R2070. The relay R2070 operates and opens its contacts 2073 to interrupt the previously traced ring-back tone signaling circuit. The relay R1950, upon restoring, opens its contacts 1956 to interrupt the above-traced operating circuit for the battery reversing relay R2025. The relay R2025 now restores and reverses the direction of current flow over the loop circuit extending between the repeaters 7 and 8. In response to this current reversal, the polarized relay R2245 restores and opens its contacts 2246 to cause the deenergization and release of the relay R2235. The latter relay, upon restoring, reverses the direction of current flow over the loop circuit extending from the repeater 7 to the manual office 5, whereby an on-hook supervisory signal is produced at the position of the calling operator. When the loop circuit extending between the manual office 6 and the repeater 8 is recompleted, the relays R2110, R1960, R1950, R2025, R2245 and R2235 are caused sequentially to reoperate in the order named, whereby an off-hook supervisory signal is produced at the position of the calling operator. It will be understood from the above explanation that if the loop circuit extending between the manual office 6 and the repeater 8 is repeatedly opened and closed, the relays R2110, R1960, R1950, R2025, R2245 and R2235 cooperate to produce a flashing recall signal at the position of the calling operator in the manual office 5. This operator is thus informed that she is being recalled by the operator handling the call in the manual office 6. It will also be understood that if the answering operator in the manual office 6 disconnects, the enumerated relays are all deenergized and remain in their restored positions so that a continuous on-hook supervisory signal is produced at the position of the calling operator to indicate that the connection may be released. In this regard, it is pointed out that during all of the supervisory signaling operations under consideration the relays R2020, R2000, R1930, R1800, R2120 and R2150 are held operated in the repeater 8. With these relays operated, the connection cannot be released under the control of the answering operator in the manual office 6. When, however, the connection is cleared out at the position of the calling operator in the manual office 5, the relay R2260 restores to interrupt the loop circuit extending between the repeaters 7 and 8 and to cause the release of the relays R2350, R2300 and R2250. The two relays R2350 and R2250, upon restoring, disconnect the connected conductors 285e and 203c from ground in the repeater 7. When the loop circuit extending between the repeaters 7 and 8 is opened, the relays R2020 and R2000 are deenergized and restored. The relay R2000, in restoring, interrupts the locking circuits for the relays R1800, R1930, R1940 and R2150. The relay R2020, upon restoring, interrupts the operating circuit for the relay R2120. Following the release of these relays the repeater 8 is fully restored to normal. Incident to the release of the relay R2000 the connected conductors 285e and 203c are disconnected from ground, thereby to cause the deenergization and release of the two relays R2300 and R2250 and the release of the illustrated link. Thus the connection is fully released.

Free service calls to the manual office 6

Briefly to consider the manner in which a free service trunk call to the manual office 6 is handled, it may be assumed that a call of this character is initiated on the subscriber's line 286, for example, and that the link illustrated is assigned to the use of the call. In this case the group relay R520 and the unit relay R560, together with the auxiliary group relay R530, are energized in the common equipment when the call is initiated. The two relays R530 and R650, upon operating, complete a path including the contacts 562 and 533 for impressing ground potential upon the restricted service lead C584. Thereafter, and when the relays R280 and R290 of the link operate, a circuit is completed for energizing the restricted service relay R1485, this circuit extending by way of the grounded lead C584, the contacts 299, C896 and the winding of R1485 to battery. The relay R1485, upon operating, closes its contacts 1486 to prepare a locking circuit for itself, this circuit including the release conductor C893 and being completed when the hold relay R860 subsequently operates to connect this lead to ground. At its contacts 1487, the relay R1485 opens a point in the operating circuit for the relay R1480. At its contacts 1488, the relay R1485 prepares the operating circuit for the ninth connector group relay R1490.

Following the seizure of the link, in the manner just explained, and when the single trunk digit comprising nine impulses is dialed at the calling substation, the impulse counting chain responds in the manner previously described. At the end of the digit the ninth counting relay R1320 is locked energized in series with its associated control relay R750. When the relays R1100, R1150 and R1160 restore shortly following the end of the digit, the prepared operating circuit for the connector group relay R1490 is

completed. This operating circuit extends by way of the grounded release conductor C893, the contacts 753, C786, the contacts 1101, 1117, 1128 and 1104, C1221, the contacts 1321, C1362', the contacts 1488, C1328', and the winding of R1490 to battery. Upon operating, the relay R1490 connects the conductors of the ten associated trunks to the ten link lines of the connector switch and completes, at its contacts 1492, a path including the conductors C1164 and the grounded release conductor C893 for short-circuiting the winding of the transfer relay R1110. At its contacts 1493, the relay R1490 prepares one of the previously traced operating circuits for the counting chain release relay R870 but this circuit is now open at the restored contacts 1126' of the transfer relay R1120. At its contacts 1491, the relay R1490 completes a circuit for energizing the connector unit relay which corresponds to the trunk preselected for use by the trunk preselect relays illustrated in Figs. 17 and 17A of the drawings. Thus, if the trunk 51 is idle the first connector unit relay R1450 is energized when the relay R1490 operates. The circuit for energizing this unit relay extends by way of the grounded release conductor C893, the contacts 753, C786, the contacts 1101 and 1125', C1085, the contacts 1321', C1351', the contacts 1491, C1797, the contacts 1771, C1247', and the winding of R1450 to battery. In operating, the relay R1450 closes its upper make contacts to connect the repeater 8 to the link line conductors C1162, C849 and C847. At its contacts 1451, the relay R1450 locks to the grounded release conductor C893 over a path including the conductor C1163, and in so doing short-circuits the transfer relay R1130. At its contacts 1451, the relay R1450 completes the previously traced circuit for energizing the counting chain release relay R870. During the resulting release of the counting chain the paths short-circuiting the transfer relays R1110 and R1130 are opened at the contacts 753, 1321 and 1331', permitting these two transfer relays to be energized in series with the connector group and unit relays R1490 and R1450, respectively. The relay R1130, upon operating, deenergizes the counting chain release relay R870 and initiates the switching-through operation of the link, all in the manner described previously with reference to the call routed to the manual office 5.

Restricted service

From the above explanation it will be apparent that the selection of one of the two available free service trunks depends upon the operation of the relay R1485. It will also be apparent that if a call is initiated at a restricted substation, ground potential is not impressed upon the restricted service lead C584 and, accordingly, the relay R1485 is not energized incident to the seizure of the link. With this relay restored, if a calling subscriber dials the single digit 9, designating the free service trunk group, the ninth counting relay R1320 is locked energized in series with its associated control relay R750 at the end of the digit. When the three relays R1100, R1150 and R1160 restore shortly following the end of the digit a circuit is completed for energizing the restricted service relay R1480, this circuit extending by way of the grounded release conductor C893, the contacts 753, C786, the contacts 1101, 1117, 1128 and 1104, C1221, the contacts 1321, C1362', the contacts 1487, and the winding of R1480 to battery. The relay R1480, in operating, locks to ground over a path including the contacts 1483, C1164, the winding of the transfer relay R1110, and the grounded release conductor C893. When this path is completed the transfer relay R1110 is short-circuited thereover. At its contacts 1482, the relay R1480 completes the prepared operating circuit for the busy test relay R1040, this circuit extending by way of the grounded release conductor C893, the contacts 1482, C1162, the contacts 1131, C1076 and the lower winding of R1040 to battery. At its contacts 1481, the relay R1480 completes an alternative circuit for energizing the counting chain release relay R870, this circuit extending by way of the grounded release conductor C893, the contacts 1481, C1165, the contacts 1135, C887, and the winding of R870 to battery. The relay R870, in operating, initiates the release of the counting chain in the manner described above. During the release of this chain, and when the relay R1320 restores, the contacts 1321 are opened to interrupt the path short-circuiting the transfer relay R1110, permitting this relay to be energized in series with the restricted service relay R1480. In operating, the relay R1110 opens its contacts 1113 to interrupt the previously traced circuit over which pulses are transmitted to the counting chain, and opens its contacts 1114 to interrupt the prepared locking circuit for the relay R1140.

The relay R1040, upon operating, locks to the grounded release conductor C893 and closes its contacts 1042 to complete the previously traced circuit for transmitting a busy tone signal over the calling end of the connection. This signal informs the calling party that the desired connection cannot be obtained. When the connection is released at this substation the illustrated link and the line circuit associated with the calling line are restored to normal, in the exact manner described above, it being pointed out in this regard that the restricted service relay R1480 is deenergized and restores when the release conductor C893 is disconnected from ground.

Conversation timing on free service calls

When the repeater 8 is seized through the first set of line contacts of the ninth group relay R1490 in the connector portion of the illustrated link from a substation entitled to free service calls, the relay R1800 is not energized in the loop circuit which is set up between this repeater and the calling substation. Accordingly, this relay remains in its restored position for the duration of the call. Aside from this difference in the position occupied by the relay R1800 and the manner in which the conversation is timed under the control of the timing device 720b, the call is handled in the exact manner described above with reference to the seizure of the repeater 8 through the outlet contacts of the tenth group relay R1400.

Incident to the seizure of the link, the relay R1930 operates to complete a path for impressing ground potential upon the timer start lead C889, this path extending from ground by way of the contacts 1936, C1988, the contacts 2054, C1853 and the contacts 1803 to the lead C889. When this lead is connected to ground, operation of the timing device 720b is initiated. At its contacts 1935, the relay R1930 prepares a circuit for energizing the relay R1820 when the timing device operates to transmit a ground pulse over the start timing lead C892. This circuit extends by way of the grounded lead C892, the contacts 1802, C1851, the contacts 1915 and 1935, C1850, the

contacts 1817 and the upper winding of R1820 to battery.

In operating, the relay R1820 locks to ground in a circuit which includes its lower winding, the contacts 1825, C1847, the contacts 2053, C1848, the contacts 1816, C1849 and the contacts 2005. At its contacts 1821, the relay R1820 prepares the operating circuit for the relay R1810. At its contacts 1822, the relay R1820 prepares an alternative path for impressing ground potential upon the test conductor 203c. At its contacts 1824, the relay opens a point in the operating circuit for the relay R1840.

It will be recalled from the previous explanation that after the call is answered in the manual office 6, the relay R1900 operates and is locked up in a circuit which includes the contacts 1952, 1933 and 1903. With this relay operated, a locking circuit for the relay R1810 is prepared at the contacts 1902. A predetermined time interval following the operation of the relay R1820, a ground pulse is transmitted by the timing device 720b over the time pulse lead C874, thereby to energize the lower winding of the relay R1810. This relay in operating locks up in the above-mentioned locking circuit which includes the contacts 1811, C1844 and the contacts 1902. At its contacts 1812, the relay R1810 completes an alternative path for impressing ground potential upon the test conductor 203c, this path extending from ground at the contacts 1906 by way of C1846, the contacts 1822 and 1812, C1845, the contacts 2039, C1979, and the contacts 1901 to the conductor 203c. After this path is completed the relay R1810 opens its contacts 1813 to disconnect the conductor 203c from ground at the contacts 1813. At its contacts 1814, the relay R1810 prepares the operating circuit for the relay R1840. At its contacts 1815, the relay R1810 completes an alternative locking circuit for the relay R1820, this circuit extending by way of the normally grounded time pulse lead C875 by way of the contacts 1815, C1848, the contacts 2053, C1847, the contacts 1825, and the lower winding of R1820 to battery. After this circuit is completed the relay R1810 opens its contacts 1816 to interrupt the initially completed locking circuit for the relay R1820. By virtue of this transfer operation, the release of the relay R1820 is placed under the control of the timing device 720b. At its contacts 1817, the relay R1810 opens the previously traced operating circuit for the relay R1820.

A predetermined time interval following the operation of the relay R1810 the timing device 720b functions to disconnect the lead C875 from ground and thus deenergize the relay R1820. In restoring, the relay R1820 opens its contacts 1825 further to interrupt the common portion of its two locking circuits as traced above. At its contacts 1821, the relay R1820 opens the operating circuit for the relay R1810. At its contacts 1823, the relay R1820 connects the test conductor 203c to ground over a path which includes the grounded release lead C888, the contacts 1823 and 1812, C1845, the contacts 2039, C1979, and the contacts 1901. After this path is completed the relay R1820 opens its contacts 1822 to disconnect the test conductor 203c from ground at the contacts 1906. At its contacts 1824, the relay R1820 further prepares the operating circuit for the relay R1840.

Shortly following the release of the relay R1820 the timing device 720b functions to transmit a ground pulse over the warning tone pulse lead C892', thereby to energize the relay R1840 in a circuit which includes this lead and the contacts 1814 and 1824. The relay R1840, in operating, closes its contacts 1841 to connect the tone start lead C895 to ground. At its contacts 1842, the relay R1840 completes a path for impressing dial tone voltage on the established talking circuit extending between the calling and called substations. This path may be traced as extending from the ungrounded terminal of the dial tone generator 435 by way of C1168, the contacts 1842, the condenser 1829, and C1856 to the negative side of the loop circuit extending between the repeater 8 and the manual office 6. The current traversing this path divides between the two ends of the connection and is transmitted through the receivers which are in use at the calling and called substations, respectively. The reproduction of this current by the two receivers serves to inform the calling and called subscribers that the connection will shortly be released automatically. If both subscribers, upon receiving this signal, immediately disconnect and the connection is immediately cleared out at the position of the operator handling the call in the manual office 6, the repeater 8, the link illustrated and the line circuit associated with the calling line are all released in the manner previously described.

If, on the other hand, the parties continue to converse over the connection for a substantial period, the timing device 720b operates to disconnect the release lead C888 from ground, thereby to interrupt the only available path over which ground potential is impressed upon the test conductor 203c. When this conductor is thus disconnected from ground the illustrated link is released in the manner previously explained. Moreover, since a calling condition is still present on the calling subscriber's line, the line circuit associated with this line assumes its lockout setting. This line circuit is only released when the call is abandoned at the calling substation.

Incident to the release of the illustrated link, the loop circuit extending from the connector portion of this link through the repeater 8 is opened, thereby to cause the deenergization and release of the relay R2020. The relay R2020, upon restoring, opens its contacts 2021 to interrupt the operating circuit for the hold relay R2000, but the latter relay is held energized over its locking circuit as traced above. At its contacts 2022, the relay R2020 opens the circuit for energizing the battery reversing relay R2120. When the latter relay restores an on-hook supervisory signal is produced at the position of the operator handling the call in the manual office 6. Upon observing this signal, the operator may release the connection by withdrawing the answer plug of her cord circuit from the jack terminating the trunk 51 in the manual office 6, thereby to cause the deenergization and sequential release of the relays R2110, R1960, R1950, R1900, R1810, R2000, R1930 and R2150, in a manner clearly apparent from the preceding explanation. Following the release of the enumerated relays, the repeater 8 is fully restored to normal and is marked as idle in the trunk preselect relays 1700.

Calls from the Manual Office 6

When the repeater 8 is seized over the trunk 51 from the operator's switchboard in the manual office 6, a calling loop circuit is established which includes the two windings of the differentially wound relay R2170, the two windings of the line relay R2110, the repeating coil windings 2018

and 2019, and the contacts 2121, 2123, 2131, 2133, 2141 and 2143. The relay R2170 is differentially wound so that it does not operate when its two windings are energized in this circuit. The relay R2110, in operating, closes its contacts 2111 to prepare a loop circuit which, when completed, extends from the repeater 8 to the associated line circuit. At its contacts 2112, the relay R2110 completes the operating circuit for the relay R1960, whereby the two relays R1960 and R1950 are caused sequentially to operate, in the manner previously explained. At its contacts 2113, the relay R2110 opens a point in the previously traced operating circuit for the relay R2070.

The relay R1950, upon operating, closes its contacts 1951 to complete a path including the contacts 1931 for impressing ground potential upon the test conductor 203c. The trunk 51 is thus marked as busy in the preselect relays 1700. At its contacts 1952, the relay R1950 completes the prepared operating circuit for the relay R2030, this circuit extending from ground by way of the contacts 1952 and 1932, C1976, and the upper winding of R2030 to battery. At its contacts 1956, the relay R1950 prepares a locking circuit for the relay R2030 and the previously traced operating circuit for the battery reversing relay R2025. The switching relay R2030, upon operating, closes its contacts 2037 further to prepare the above-mentioned locking circuit for itself, and opens its contacts 2039 further to interrupt the previously traced path for impressing ground potential upon the test conductor 203c. At its contacts 2038, the relay R2030 completes a circuit for energizing the slow-to-operate relay R2040, this circuit extending from ground by way of the contacts 1813, C1845, the contacts 2038 and the winding of R2040 to battery. At its contacts 2031', the relay R2030 prepares an alternative operating circuit for the relay R2070. At its contacts 2032', the relay R2030 prepares one of the operating circuits for the release relay R1820. At its contacts 2033', the relay R2030 prepares the operating and locking circuits for the relay R2100. At its contacts 2034', the relay R2030 completes a path including the contacts 2054, C1853 and the contacts 1803 for impressing ground potential upon the timer start lead C889, thereby to initiate the operation of the timing device 720b in the event this device is not already operating. At its contacts 2035', the relay R2030 completes an obvious circuit for energizing the lower or polarizing winding of the electro-polarized relay R2080. This relay is so constructed that it only operates when both of its windings are energized by current of the same polarity. At its contacts 2032 and 2034, the relay R2030 opens two points in the previously traced circuit for energizing the line relay R2020. At its contacts 2031, 2033, 2035 and 2036, the relay R2030 completes the above-mentioned loop circuit which extends to the line circuit associated with the repeater 8. This loop circuit may be traced as extending from ground by way of one winding of the line relay embodied in the line circuit individual to the repeater 8, the conductor 1860a, the contacts 2031, the winding 2016, the contacts 2033, the upper winding of R2080, the resistor 2083, the contacts 2062 and 2035, the winding 2017, the contacts 2036, C2085, the contacts 2111, the conductor 1860b and the other winding of the line relay embodied in the line circuit, to battery. The direction of current flow over this circuit is such that the relay R2080 does not operate. The line relay of the associated line circuit, in operating, causes the loop circuit just traced to be extended through the finder portion of an assigned link to the connector portion of the link, in the manner previously explained with reference to the operation of the repeater 7. After a loop circuit is thus established between the repeater 7 and the connector portion of an assigned link, such, for example, as the illustrated link, the usual dial tone signal is transmitted from the link through the repeating coil 2015 and over the trunk 51, to signal the calling operator in the manual office 6 that the dialing operation may be started. In this regard, it will be understood that if all of the links are busy at the time the call is initiated the calling operator will fail to receive the dial tone signal and will thus be informed that an all-links-busy condition exists in the community exchange. The absence of the dial tone signal may, if desired, be supplemented by an all-trunks-busy signal derived from the line circuit associated with the repeater 8, in the manner previously explained with reference to the operation of the line circuit 20.

The relay R2040, upon operating, closes its contacts 2041 to shunt the restored break contacts 2062 of the slow-to-operate relay R2060, and closes its contacts 2042 to complete the operating circuit for the latter relay. At its contacts 2043, the relay R2040 completes the prepared locking circuit for the relay R2030, this circuit extending from ground by way of the contacts 1956, C1991, the contacts 2043 and 2037, and the winding of R2030 to battery. At its contacts 2044, the relay R2040 opens a point in the locking circuit for the relay R2060. The relay R2060, in operating, opens its contacts 2062 to interrupt the path shunting the operated make contacts 2041 of the relay R2040, which contacts are included in the loop circuit extending from the repeater 8 to the connector portion of the illustrated link. At its contacts 2063, the relay R2060 prepares a locking circuit for itself. At its contacts 2061, the relay R2060 completes a multiple path including the conductor C1973 and the contacts 1931 for impressing ground potential upon the test conductor 203c.

After receiving the dial tone signal, the calling operator in the manual office 6 may dial the digits of the directory number designating the desired line terminating at the community exchange. During the dialing operation, the relay R2110 operates to repeat the dial impulses to the connector portion of the illustrated link. More specifically this relay opens its contacts 2111 at the beginning of the open-circuit period of each impulse, and recloses these contacts at the end of the open-circuit period of each impulse. The relay R2110 also opens its contacts 2112 for the duration of the open-circuit period of each impulse, thereby to interrupt the operating circuit for the relay R1960. Due to its slow-to-release characteristic, the latter relay remains operated during impulsing. Upon first restoring at the beginning of each digit, the relay R2110 closes its contacts 2113 to complete the prepared operating circuit for the relay R2070, this circuit extending from ground by way of the contacts 2113, C1983, the contacts 2031', C1982, the contacts 1953, C1981, and the winding of R2070 to battery. In operating, the relay R2070 closes its contacts 2071 to prepare the previously traced locking circuit for itself, opens its contacts 2073 to interrupt the previously traced ring-back tone signaling circuit, and closes its contacts 2072 to complete a path including the resistor 2094 for excluding the upper

winding of the relay R2080, the resistor 2083 and the repeating coil winding 2071 from the loop circuit which extends between the repeater 8 and the connector portion of the illustrated link. Due to its slow-to-release characteristic, the relay R2070 remains operated throughout each digit dialed at the calling operator's position in the mannal office 6 and restores shortly following the end of each digit. In this regard it will be understood that, at the end of each digit, the line relay R2110 remains in its operated position to maintain the slow-acting relay R1960 energized. The manner in which the desired line is selected by the connector portion of the link, is tested, and the busy signal is transmitted back over the connection in the event the line is busy, is exactly the same as set forth above. In the event the called line is idle, ringing current of the selected code is transmitted thereover to signal the called substation in the usual manner.

The desired talking circuit is completed when the call is answered at the called substation. In this connection it will be recalled that the right cut-off, back-bridge and battery reversing relays R980, R920 and R800, respectively, of the link, operate when the receiver provided at the called substation is removed to establish an answering loop circuit. When the direction of current flow over the loop circuit extending between the repeater 8 and the connector portion of the link is thus reversed, the polarized relay R2080 operates and closes its contacts 2082 to complete the prepared operating circuit for the relay R2100, this circuit extending from ground by way of the contacts 2033' and 2082, C2091, and the winding of R2100 to battery. At its contacts 2081, the relay R2080 completes a circuit including the conductor C2089 for energizing the battery reversing relay R2120. In operating, the relay R2120 reverses the direction of current flow over the loop circuit extending from the repeater 8 to the position of the calling operator in the manual office 6, whereby an off-hook supervisory signal is produced at this position in the usual manner. The relay R2100, in operating, locks to ground over a path including the contacts 2103, C2092 and the contacts 2033'. At its contacts 2102, the relay R2100 prepares an alternative path for impressing ground potential upon the test conductor 203c.

After the desired talking circuit is established in the manner pointed out above, the operator handling the call in the manual office 6 may retire from the connection and rely upon the supervisory lamps associated therewith for information as to the condition of the connection. In this regard, it is pointed out that if the called subscriber desires to recall the operator handling the call in the manual office 6, he may do so by flashing the switchhook provided at the called substation. In response to this operation the relays R920 and R800 cooperate momentarily to reverse the direction of current flow over the loop circuit extending between the connector portion of the illustrated link and the repeater 8. In response to this current reversal the relay R2080 restores and opens its contacts 2081 to deenergize the battery reversing relay R2120. The latter relay now restores to reverse the direction of current flow over the loop circuit extending from the repeater 8 to the manual office 6, whereby an on-hook supervisory signal is produced at the position of the calling operator in this office. This signal is of only short duration, however, since the relays R2080 and R2120 sequentially reoperate in response to the reoperation of the relay R800 when the answering loop circuit is recompleted at the called substation. It will be understood that if the switchhook provided at the called substation is operated repeatedly to open and then close the answering loop circuit, the supervisory lamp associated with the trunk 51 at the position of the calling operator in the manual office 6 is intermittently energized to produce the usual flashing recall signal. Upon observing this signal the operator may reenter the connection and ascertain the service desired by the called subscriber.

It will be understood from the above explanation that when the connection is released at the called substation, the four relays R920, R800, R2080 and R2120 are deenergized and remain in their restored positions, so that a continuous on-hook supervisory signal is produced at the position of the calling operator in the manual office 6. When this signal is received the operator may initiate the release of the connection by withdrawing the calling plug of her cord circuit from the jack terminating the trunk 51, thereby to cause the sequential release of the relays R2110, R1960 and R1950, in the manner previously described. The relay R2110, in restoring, opens its contacts 2111 to interrupt the loop circuit extending from the repeater 8 to the connector portion of the link, whereby the link is released in the manner previously explained. The relay R1950, in releasing, opens its contacts 1951 to interrupt one of the paths over which ground potential is impressed upon the test conductor 203c. At its contacts 1952, the relay R1950 opens the above-traced operating circuit for the relay R2030. At its contacts 1953, the relay R1950 opens the above-traced operating circuit for the relay R2070. At its contacts 1956, the relay R1950 interrupts the previously traced locking circuit for the relay R2030. The relay R2030, in restoring, opens its contacts 2033' to interrupt the operating and locking circuits for the relay R2100. At its contacts 2038, the relay R2030 opens the previously traced operating circuit for the relay R2040. Thus the three relays R2000, R2040 and R2100 are caused to restore. The relay R2040, upon restoring, opens its contacts 2042 to deenergize the relay R2060. The relay R2060 now restores and opens its contacts 2061 to disconnect the test conductor 203c from ground and thus identify the trunk 51 as idle in the trunk preselect relays 1700. Following the release of the relay R2060 the repeater 8 is fully restored to normal.

Supervision between the offices 6 and 5

A call originating on a line served by the manual office 6, and intended for a substation served by the manual office 5, may be routed by way of the trunk 51, the repeater 8, the illustrated link, the repeater 7 and the trunk 30 to the operator's swichboard in the manual office 5, and from this switchboard to the desired substation, in a manner which will be clearly apparent from the above description. It will be noted that when the connection is extended through the illustrated link to the repeater 7, the control or test conductors 285d and 203e are connected together through the link. In the repeater 8 these two leads are connected to ground over a path including the contacts 2043, C1991 and the contacts 1956 prior to the operation of the con-

nector portion of the link to seize the repeater 7. When the repeater 7 is seized the relays R2320, R2330 and R2360 are caused sequentially to operate in the manner previously explained. The four relays R2200, R2210, R2220 and R2230 respond to the operation of the relay R2330 by transmitting a splash of ringing current over the trunk 30 to signal the operator attending the switchboard in the manual office 5, in the exact manner previously described. From this preceding explanation it will be recalled that after the splash of ringing current is transmitted, the relay R2210 is maintained in its operated position. Incident to the operation of the relay R2210, the operating circuit for the relay R2235 is completed. This relay, in operating, reverses the connections of the conductors of the trunk 30 to the line terminals of the repeating coil 2205, so that an off-hook supervisory signal will be produced at the position of the answering operator when the call is answered. The relay R2330, in operating, connects the two conductors 285*d* and 203*c* to ground over a path including the contacts 2332, the lower winding of R2340, and the contacts 2393. Thus the lower winding of the relay R2340 is short-circuited and remains in its restored position for the duration of the call.

When the call is answered at the operator's switch-board in the manual office 5, the relays R2260, R2350, R2370 and R2380 are sequentially energized in the manner described above. During the interval which separates the operation of the pendulum relay R2370 and the slow-to-operate relay R2380, the relay R2325 is energized over a circuit including the contacts 2389, 2376 and 2341. In operating, the relay R2325 locks to ground over a path including the contacts 2327 and 2388. At its contacts 2326, the relay R2320 completes a circuit including the contacts 2353 for energizing the battery reversing relay R2310. The relay R2310, in operating, closes its contacts 2312 and 2314 and then opens its contacts 2311 and 2313, thereby to reverse the direction of current flow over the loop circuit extending between the repeaters 7 and 8. In response to this current reversal the relays R2080 and R2120 cooperate in the manner described above to reverse the direction of current flow over the loop circuit extending between the repeater 8 and the manual office 5, whereby an off-hook supervisory signal is produced at the position of the calling operator in this office.

If the calling operator in the manual office 6 desires to signal the answering operator in the manual office 5 after a connection is set up in the manner explained above, she may do so by opening and then reclosing the loop circuit extending from the manual office 6 to the repeater 8, thereby to cause the release and reoperation of the relay R2110. This relay, in restoring, opens its contacts 2111 to interrupt the loop circuit extending between the repeaters 7 and 8, and opens its contacts 2112 to interrupt the operating circuit for the hold relay R1960. At its contacts 2113, the relay R2110 completes the previously traced operating circuit for the relay R2070. The relay R2070 now operates and opens its contacts 2073 to interrupt the previously traced ring-back tone signaling circuit. The relays R1960 and R1950 may or may not restore during the interval when the relay R2110 is deenergized. If this interval is sufficiently long, these two relays are deenergized and restore but the release thereof is of no effect. Thus it will be noted that the relay R2030 is locked up in a circuit including the control conductor 203*e* which is now connected to ground at the contacts 2393 in the repeater 7. The opening of the operating circuit for the relay R2030 is thus ineffective to cause the release of the relays R2030, R2040, R2060 and R2100.

When the loop circuit extending between the repeaters 7 and 8 is interrupted by the relay R2110, the relay R2320 restores and opens its contacts 2321 to interrupt the operating circuit for the relay R2330. The latter relay is at this time energized in its locking circuit as traced above and, accordingly, remains operated. At its contacts 2322, the relay R2320 opens the circuit for energizing the battery reversing relay R2235. The relay R2235 now restores to reverse the direction of current flow over the loop circuit extending between the repeater 7 and the position of the answering operator in the manual office 5, whereby an on-hook supervisory signal is produced at this operator's position. It will be understood that when the loop circuit extending from the manual office 6 to the repeater 8 is recompleted, the relays R2110, R1960 and R1950, together with the supervisory relays R2080 and R2120, all reoperate, and that the loop circuit extending between the repeaters 7 and 8 is recompleted. When the last-mentioned loop circuit is recompleted the relays R2320 and R2235 reoperate, whereby an off-hook supervisory signal is produced at the position of the answering operator in the manual office 5. The sequence of relay operations just described is repeated each time the loop circuit extending between the manual office 5 and the repeater 8 is opened and then closed at the position of the calling operator. Thus a flashing recall signal is produced at the position of the answering operator in the manual office 5. Upon observing this signal, the answering operator may reenter the connection and ascertain the service desired by the calling operator in the manual office 6.

In the event the connection is cleared out at the position of the calling operator in the manual office 6 prior to its release in the manual office 5, the relays R2110, R1960, R1950, R2080 and R2120 in the repeater 8 are all deenergized and restore in a manner clearly apparent from the above explanation. Incident to the release of the relay R2110 the loop circuit extending between the two repeaters 7 and 8 is opened, whereby the two relays R2320 and R2235 are caused to restore. Incident to the release of the relay R2235 the direction of current flow over the loop circuit extending between the manual office 5 and the repeater 7 is reversed so that an on-hook supervisory signal is produced at the position of the answering operator.

In order to release the connection the answering operator may withdraw the answer plug of her cord circuit from the jack terminating the trunk 30 in the manual office 5, thereby to cause the sequential release of the relays R2260, R2350, R2310 and R2380. The relay R2380, in restoring, interrupts the locking circuit for the relay R2330, and opens one of the locking circuits for the relay R2325. The relay R2330 now restores and opens its contacts 2332 to disconnect the two connected test conductors 285*d* and 203*e* from ground. At its contacts 2333, the relay R2330 opens the locking circuit for the relay R2210. At its contacts 2336, the relay R2330 interrupts the locking circuit for the relay R2325. Following the release of the two relays R2210 and R2325

the repeater 7 is fully restored to normal. When the test conductor 285*d* is disconnected from ground the illustrated link and the line circuit associated with the repeater 8 are released in the manner previously explained. When the control conductor 203*e* is disconnected from ground the relay R2030 is deenergized and restores. This relay, in restoring, opens its contacts 2038 to deenergize the relay R2040, and opens its contacts 2033' to deenergize the relay R2100. At its contacts 2035', the relay R2030 interrupts the circuit for energizing the lower winding of the relay R2080. The relay R2040, upon restoring, opens its contacts 2042 to deenergize the relay R2060. When the relay R2060 restores it opens its contacts 2061 to disconnect the test conductor 203*c* from ground, thereby to mark the trunk 51 as idle in the trunk preselect relays 1700. Following the release of the relay R2060 the repeater 8 is fully restored to normal.

In the event the answering operator in the manual office 5 desires to recall the calling operator in the manual office 6, she may do so by opening and then reclosing the loop circuit extending between the manual office 5 and the repeater 7. When this circuit is opened the relay R2260 restores to deenergize the relay R2350. The relay R2350, in restoring, opens its contacts 2353 to interrupt the locking circuit for the relay R2380 and the circuit for energizing the relay R2310, causing both of these relays to restore. The relay R2380, in restoring, closes its contacts 2386 to reprepare the operating circuit for the relay R2370 and opens its contacts 2385 further to interrupt its own locking circuit. Aside from these two switching operations the release of the relay R2380 is without effect. In this regard, it will be recalled from the preceding explanation that the relay R2320 is operated to prevent the release of the relays R2330 and R2360. The relay R2310, in restoring, reverses the direction of current flow over the loop circuit extending between the repeaters 7 and 8, whereby the relays R2080 and R2120 are caused to release to reverse the direction of current flow over the loop circuit extending between the repeater 8 and the manual office 5. In response to the last-mentioned current reversal an on-hook supervisory signal is produced at the position of the calling operator in the manual office 6. When the loop circuit extending between the manual office 5 and the repeater 7 is recompleted at the position of the answering operator, the relays R2260 and R2350 sequentially reoperate. The relay R2350, in operating, recompletes the circuit for energizing the battery reversing relay R2310 and completes the prepared operating circuit for the relay R2370. The relay R2370 now operates to reclose the operating circuit for the relay R2380. After a predetermined time interval the relay R2380 reoperates to complete its locking circuit, to recomplete the locking circuit for the relay R2330 and to open the operating circuit for the relay R2370 in the manner previously explained. When the battery reversing relay R2310 reoperates the direction of current flow over the loop circuit extending between the repeaters 7 and 8 is again reversed, whereby the two relays R2080 and R2120 are caused to reoperate. These two relays, in reoperating, again reverse the direction of current flow over the loop circuit extending between the manual office 6 and the repeater 8, whereby an off-hook supervisory signal is produced at the position of the calling operator in this office.

It will be understood, from the above explanation, that if the loop circuit extending between the manual office 5 and the repeater 7 is repeatedly opened and closed, a flashing recall supervisory signal is produced at the position of the calling operator in the manual office 6. Upon observing this signal, the operator at this position may reenter the connection and ascertain the service desired by the answering operator. It will also be understood from the above explanation that when the answering operator in the manual office 5 disconnects the relays R2260, R2350, R2300, R2080 and R2120 are all deenergized and restore to produce a continuous on-hook supervisory signal at the position of the calling operator in the manual office 6. The calling operator is thus informed that the connection may be released.

In order to release the connection, the calling operator withdraws the calling plug of her cord circuit from the jack terminating the trunk 51 in the manual office 6, thereby to cause the deenergization and sequential release of the relays R2110, R1960 and R1950. In releasing, the relay R2110 opens its contacts 2111 to interrupt the loop circuit extending between the repeaters 7 and 8. The relay R2320, included in this loop circuit, now restores and opens its contacts 2321 to deenergize the relay R2330. At its contacts 2322 the relay R2320 opens the circuit for energizing the relay R2235. Thus the two relays R2235 and R2330 are deenergized and restore. In releasing, the relay R2330 opens its contacts 2332 to disconnect the two conductors 285*d* and 203*e* from ground. At its contacts 2333, the relay R2330 opens the locking circuit for the relay R2210. At its contacts 2335, the relay R2330 opens the operating circuit for the relay R2360. Following the release of the two relays R2210 and R2360 the repeater 7 is fully restored to normal.

When the two conductors 285*d* and 203*e* are disconnected from ground, the illustrated link and the line circuit associated with the repeater 8 are released, in the manner previously explained. Also, when ground potential is removed from the control conductor 203*e* the relay R2030 is deenergized and restores to cause the sequential release of the relays R2040, R2060 and R2100, in a manner clearly apparent from the preceding explanation. When the relay R2060 restores it opens its contacts 2061 to disconnect the test conductor 203*c* from ground, whereby the repeater 8 is marked as idle in the trunk preselect relays 1700. Following the release of this relay the repeater 8 is fully restored to normal.

Conversation timing

Provisions are made in the repeater 8 for restricting the duration of a call routed therethrough to a predetermined period after which the connection is automatically released. In considering this feature of the repeater it may be assumed that a connection is routed from the manual office 6 by way of the trunk 51, the repeater 8 and the illustrated link to a subscriber's line terminating at the community exchange. After such a connection is set up and the call is answered at the called substation the relays R1950, R1960, R2030, R2040, R2060, R2080, R2100 and R2120 are operated in the repeater. Incident to the setting up of the connection, and more specifically when the relay R2030 operates, a path including the contacts 2034' and 2054, C1853 and the contacts 1803 is completed for impressing ground potential upon the start lead

C889, whereby the operation of the timing device 720b is initiated in the event this device is not already in operation. At its contacts 2032' the relay R2030 prepares one of the operating circuits for the relay R1820.

When the timing device 720b operates to transmit a ground pulse over the start timing lead C892, following the operation of the relay R2030, a circuit is completed for energizing the relay R1820, this circuit extending by way of the grounded lead C892, the contacts 1802, C1851, the contacts 2032', C1850, the contacts 1817 and the upper winding of R1820 to battery. When thus energized, the relay R1820 locks to ground in a circuit including its lower winding, the contacts 1825, C1847, the contacts 2053, C1848, the contacts 1816, C1849, the contacts 2004, C1986 and the contacts 1954. At its contacts 1821, the relay R1820 prepares the operating circuit for the relay R1810. At its contacts 1822, the relay R1820 prepares an alternative circuit for energizing the relay R2040. At its contacts 1824, the relay R1820 opens a point in the operating circuit for the relay R1840.

As indicated above, a predetermined time interval following the operation of the relay R1820, a ground pulse is transmitted over the lead C874 by the timing device 720b to energize the relay R1810. In operating, the relay R1810 locks to ground over a path including its contacts 1811, C1844 and the contacts 2035'. At its contacts 1812, the relay R1810 completes the prepared alternative circuit for energizing the relay R2040, this circuit extending from ground by way of the contacts 2102, C1846, the contacts 1822 and 1812, C1845, the contacts 2038 and the winding of R2040 to battery. After this circuit is completed the relay R1810 opens its contacts 1813 to interrupt the initially completed circuit for energizing the relay R2040. At its contacts 1814, the relay R1810 prepares the operating circuit for the relay R1840. At its contacts 1815 and 1816, the relay R1810 includes the normally grounded time cut-off lead C875 in the locking circuit for the relay R1820 and opens the portion of this circuit which extends to ground at the contacts 1954. At its contacts 1817, the relay R1810 interrupts the above-traced operating circuit for the relay R1820.

A predetermined time interval after the relay R1810 operates, the timing device 720b functions to disconnect the time cut-off lead C875 from ground, thereby to cause the deenergization and release of the relay R1820. In restoring, this relay opens its contacts 1825, further to interrupt its own locking circuit, and closes its contacts 1824 further to prepare the operating circuit for the relay R1840. At its contacts 1823, the relay R1820 completes an alternative circuit for energizing the relay R2040, this circuit extending by way of the normally grounded release lead C888, the contacts 1823 and 1812, C1845, the contacts 2038 and the winding of R2040 to battery. After this circuit is completed the relay R1820 opens its contacts 1822 to interrupt the first-completed alternative circuit for energizing the relay R2040. At its contacts 1821, the relay R1820 interrupts the operating circuit for the relay R1810.

Shortly after the relay R1820 restores, the timing device 720b operates to impress ground potential upon the warning tone lead C892', thereby to energize the relay R1840. In operating, the relay R1840 closes its contacts 1841 to connect the tone start lead C895 to ground and thus initiate the operation of the tone generating equipment illustrated in Fig. 4 of the drawings. At its contacts 1842, the relay R1840 completes the previously traced path for impressing dial tone voltage upon the established talking circuit. The current traversing this path is transmitted over the calling and called ends of the connection and is reproduced by the receivers provided at the calling and called substations to indicate that the connection will shortly be released automatically. After this signal is received, the subscribers may hang up to give the operator in the manual office 6 disconnect supervision, and this operator may release the connection in the manner explained above. In such case the relay R1810 is deenergized and restores in response to the release of the relay R2030. If the connection is not released in the normal manner shortly after the warning signal is transmitted thereover, the timing device 720b operates to disconnect the release lead C888 from ground and thus deenergize the relay R2040. The relay R2040 now restores and opens its contacts 2041 to interrupt the loop circuit extending from the repeater 8 to the illustrated link. When this loop circuit is opened the relay R2080 is deenergized and restores and the illustrated link is released in the manner previously explained. At its contacts 2043, the relay R2040 opens the above-traced locking circuit for the relay R2030. At its contacts 2044, the relay R204C completes the prepared locking circuit for the relay R2060, this circuit extending by way of the control conductor 203e, which is now grounded in the link, by way of the contacts 2044 and 2063, and the winding of R2060 to battery. Thus the relay R2060 is held operated, to hold the loop extending to the illustrated link open, until the link is fully released, it being noted in this regard that the operating circuit for the relay R2060 is opened at the contacts 2042 when the relay R2040 restores. The relay R2080, upon restoring, opens its contacts 2081 to deenergize the battery reversing relay R2120, whereby the direction of current flow over the loop circuit extending between the manual office 6 and the repeater 8 is reversed to produce an on-hook supervisory signal at the position of the operator handling the call in this office. When the illustrated link is fully restored to normal, the control conducter 203e is disconnected from ground therein, thereby to cause the deenergization and release of the cut-off relay embodied in the line circuit associated with the repeater 8 and the release of the relay R2060. The relay R2060, upon restoring, closes its contacts 2062 to establish a loop circuit which extends from the repeater 8 to its associated line circuit. In this regard it will be noted, from a consideration of the line circuit 20, that when the cut-off relay embodied therein restores, the associated line relay is again connected to the talking conductors 285a and 285b. Hence, it will be understood that the upper winding of the polarized relay R2080 is energized in series with the two windings of the line relay embodied in the line circuit associated with the repeater 8, when the relay R2060 restores. It will also be understood that the direction of current flow over this loop circuit is such that the relay R2080 does not reoperate. The line relay of the associated line circuit, however, reoperates to complete the prepared locking circuit for the associated lockout relay and to connect the control conductor 203e to ground. Thus the repeater 8 and the trunk 51 are locked out of service until released under the control of the operator handling the call in the manual office 6.

When the disconnect signal is received, the calling operator may clear out the connection in the manner explained above. During the release of the repeater 8, the relay R1810 is deenergized and restores when its locking circuit is opened at the contacts 2035' by the relay R2030. It will be noted that when the relay R2030 restores, the loop circuit extending between the repeater 8 and its associated line circuit is opened to cause the deenergization and release of the line and lockout relays embodied in this line circuit.

In handling toll calls routed by way of the repeater 8 from the manual office 6 to the manual office 5, it is desirable to render the conversation timing facilities inactive, since otherwise a toll connection might automatically be released without the consent of the parties using the connection. It is for this reason that the two relays R2170 and R2050 are provided in the repeater 8, the first of these relays being of the differentially wound type. In order to render the timing facilities inactive in setting up a toll connection of the character under consideration, the operator in the manual office 6, after seizing the repeater 8 and before dialing the directory number assigned to the group of inter-office trunks extending to the manual office 5, momentarily operates a key in her cord circuit to impress ground potential upon the positive conductor of the trunk 51. When this conductor is connected to ground, the upper winding of the relay R2170 is short-circuited over a path including the contacts 2141, 2131 and 2121, the repeating coil winding 2018, C2084 and the upper winding of the line relay R2110. It will be noted that this short-circuiting path may be completed without deenergizing the respective lower windings of the two relays R2170 and R2110. When its upper winding is thus deenergized, the relay R2170 operates and closes its contacts 2171 to complete a circuit including the conductor C2087 over which the relay R2050 is energized. The relay R2050, in operating, locks to ground over a path including the contacts 2051, C1978 and the contacts 1952. Thus the relay R2050 is held operated when the positive conductor of the trunk 51 is disconnected from ground to cause the release of the differentially wound relay R2170. In operating, the relay R2050 opens its contacts 2053 to interrupt the previously traced locking circuit for the relay R1820. At its contacts 2052, the relay R2050 prepares an alternative locking circuit for the relay R1820. At its contacts 2054, the relay R2050 opens the previously traced path for impressing ground potential upon the start lead C889. It may occur that the timing device 720b is in operation due to the presence of another call in the community exchange, or that the operation of this device is initiated, before the toll call under consideration is completed. In such case, the relays R1820 and R1810 may be caused to operate under the control of the timing device 720b in the manner described above. In this case, however, the relay R1820, following its operation, is locked up in a circuit which extends to ground over a path including the contacts 1825, C1847, the contacts 2052 and 2004, C1986, and the contacts 1954.

Accordingly, this relay remains in its operated position for the duration of the call. With this relay operated, the relay R2040 cannot be released under the control of the timing device 720b, for the reason that it is energized over a circuit which is independent of the release lead C888 and extends to ground at the contacts 2102 of the operated relay R2100. Accordingly, the timing facilities are rendered inoperative automatically to release the connection in the manner explained above.

Forced Release of the Repeater 8

In the event a call is routed by way of the illustrated link, the repeater 8 and the trunk 51 to the operator's switchboard in the manual office 6 and, due to a defective condition of this trunk or for some other reason, the call is not answered within a reasonable time interval, the two relays R1810 and R1820 cooperate forcibly to release the connection and to lock the calling line out of service. Thus it will be recalled from the preceding explanation that when the repeater 8 is seized on a call incoming to the manual office 6 the relay R1930 operates to impress ground potential upon the start lead C889, whereby operation of the timing device 720b is initiated. The relay R1930 also closes its contacts 1935 to prepare the previously traced operating circuit for the relay R1820. It will also be recalled that after the central office operator is signaled and before the call is answered, the relays R2020, R2000, R1930, R2120 and R2150 are operated in the repeater. In the event the call is not answered, a ground pulse is delivered to the upper winding of the relay R1820 from the timing device 720b in the manner previously explained. The relay R1820, in operating, prepares the operating circuit for the relay R1810 and locks to ground at the contacts 2005. At its contacts 1823, the relay R1820 opens the prepared connection between the release lead C888 and the conductor C1845. Thereafter, and when the relay R1810 operates under the control of the timing device 720b, it closes its contacts 1815 to complete the previously traced alternative locking circuit for the relay R1820. At its contacts 1812 and 1813, the relay R1810 disconnects the test conductor 203c from ground, thereby to cause the release of the illustrated link and the locking out of the calling line in the manner previously explained. Incident to the release of the link, the loop circuit extending between the connector portion of the link and the repeater 8 is opened to cause the deenergization and release of the relays R2020, R2000, R1930, R2120 and R2150, all in a manner clearly apparent from the above explanation. In this case no locking circuit is provided for the relay R1810 due to the deenergized condition of the relays R1900 and R2030. Accordingly, the relay R1810 restores at the end of the ground pulse transmitted over the time pulse lead C874 by the timing device 720b. In restoring the relay R1810 opens its contacts 1815 to interrupt the locking circuit for the relay R1820, causing the latter relay to restore. Following the release of the two relays R1810 and R1820, the repeater 8 is fully restored to normal and is marked as idle in the trunk preselect relays 1700.

If the conductors of the trunk 51 becomes short-circuited, or a permanent calling condition is otherwise created on this trunk, the repeater 8 operates to seize an assigned one of the links in the community exchange in the exact manner previously described. In this case, the relays R2110, R1960, R1950, R2030, R2040 and R2060 are operated to cause the seizure of an assigned link, when the calling condition first appears on the trunk 51. Under the conditions assumed, no dial pulses are transmitted through the repeater 8 to the seized link and, accordingly, the release relays of the link are caused to operate

under the control of the timing device 720b, in the manner previously described with reference to the operation of the link relays R900 and R910 of the illustrated link. Concurrently with the operation of the link release relays of the link, the two relays R1810 and R1820 operate to deenergize the relay R2040 in the manner previously explained. In releasing, the relay R2040 opens its contacts 2043 to disconnect the control lead 203c from ground in the repeater 8. Thus, the hold relay of the link is deenergized and restores to initiate the release of the link. Incident to the release of the link the line and lockout relays of the line circuit associated with the repeater 8 are caused to operate, whereby this repeater and the trunk 51 are locked out of service. These units are only restored to normal and rendered available for further use when the fault present on the trunk 51 is cleared.

TRUNK PRESELECTION

As indicated in the preceding explanation, the trunk preselect relays 1700, illustrated in Figs. 17 and 17A of the drawings, are controlled in accordance with the idle or busy condition of the trunks extending to the manual office 6 to select an idle one of the trunks immediately a previously selected trunk becomes busy. More specifically, the circuit arrangement of these relays is such that the two toll trunks, i. e., the first two trunks of the group, are alternately seized through the connector switches provided in the community exchange, assuming that the toll calls are handled non-concurrently. These two trunks, it will be recalled, are reserved for toll calls exclusively, and the arrangement permitting trunk rotation prevents the repeated seizure of a defective trunk upon repeated efforts of a party to obtain a connection to the manual office 6. The last two trunks of the group, namely the combination toll and free service trunks, are arranged to be seized on a preferential basis over the toll paths of the connector switches provided in the community exchange. More specifically, the first trunk, i. e., the trunk 51, and its associated repeater 8 will, in all cases, be seized through the toll paths of the connector switches in preference to the second combination toll and free service trunk, when both of the trunks are idle. The two combination trunks are seized in rotation over the free service paths of the connector switches.

In considering the operation of the trunk preselect relays 1700, it will be recalled that each time one of the four trunks extending to the manual office 6 is seized, either from the switchboard in this office or through one of the connector switches in the community exchange, ground potential is impressed upon the associated test conductor. It is pointed out further, that when all of the four trunks are idle, the relay R1720, individual to the first trunk of the group, is locked up in a circuit which extends from ground by way of the contacts 1791, 1762, 1745, 1782 and 1724 and the winding of R1720 to battery. With the preselect relays 1700 set in this manner, if a toll call is routed to the illustrated link and the digit 0 is dialed the relay R1400 is caused to operate in the manner previously explained. In operating, the relay R1400 completes a circuit for energizing the unit relay R1450 corresponding to the first trunk, this circuit extending by way of the grounded release conductor C893, the contacts 773, C786, the contacts 1101 and 1125', C1085, the contacts 1331', C1361', the contacts 1401, C1792, the contacts 1721, C1247' and the winding of R1450 to battery. When the relay R1450 operates, the calling loop circuit is switched through to the repeater associated with the first trunk of the group, in the manner previously explained. In this regard, it will be noted that with the trunk relay R1720 individual to the first trunk operated, circuits are prepared at the upper make contacts thereof for energizing the first connector unit relay in each of the several links. When the repeater associated with the first trunk of the group is seized, in the manner just explained, ground potential is impressed upon the test conductor 201c to energize the relay R1710. This relay, in operating, closes its contacts 1713 to prepare the operating circuit for the relay R1760, opens its contacts 1711 to interrupt the operating circuit for the relay R1720, and closes its contacts 1712 to complete the operating circuit for the trunk relay R1740 individual to the second trunk of the group, this latter circuit extending from ground by way of the contacts 1791, 1742, 1722, 1712 and 1731, and the winding of R1740 to battery. The relay R1740 now operates and locks to ground over a path including its preliminary make contacts 1746 and the contacts 1783, 1762 and 1791. At its contacts 1742, the relay R1740 opens a point in its operating circuit and the operating circuit for the relay R1720. At its contacts 1743, the relay R1740 completes an alternative locking circuit for itself, this circuit extending from ground by way of the contacts 1791, 1743 and 1731, and the winding of R1740 to battery. At its contacts 1745, the relay R1740 opens the previously traced locking circuit for the relay R1720, causing the latter relay to restore. In releasing, the relay R1720 opens its contacts 1721 to interrupt the above-traced operating circuit for the first unit relay R1450. In a similar manner, the relay R1720, at its other upper make contacts, opens a point in the operating circuits for the other first connector unit relays. At its contacts 1723, the relay R1720 reprepares its own operating circuit. At its contacts 1724, the relay R1720 opens another point in its own locking circuit.

In the event the call under consideration is terminated, thereby to cause the release of the repeater associated with the first trunk of the group, before the second trunk of the group is seized either from the manual office 6 or through another of the finder-connector links provided in the community exchange, the test conductor 201c is disconnected from ground to cause the deenergization and release of the relay R1710. This relay, in restoring, opens its contacts 1712 to interrupt the operating circuit for the relay R1740 and closes its contacts 1711 to reprepare the operating circuit for the relay R1720. It will be noted, however, that the relay R1740 is not deenergized in response to the release of the relay R1710. Accordingly, when another toll call is subsequently initiated on a line terminating at the community exchange, the second trunk of the group is seized. Assuming that the illustrated link is utilized in setting up this second toll connection, the relay R1400, upon operating in response to the dialing of the toll trunk select digit at the calling substation, completes the prepared circuit for energizing the second connector unit relay R1430, this circuit extending by way of the grounded conductor C1361', the contacts 1401, C1792, the contacts 1741, C1257 and the winding of R1430 to battery. The relay R1430, in operating, causes the calling loop cir-

cuit to be switched through to the repeater associated with the second trunk of the group, in a manner clearly apparent from the above explanation. When the repeater associated with the second trunk of the group is thus seized, ground potential is impressed upon the test conductor 202c to energize the relay R1730. This relay, in operating, closes its contacts 1733 to prepare the operating circuit for the relay R1760, opens its contacts 1731 to interrupt one of the above-traced locking circuits for the relay R1740, and closes its contacts 1732 to complete a circuit for energizing the relays R1720 and R1790 in series. This series circuit extends from ground by way of the contacts 1791, 1743 and 1732, the winding of R1790, the contacts 1711 and the winding of R1720 to battery. When thus energized, the relay R1790 operates after an interval and opens its contacts 1791 to interrupt the operating and locking circuits for itself and the relays R1720 and R1740. The relay R1740 is thus deenergized and restores. At its contacts 1743 and 1746, the relay R1740 further interrupts its two locking circuits as traced above. At its contacts 1743, the relay R1740 opens another point in the above-traced circuit for energizing the two relays R1720 and R1790 in series. At its contacts 1745, the relay R1740 reprepares the operating circuit for the relay R1720 individual to the first trunk of the group. At its contacts 1741, and the other make contacts individual to the other links, the relay R1740 opens the prepared operating circuits for the respective second connector unit relays of the links. Shortly after the relay R1740 restores, the relay R1790 releases and closes its contacts 1791 to complete the prepared operating circuit for the relay R1720, this circuit extending from ground by way of the contacts 1791, 1762, 1745, 1723 and 1711, and the winding of R1720 to battery. In operating, the relay R1720 connects the lead C1792 to the conductor C1247' extending to the first unit relay of the illustrated link and locks to ground through its contacts 1722 and 1724. Thus the trunk preselect relays 1700 are conditioned to route the next toll call over the first trunk of the group. From the above explanation, it will be apparent that so long as the toll calls do not overlap, the first two trunks of the group are used in rotation.

If both of the toll trunks are in use at the same time, both of the test conductors 201c and 202c are connected to ground so that the two relays R1710 and R1730 are both operated. With these two relays concurrently operated, a circuit including the contacts 1713, 1733 and 1751 is completed for energizing the relay R1760. In operating, the relay R1760 opens its contacts 1762 to interrupt the previously traced locking circuits for the two relays R1720 and R1740, whereby the operated one of these two relays is caused to restore. At its contacts 1761, and the other make contacts controlled thereby, the relay R1760 prepares the operating circuits for the third connector unit relays of the respective links. Thus, if a third toll call is initiated before either of the first two trunks of the group is released, it will be routed by way of the repeater 8 and the trunk 51 to the manual office 6. Moreover, if this repeater is seized from a non-restricted substation through the ninth connector group relay R1490 of the link illustrated, for example, the third connector unit relay R1440 will be energized and will operate to switch the calling loop circuit through to the repeater 8. The trunk 51 and its associated repeater 8 may also be seized from the operator's switchboard in the manual office 6 at a time when the first two toll trunks are both busy. Regardless of the route over which this repeater is seized, ground potential is impressed upon the test conductor 203c to energize the relay R1750. This relay, in operating, opens its contacts 1751 to deenergize the relay R1760, and closes its contacts 1752 to energize the relay R1780. The relay R1760, in restoring, closes its contacts 1762 to reprepare the operating and locking circuits for the three relays R1720, R1740 and R1790. At its upper make contacts, the relay R1760 interrupts the prepared operating circuits for the third connector unit relays of the respective links. The relay R1780, in operating, opens its contacts 1782 and 1783 further to interrupt the locking circuits for the relays R1720 and R1740 and closes its make contacts to prepare the operating circuits for the fourth unit relays provided in the respective connector switches, whereby the fourth trunk is selected for seizure through the various links.

From the above explanation it will be understood that if the first combination toll and free service trunk 51 is occupied with a call at the time the two toll trunks become busy, the relay R1780 is immediately energized when the last of the two toll trunks is made busy. Accordingly, the fourth trunk of the group is selected for seizure through the various links. It will also be understood that if one of the first two toll trunks should become idle at a time when the relay R1760 or the relay R1780 is operated, the trunk preselect relays 1700 are reset to select the idle toll trunk in preference to the first or second of the combination toll and free service trunks. Thus, if the first toll trunk is released under such circumstances, the associated relay R1710 restores and opens its contacts 1713 to deenergize the operated one of the two relays R1760 and R1780. Assuming that the relay R1760 is deenergized, this relay now restores to interrupt the prepared operating circuits for the respective third connector unit relays. At its contacts 1762, the relay R1760 also completes the operating circuit for the relay R1720 individual to the first trunk. In reoperating, the relay R1720 locks to ground at the contacts 1791 and conditions the connector unit relay control circuits so that the first toll trunk will be seized when the next toll call is initiated on one of the lines terminating at the community exchange. Similarly, if the second toll trunk becomes idle when the relay R1760, for example, is operated, the relay R1730 restores to cause the release of the relay R1760 followed by the reoperation of the relay R1740 individual to the second trunk. It will also be understood from the above explanation that if the relays R1750 and R1780 are operated to select the fourth trunk of the group for seizure through the links of the community exchange, and the third trunk of this group becomes idle, the relay R1750 restores to deenergize the relay R1780 and to energize the relay R1760 whereby the third trunk is selected to handle the next toll call in lieu of the fourth trunk of the group.

The normal preselection of the combined toll and free service trunks is under the control of the relays illustrated in Fig. 17A of the drawings, which relays are controlled in accordance with the idle or busy condition of the two associated trunks. As long as both of these trunks are idle, the relay R1770 is locked up in a circuit which

includes the contacts 1796, 1788 and 1774 and, accordingly, occupies its operated position. With this relay operated, the contacts 1771 are closed to prepare one of the operating circuits for the first unit relay R1450 provided in the connector portion of the illustrated link. At the remaining make contacts of this relay, similar circuits are prepared for the first connector unit relays respectively provided in the other links. If, with the relay R1770 operated, a free service call is initiated at one of the non-restricted substations of the system and is routed to the link illustrated, and the digit 9 is dialed at the calling substation, the relay R1490 operates to complete the prepared operating circuit for the first unit relay R1450. This circuit, it will be recalled, extends from ground by way of the release conductor C893, the contacts 763, C786, the contacts 1101 and 1125', C1085, the contacts 1321', C1351', the contacts 1491, C1797, the contacts 1771, C1247', and the winding of R1450 to battery. The relay R1450, upon operating, locks up and causes the calling loop circuit to be switched through to the repeater 8 in the manner previously explained. Incident to the seizure of this repeater, ground potential is impressed upon the test conductor 203c to energize the two relays R1750 and R1765 in parallel. The relay R1750 performs the functions described above. The relay R1765, in operating, opens its contacts 1766 further to interrupt the incomplete operating circuit for the relay R1770, and closes its contacts 1767 to complete the prepared operating circuit for the relay R1785, the latter circuit extending from ground by way of the contacts 1796, 1786, 1772, 1767 and 1776, and the winding of R1785 to battery. When thus energized, the relay R1785 locks to ground over a path including its preliminary make contacts 1789 and the contacts 1796. At its contacts 1788, the relay R1785 opens the established locking circuit for the relay R1770. The relay R1770 now restores and opens its contacts 1774 further to interrupt its locking circuit. At its contacts 1773, the relay R1770 reprepares its operating circuit. At its upper make contacts, the relay R1770 opens the prepared operating circuits for the first connector unit relays of the several links and, in so doing, interrupts the previously traced circuit for energizing the first unit relay R1450 of the illustrated link.

In the event the call under consideration is terminated, thereby to cause the release of the repeater 8, before the second combination trunk of the group is seized, the test conductor 203c is disconnected from ground to cause the deenergization and release of the relay R1765. This relay, in restoring, opens its contacts 1767 to interrupt the operating circuit for the relay R1785 and closes its contacts 1766 to reprepare the operating circuit for the relay R1770. It will be noted, however, that the relay R1785 is not deenergized in response to the release of the relay R1765. With the relay R1785 operated, if a second free service call is initiated at one of the non-restricted substations served by the community exchange, the call is routed through the repeater associated with the second combination toll and free service trunk to the operator's switchboard in the manual office 6. In this case the second connector unit relay of the link occupied with the call is energized over a circuit which may partially be traced as extending by way of the conductor C1797, the contacts 1786', and the conductor C1257 to the second connector unit relay of the link occupied with the call. Incident to the seizure of the repeater associated with the fourth trunk of the group, i. e., the second combination toll and free service trunk, ground potential is impressed upon the test conductor 204c to energize the relay R1775. This relay, in operating, opens its contacts 1776 to interrupt the above-traced operating circuit for the relay R1785, and closes its contacts 1777 to complete a circuit for energizing the relays R1770 and R1795 in series, this circuit extending from ground by way of the contacts 1796, 1787 and 1777, the winding of R1795, the contacts 1766 and the winding of R1770 to battery. In operating, the relay R1795 opens its contacts 1796 to deenergize itself and the two relays R1770 and R1785. In releasing, the two relays R1785 and R1795 complete the prepared operating circuit for the relay R1770, this circuit extending from ground by way of the contacts 1796, 1788, 1773 and 1766, and the winding of R1770 to battery. The relay R1770 now operates and locks to ground over a path including its preliminary make contacts 1774 and the contacts 1788 and 1796. With the relay R1770 operated, the trunk 51 is selected for seizure over the free service paths of the links.

From the above explanation it will be apparent that so long as the free service calls to the manual office 6 do not overlap, the trunk 51 and the other combination trunk are seized over the free service paths of the connector switches in rotation. It will also be understood that when both of the combination trunks are busy, the two relays R1765 and R1775 are operated so that the relay R1795 is short-circuited over a path including the contacts 1767 and 1777. If the second combination trunk is the first to be released, the relay R1775 restores and opens its contacts 1777 to interrupt the path short-circuiting the relay R1795, and closes its contacts 1776 to reprepare the operating circuit for the relay R1785. The latter relay in all cases remains operated until the first combination trunk 51 is released.

All trunks busy

If a toll or free service call intended for the manual office 6 is routed through the illustrated link at a time when all of the trunks extending to this office are busy, the link operates to transmit the usual busy signal to the calling subscriber. Assuming that the call is routed over the toll path of the connector, the group relay R1400 and the fourth connector unit relay are energized and operate, all in the manner previously explained, when the relays R1100, R1150 and R1160 restore shortly atfer the trunk select digit is dialed at the calling substation. Since the fourth trunk of the group is busy, the test conductor 204c thereof is connected to ground in the associated repeater and, accordingly, a circuit is completed for energizing the busy test relay R1040 immediately the connector group and unit relays operate and before the transfer relays R1110 and R1130 can operate. This circuit extends by way of the grounded test conductor 204c, the contacts 1404, the contacts of the fourth connector unit relay, not shown, C1162, the contacts 1131, C1076 and the lower winding of R1040 to battery. The busy test relay, in operating, locks up and, in cooperation with the transfer relay R1110, completes the busy signaling circuit in the exact manner previously explained. The manner in which the link is released when the calling party disconnects will be

clearly apparent from the preceding explanation.

OPERATION OF THE TONE GENERATING EQUIPMENT

As indicated previously, the dial tone generator 435 and the busy tone generator 440 are identical in arrangement. The operation of these two tone units is initiated in response to the application of ground potential to the start lead C895. Thus, when this lead is connected to ground, an obvious circuit is completed for energizing the start relay R400. The relay R400, upon operating, completes, at its contacts 401, an obvious path for grounding the start lead C405 individual to the dial tone generator 435. At its contacts 403, the relay R400 completes a circuit including the resistor 473 for energizing the slow-to-operate relay R470, thereby to initiate the operation of the reverting call tone generator 475. At its contacts 404, the relay R400 completes a circuit for energizing the start winding of the tone buzzer 430, this circuit extending from ground by way of the contacts 404 and 422, the right or start winding of the buzzer 430 and through the contacts 426 and the resistor 413 to battery. Parallel branches of this circuit also extend through the resistor 437 and the lower winding of the transformer 432' to battery. It is noted that in the preferred arrangement the right or start winding of the buzzer 430 is of approximately 400 ohms resistance, the left winding of this resistor is of approximately 1000 ohms resistance, the lower winding of the transformer is of approximately 600 ohms resistance, and the three resistors 437, 432 and 413 are of 1500 ohms, 2000 ohms and 100 ohms resistance, respectively. Accordingly, when the low resistance start winding of the buzzer 430 is energized in series with the resistor 413, it is energized by a heavy current which causes the armature controlling the contacts 431 rapidly to be attracted to its extreme operated position. In response to this operation the contacts 431 are closed to complete a circuit for energizing the slow-to-operate relay R410. This circuit extends from ground by way of the contacts 404, 431 and 424, and the winding of R410 to battery. The relay R410 operates after an interval and locks to ground through the contacts 411 and 404. At its contacts 412, the relay R410 completes an obvious operating circuit for the relay R420. The slow-operating period of the relay R410 and the operating time of the relay R420 afford the buzzer 430 an opportunity fully to attract the vibratory armature controlling the contacts 431 before the initially completed start circuit is interrupted in the manner described below.

In operating, the relay R420 first opens its contacts 422 to interrupt the path normally shunting the left winding of the buzzer 430 and the resistor 432, thereby to insert these parallel connected elements in the above-traced circuit for energizing the right or start winding of the buzzer. Thus, the current flow over the circuit for energizing the buzzer is reduced somewhat. The relay R420, in operating, next opens its contacts 426 to remove the 100 ohm resistor 413 from the buzzer operating circuit. After these contacts are opened the buzzer windings are energized over branch circuits, one of which extends from ground through the two windings of the buzzer in series and the parallel network including the resistor 437 and the lower winding of the transformer 432' to battery. Another branch of this circuit extends from ground through the contacts 421, the resistor 432, the right or start winding of the buzzer 430 and the parallel network including the resistor 437 and the lower winding of the transformer 432' to battery. It will be noted that the removal of the resistor 413 from the operating circuit for the buzzer results in a further reduction in the magnitude of the current flow through the buzzer windings.

The third function performed by the relay R420 is that of opening its contacts 421 to open the path including the resistor 432 in shunt with the left winding of the buzzer 430. Thus, the current flow through the right or start winding of the buzzer 430 is further reduced. The purpose of reducing the current flow through this buzzer winding in steps is to prevent the sudden and premature release of the vibrating armature controlling the contacts 431 due to a too sudden reduction of the start current.

Following the operations just described the relay R420 closes its contacts 423 to complete the tone circuit and opens its contacts 424 to interrupt the above-traced operating circuit for the relay R410. Finally, the relay R420 completes, at its contacts 425, an obvious path for short-circuiting the series-connected windings of the tone buzzer. When this path is completed, the tone buzzer is deenergized and releases its vibratory armature to open the contacts 431. Immediately these contacts are opened, the two windings of the buzzer are energized in series over a circuit including the contacts 404 and the lower winding of the transformer 432'. Thus, the buzzer operates intermittently to open and close its contacts 431 so long as the start relay R400 is held in its operated position. It will be observed that each time the contacts 431 are closed, the full voltage of the exchange battery is impressed across the lower winding of the transformer 432'. On the other hand, when the contacts 431 are opened, a portion of the available voltage is dissipated as a potential drop across the parallel network comprising the windings of the buzzer 430, the resistor 433 and the condenser 434. Thus, a periodically varying current is caused to traverse the lower winding of the transformer 432'. This current causes an induced voltage to be developed in the upper winding of the transformer 432', which is impressed across the terminals of the condenser 436 and is also impressed through the windings of the radio frequency choke coil 445 upon the busy tone lead C1089. It will be observed that the condenser 436 is periodically charged and discharged by the induced voltage developed in the upper winding of the transformer 432' and, thus, acts as a smoothing capacitance to improve the wave form of the voltage impressed upon the busy tone lead C1089. The series-connected resistor 433 and condenser 434 function to prevent sparking at the contacts 431 during the intermittent opening and closing of these contacts. Due to the fact that the voltage output of the generator 440 is derived from the secondary winding of the transformer 432', the load imposed upon the generator does not influence the operation of the buzzer 430. Hence, the generator will operate as well when its output circuit is heavily loaded or short-circuited as when no load is imposed on the generator.

The three slow-to-operate relays R450, R460 and R470 serve a dual purpose. One of the functions assigned to these relays is that of intermittently connecting the busy tone current lead C1089 to the high potential terminal of the con-

denser 436. The other function assigned to these relays is that of intermittently connecting the reverting call tone lead C907 to the negative terminal of the exchange battery. Operation of these relays is initiated in response to operation of the relay R400 or the application of ground potential to the tone start lead C879. More specifically, when the conductor C879 is grounded, the relay R470 is energized in series with the resistor 473 and operates after an interval to prepare, at its contacts 471, the operating circuit for the relay R480. At its contacts 472, the relay R470 opens the path normally short-circuiting the relay R460, permitting the latter relay to be energized in series with the resistor 474. The relay R460, upon operating, opens the path normally short-circuiting the winding of the relay R450, permitting the latter relay to be energized in series with the resistor 463. The relay R450, upon operating, completes the above-mentioned operating circuit for the relay R480 and closes its contacts 452 to short-circuit the relay R470. At its contacts 453, the relay R450 connects the busy tone lead C1089 to the high potential terminal of the condenser 436. When its winding is short-circuited, the relay R470 restores to short-circuit the relay R460. The relay R460 in turn restores to short-circuit the relay R450. The relay R450, upon restoring, opens the operating circuit for the relay R480, disconnects the busy tone lead C1089 from the high potential terminal of the condenser 436, and opens the path short-circuiting the relay R470. It will be observed that during the cyclic operation of these relays, the busy tone lead C1089 is only connected to the high potential terminal of the condenser 436 during those intervals when the relay R450 is operated. It will also be observed that the operating circuit for the relay R480 is closed and opened twice during each cycle of operation of the three cyclically operating relays. This circuit is initially completed in response to operation of the relay R450. It is thereafter opened in response to the release of the relay R470. It is again closed in response to the release of the relay R460 and again opened in response to the release of the relay R450. Thus, the relay R480 is caused intermittently to operate and restore. Each time this relay operates, it opens its contacts 481 to disconnect the reverting call tone lead C907 from the grounded resistor 483, and closes its contacts 482 to connect the indicated lead through the resistor 484 to the negative terminal of the exchange battery. This operation of the relay R480 alternately to connect the lead C907 to opposite terminals of the exchange battery causes an undulating voltage to be impressed upon the lead which is utilized for the signaling purposes previously described.

The release of the dial and busy tone generators is entirely under the control of the tone start relay R400. Thus, it will be apparent that when this relay is deenergized and restores, the operating and locking circuits for the relays R410 and R420, and the circuits for energizing the windings of the tone buzzer 430, are all interrupted. The dial tone generator 435 is restored to normal in a similar manner when the start relay R400 restores to disconnect ground potential from the start lead C405 individual thereto. The release of the reverting call tone generator 475 only occurs when ground potential is removed from the start lead C879, the three slow-to-operate relays R450, R460 and R470 all being deenergized when this lead is disconnected from ground.

Operation of the Charging Equipment

In considering the operation of the charging equipment illustrated in Fig. 3 of the drawings, it may be stated that the test relay R350 is normally energized in a circuit including the contacts 372 and 362 and the resistor 346. This circuit is intermittently opened under the control of the pulsing relay R370, the relay R350 being so constructed and adjusted that when the voltage of the exchange battery drops below a predetermined value of approximately 48 volts it will fail to reoperate when its operating circuit is opened and then completed. With the relay R350 normally operated, the relay R360 is normally energized in a circuit including the contacts 351.

As indicated above, each time a call is initiated on one of the lines terminating at the exchange illustrated, the slow-acting relay R610, included in the common equipment, momentarily operates to impress ground potential upon the start lead C617 extending to the charging equipment. Each time a ground pulse is transmitted over this lead, the relay R370 is energized in an obvious circuit, and opens its contacts 372 to interrupt the circuit for energizing the relay R350. At its contacts 371, the relay R370 completes an obvious locking circuit for the slow-to-release relay R360. The relay R350, in releasing, opens its contacts 351 to interrupt the circuit over which the relay R360 is normally energized. Each time the relay R370 restores at the end of a ground pulse, it opens its contacts 371 to interrupt the locking circuit for the relay R360 and closes its contacts 372 to recomplete the circuit for energizing the low voltage test relay R350. So long as the voltage of the exchange battery exceeds 48 volts the relay R350 is sufficiently energized to reoperate in this circuit. In reoperating the relay R350 recompletes the operating circuit for the relay R360 before the latter relay can restore.

When the voltage of the exchange battery falls below a value of 48 volts, the relay R350 is insufficiently energized to operate and, accordingly, remains in its restored position following the release of the relay R370. With the relays R350 and R370 restored, the relay R360 is also deenergized and restores after an interval. In releasing, the relay R360 opens its contacts 361 further to interrupt its locking circuit, and opens its contacts 362 to interrupt the circuit for energizing the relay R350. At its contacts 361, the relay R360 further interrupts its own locking circuit. At its contacts 363, the relay R360 completes a circuit including the contacts 372 and the resistor 302 for energizing the medium voltage test relay R300. The relay R300 is marginal and is so adjusted that it will not operate in the circuit just traced until the voltage of the exchange battery exceeds a value of approximately 50 volts. At its contacts 364, the relay R360 completes an obvious circuit for energizing the two relays R310 and R330 in parallel.

The two relays R310 and R330, in operating, close their contacts 312 and 332 respectively to complete the respective input circuits of the two rectifiers 315 and 305. At its contacts 311, the relay R310 connects the output terminals of the rectifier 315 across the positive and negative terminals of the exchange battery. Similarly, the relay R330 closes its contacts 331 to connect the output terminals of the rectifier 305 across

the terminals of the exchange battery. Thus the charging operation is started.

With the two rectifiers **305** and **315** in operation, the pulsing relay **R370** continues to operate intermittently to open the circuit for energizing the medium voltage test relay **R300**. When the voltage of the exchange battery exceeds a medium value of approximately 52 volts, the relay **R300** is sufficiently energized in the above-traced circuit to operate. In operating, this relay closes its contacts **301** to complete an obvious circuit for energizing the slow-to-release relay **R340**. The relay **R340** now operates and closes its contacts **342** to prepare a locking circuit for itself. At its contacts **343**, the relay **R340** completes an obvious circuit for energizing the relay **R320**. At its contacts **344**, the relay **R340** completes an obvious path for short-circuiting the resistor **345**, whereby the energization of the low voltage alarm relay **R390** is substantially increased. At its contacts **341**, the relay **R340** completes an alternative test circuit for bridging the winding of the test relay **R350** across the terminals of the exchange battery, this circuit extending from the grounded or positive battery terminal by way of the contacts **372**, the adjustable resistor **353**, the contacts **341**, the winding of **R350** and the resistor **346** to the negative terminal of the exchange battery. Preferably, the resistor **353** is so adjusted that the relay **R350** will only operate when energized in this circuit by a battery voltage exceeding 56 volts.

The relay **R320**, upon operating, opens its contacts **321** to deenergize the relay **R310**. At its contacts **322**, the relay **R320** opens the path normally short-circuiting the adjustable resistor **324**, whereby the charging current delivered from the rectifier **305** to the exchange battery is reduced. The relay **R310**, in restoring, opens its contacts **311** to interrupt the circuit for delivering charging current from the rectifier **315** to the exchange battery. At its contacts **312**, the relay **R310** interrupts the input circuit to the rectifier **315**. Thus the last-mentioned rectifier is excluded from the charging circuit and the current delivered from the other rectifier **305** to the exchange battery is substantially reduced. By virtue of the switching operations just described, a tapering of the charging current delivered to the exchange battery is effected during the final portion of the charging period.

Following the operation of the switching relay **R320** and the release of the switching relay **R310**, the pulsing relay **R370** continues its intermittent operation. Each time this relay operates it opens its contacts **372** to interrupt the test circuit over which the medium voltage test relay **R300** is normally energized and closes its contacts **373** to complete the prepared locking circuit for the relay **R340**. Conversely, each time the relay **R370** restores it opens the locking circuit for the relay **R340** and recloses the medium voltage test circuit to cause the reoperation of the relay **R300**. So long as the medium voltage test relay **R300** operates in response to operation of the relay **R370**, the operating circuit for the relay **R340** is completed concurrently with the opening of the locking circuit for this relay. Accordingly, the relay **R350** remains in its operated position. If, for any reason, the battery voltage is decreased below a value of 52 volts during the final charging period under consideration, the medium voltage test relay **R300** will fail to reoperate in response to the release of the relay **R370**. This drop in battery voltage may be caused by a sudden rise in the load current demands of the system. In such case the relay **R300** and the relay **R370** will concurrently occupy their restored positions so that the relay **R340** is deenergized and restores. In releasing, the relay **R340** opens its contacts **343** to deenergize the switching relay **R320**. The relay **R320**, in releasing, closes its contacts **321** to again energize the relay **R310**, and closes its contacts **322** to short-circuit the adjustable resistor **324**. The relay **R310**, in reoperating, again includes the rectifier **315** in the charging circuit. Thus the two rectifiers **305** and **315** are again rendered operative to deliver their full-rated output currents to the exchange battery and the exchange load in parallel. In this regard it will be understood that when the voltage of the battery again rises to a value exceeding 52 volts, the relays **R300**, **R340** and **R320** will be operated in sequence to cause the release of the relay **R310** and thus reduce the charging current. With these three relays operated, charging current is delivered to the exchange battery from the rectifier **305** through the adjustable resistor **324**, so that ultimately the voltage of the battery will rise to a value exceeding 56 volts. When this occurs the relay **R350**, as energized in the above-traced high voltage test circuit, operates and closes its contacts **351** to complete the operating circuit for the relay **R360**. The relay **R360** now operates to prepare its own locking circuit and to complete the locking circuit for the relay **R350**. At its contacts **363**, the relay **R360** opens the medium voltage test circuit, thereby to cause the deenergization and release of the relay **R300**. At its contacts **364**, the relay **R360** interrupts the above-traced operating circuit for the relays **R310** and **R330**. The relay **R300**, in restoring, opens its contacts **301** to interrupt the operating circuit for the relay **R340**, and thus causes the sequential release of the relays **R340** and **R320**. The relay **R330**, in restoring, opens its contacts **331** and **332** to interrupt the input and output circuits of the rectifier **305**. Thus the charging operation is terminated and the control equipment is restored to its normal condition. It will be understood that the charging cycle just described is repeated each time the voltage of the exchange battery drops below the start charging value of 48 volts.

In the event the voltage of the battery drops below the start charging value during a period when the pulsing relay **R370** occupies its restored position, the low voltage alarm relay **R390** becomes insufficiently energized to remain in its operated position and, accordingly, restores. In this regard it will be appreciated that since the pulses for intermittently energizing the relay **R370** are derived from the common equipment illustrated in Fig. 6 of the drawings, this relay may not operate for substantial time intervals during the light traffic periods. It is possible, therefore, that the voltage of the exchange battery may drop below the start charging value during one of the prolonged periods when the relay **R370** occupies its restored position. In releasing, the relay **R390** closes its contacts **391** to complete an obvious circuit for energizing the slow-to-operate relay **R380** in parallel with the lower winding of the pulsing relay **R370**. The relay **R370** now operates and, shortly thereafter, the relay **R380** operates. The latter relay, in operating, opens its contacts **382** to cause the deenergization and release of the relay **R370**.

When the relay R370 is thus operated and released, the relay R350 fails to reoperate due to the low voltage condition of the exchange battery. Accordingly the relay R360 is deenergized and restores. In operating, the relay R380 also closes its contacts 383 to complete an obvious alternative circuit for energizing the two switching relays R310 and R330, whereby the operation of the two rectifiers 305 and 315 to deliver charging current to the exchange battery is initiated. At its contacts 381, the relay R380 also completes an obvious circuit for energizing the signal device 392. This signal device, in operating, serves to indicate the low voltage condition of the exchange battery. The relay R380, in operating, also functions to condition the associated alarm signaling equipment, not shown, to transmit an alarm signal to a supervisory operator's position located in one of the distant manual offices 5 and 6, all in a manner well understood in the art.

After the operation of the two rectifiers 305 and 315 is initiated by the low voltage alarm relay R390, in the manner just explained, the voltage of the exchange battery will ultimately rise to a value exceeding 52 volts, whereby the two relays R300 and R340 are caused sequentially to operate in the manner explained above. The relay R340, in operating, closes its contacts 344 to short-circuit the resistor 345 and thus increase the energization of the low voltage alarm relay R390. The relay R390 now reoperates and opens its contacts 391 to cause the deenergization and release of the relay R380. The relay R380, upon restoring, opens the alarm signaling circuits and opens its contacts 383 to interrupt the above-described alternative operating circuit for the two switching relays R310 and R330. Following the reoperation of the relay R390 and the release of the relay R380, the charging circuit is controlled in the normal manner described above.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein, and it is contemplated to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a telephone system, a plurality of subscribers' lines divided into groups and arranged for different classes of service, a plurality of trunk lines, a plurality of links for setting up connections between said lines, and apparatus common to said links and including means controlled on a per line basis in accordance with the classification of different calling subscribers' lines for permitting certain of the subscribers' lines of one group to obtain access to said trunk lines through said links and for preventing other subscribers' lines of the same group from obtaining access to said trunk lines through said links.

2. In a telephone system, a plurality of subscribers' lines divided into groups and arranged for different classes of service, a plurality of trunk lines, a plurality of links each including a finder switch comprising group and unit relays, equipment common to said links and including auxiliary groups and unit relays operative to control the group and unit relays of said finder switches in setting up connections through said links, and means comprising said auxiliary group and unit relays for permitting the subscribers' lines of one class in one of said groups to obtain access to said trunk lines through said links and for preventing the subscribers' lines of another class in said one group from obtaining access to said trunk lines through said links.

3. In a telephone system, a plurality of subscribers' lines divided into groups and arranged for different classes of service, a plurality of trunk lines, a plurality of links each including a finder switch comprising group and unit relays, equipment common to said links and including auxiliary group and unit relays operative to control the group and unit relays of said finder switches in setting up connections through said links, right of way control circuits individual to said links and each including means for permitting calling lines to obtain access to said trunk lines through the associated link, and means comprising said auxiliary group and unit relays for controlling said circuits to permit the subscribers' lines of one class in one of said groups to obtain access to said trunk lines through said links and to prevent the subscribers' lines of another class in said one group from obtaining access to said trunks through said links.

4. In a telephone system, a plurality of subscribers' lines divided into groups and arranged for different classes of service, a plurality of trunk lines, a plurality of finder-selector links each including a finder switch having access to said subscribers' lines and a selector switch having access to said trunk lines, each of said switches including group and unit relays, one of the group relays of each selector switch having outlet contacts through which said trunk lines are accessible to the associated link, an operating circuit for each of the trunk group access relays of said selector switches, each of said links including a control relay operative to prepare the associated one of said operating circuits, equipment common to said links and including auxiliary group and unit relays for controlling the group and unit relays of said finder switches in setting up connections through said links, and means including said auxiliary group and unit relays for selectively energizing said control relays to permit the subscribers' lines of one class in one of said groups to obtain access to said trunk lines through said links and for preventing the subscribers' lines of another class in said one group from obtaining access to said trunk lines through said links.

5. In a telephone system, a plurality of subscribers' lines divided into groups and arranged for different classes of service, a plurality of trunk lines, a plurality of finder-selector links each including a finder switch having access to said subscribers' lines and a selector switch having access to said trunk lines, each of said switches including group and unit relays, one of the group relays of each selector switch having outlet contacts through which said trunk lines are accessible to the associated link, each of said links including a signaling circuit, a pulsing circuit and a restricted service relay operative to control said circuits, an operating circuit for each of said restricted service relays, an operating circuit for each of the trunk group access relays of said selector switches, each of said links further comprising a control relay which in one position is operative to prepare the operating circuit for the associated restricted service relay and in another position is operative to prepare the operating circuit for the associated trunk group access relay, equipment common to said links and including auxiliary group and unit relays for controlling the group and unit relays of said finder switches in setting up connections through said

links, and means including said auxiliary group and unit relays for selectively energizing said control relays to permit the subscribers' lines of one class in one of said groups to obtain access to said trunk lines through said links and for preventing the subscribers' lines of another class in said one group from obtaining access to said trunk lines through said links.

6. In a telephone system, a plurality of subscribers' lines divided into groups and arranged for different classes of service, a plurality of trunks, a plurality of links each including a finder switch having access to said subscribers' lines and a selector switch having access to said trunk lines, equipment common to said links and including apparatus for controlling said finder switches in setting up connections through said links, each of said links including a signaling circuit and a restricted service relay operative to cause the completion of said signaling circuit, and means including said apparatus for controlling said relays to cause the energization thereof when calls intended for said trunk lines are routed to the associated links over calling subscribers' lines of one class and for preventing the energization of said relays when calls intended for said trunk lines are routed to the associated links over calling lines of another class.

7. In a telephone system, a plurality of subscribers' lines divided into groups and arranged for different classes of service, a plurality of trunks, a plurality of links each including a finder switch having access to said subscribers' lines and a selector switch having access to said trunk lines, equipment common to said links and including apparatus for controlling said finder switches in setting up connections through said links, each of said links including a pulsing circuit over which the selector switch of the link is controlled and a restricted service relay operative to cause the interruption of said pulsing circuit, and means including said apparatus for controlling said relays to cause the energization thereof when calls intended for said trunk lines are routed to the associated links over calling subscribers' lines of one class and for preventing the energization of said relays when calls intended for said trunk lines are routed to the associated links over calling lines of another class.

8. In a telephone system, a plurality of subscribers' lines divided into groups and arranged for different classes of service, a plurality of trunks, a plurality of links each including a finder switch having access to said subscribers' lines and a selector switch having access to said trunk lines, equipment common to said links and including apparatus for controlling said finder switches in setting up connections through said links, each of said links including a signaling circuit, a pulsing circuit over which the selector switch is controlled and a restricted service relay operative to cause the completion of said signaling circuit and the interruption of said pulsing circuit, and means including said apparatus for controlling said relays to cause the energization thereof when calls intended for said trunk lines are routed to the associated links over calling subscribers' lines of one class and for preventing the energization of said relays when calls intended for said trunk lines are routed to the associated links over calling lines of another class.

9. In a selector switch of the type which includes group and unit relays, a restricted service relay, impulse controlled means for selectively energizing a predetermined one of said group relays and said restricted service relay in response to a predetermined series of impulses transmitted to said switch, and a signaling circuit controlled by said restricted service relay.

10. In a selector switch of the type which includes group and unit relays, a restricted service relay, a pulsing circuit, means controlled over said circuit for selectively energizing a predetermined one of said group relays and said restricted service relay in response to a predetermined series of impulses transmitted to said switch, a signaling circuit, and means responsive to operation of said restricted service relay for completing said signaling circuit and for opening said pulsing circuit.

11. In a selector switch of the all-relay type which is accessible to calling lines arranged for different classes of service, group and unit relays, a restricted service relay, an operating circuit for one of said group relays, an operating circuit for said restricted service relay, means controlled in accordance with the classification of a calling one of said lines over which said switch is seized for selectively preparing said circuits, impulse controlled means for completing the prepared one of said circuits in response to a predetermined series of impulses transmitted to said switch, and a signaling circuit controlled by said restricted service relay.

12. In a selector switch of the all-relay type which is accessible to calling lines arranged for different classes of service, group and unit relays, a restricted service relay, an operating circuit for one of said group relays, an operating circuit for said restricted service relay, means controlled in accordance with the classification of a calling one of said lines over which said switch is seized for selectively preparing said circuits, impulse controlled means for completing the prepared one of said circuits in response to a predetermined series of impulses transmitted to said switch, a signaling circuit extending from said switch to said calling line, and means responsive to operation of said restricted service relay for completing said signaling circuit and for rendering said switch non-responsive to further impulses transmitted over said calling line.

13. In a link of the all-relay type which includes a finder switch controllable by apparatus common to several links to seize calling lines arranged for different classes of service; a selector switch comprising group and unit relays, a restricted service relay, an operating circuit for one of said group relays, an operating circuit for said restricted service relay, means controlled by said common equipment in accordance with the classification of a calling one of said lines over which said link is seized for selectively preparing said circuits, impulse controlled means for completing the prepared one of said circuits in response to a predetermined series of impulses transmitted to said link over the calling line, and a signaling circuit controlled by said restricted service relay.

14. In a link of the all-relay type which includes a finder switch controllable by apparatus common to several links to seize calling lines arranged for different classes of service; a selector switch comprising group and unit relays, a restricted service relay, an operating circuit for one of said group relays, an operating circuit for said restricted service relay, means controlled by said common equipment in accordance with the classification of a calling one of said lines

over which said link is seized for selectively preparing said circuits, impulse controlled means for completing the prepared one of said circuits in response to a predetermined series of impulses transmitted to said link over the calling line, a signaling circuit extending from said switch to said calling line, and means responsive to operation of said restricted service relay for completing said signaling circuit and for rendering said switch non-responsive to further impulses transmitted over said calling line.

15. In a telephone system, a group of trunks, a plurality of selectors each including unit relays and a group relay having outlet contacts through which said trunks may be seized, and means for controlling the unit relays of said selectors so that said trunks are seized through said selectors in rotation.

16. In a telephone system, a pair of trunks, a plurality of selectors each including unit relays corresponding to said trunks and a group relay having outlet contacts through which said trunks may be seized, means for controlling the unit relays of one of said selectors to seize one of said trunks, and means for controlling the unit relays of another of said selectors to seize the other of said trunks regardless of the idle or busy condition of said one trunk.

17. In a telephone system, a group of trunks, a plurality of selectors each including unit relays corresponding to said trunks and a group relay having control contacts and outlet contacts through which said trunks may be seized, a group of trunk preselect relays, circuits extending by way of said control contacts and the contacts of said preselect relays for energizing said unit relays, and means including said preselect relays for controlling said circuits so that said trunks are seized through said selectors in rotation.

18. In a telephone system, a group of trunks including trunks of two different classes, a plurality of selectors each including unit relays corresponding to said trunks and a group relay having outlet contacts through which said trunks may be seized, means for controlling the unit relays of said selectors so that the trunks of one class in said group are seized through said selectors in rotation, and means for controlling the unit relays of said selectors so that the trunks of the other class in said group are seized through said selectors in accordance with a predetermined preference pattern.

19. In a telephone system, a group of trunks including trunks of two different classes, a plurality of selectors each including unit relays corresponding to said trunks and a group relay having sets of outlet contacts through which said trunks may be seized, said sets of outlet contacts having consecutive directory number assignments, means for controlling the unit relays of said selectors so that the trunks of one class in said group are seized in rotation without regard to the directory number assignments of the associated contact sets so long as calls are nonconcurrently handled by said trunks, and means for controlling the unit relays of said selectors so that the trunks of the other class in said group are seized through said selectors in the order of increasing directory number assignments of the associated contact sets as successive and overlapping calls are routed through said selectors to said trunks.

20. In a telephone system, a group of trunks including trunks of two classes, a plurality of directively-controlled selectors each including consecutively numbered sets of outlet contacts arranged in groups, all of the trunks of said group being accessible to each of said selectors through consecutively numbered first sets of outlet contacts in one group of contacts of the selector and the trunks of one class in said group also being accessible to each of said selectors through consecutively numbered second sets of outlet contacts in another group of contacts of the selector, means for controlling the trunk selecting operation of said selectors so that the trunks of said one class are seized through the first sets of outlet contacts of said selectors on a preferential basis in the order of increasing numbers of the corresponding contact sets and the trunks of the other class are seized through the first sets of outlet contacts of said selectors in rotation, and means for further controlling the trunk selecting operation of said selectors so that the trunks of said one class are seized through the second sets of outlet contacts of said selectors in rotation.

21. In a telephone system, a group of trunks including trunks of two classes, a plurality of directively-controlled selectors each having access to the trunks of one class over paths extending through the outlet contacts thereof and each having access to each of the trunks of the other class over either of two alternative paths both extending through the outlet contacts thereof, means for imposing a restriction on the use of the trunks of said other class when seized through said selectors over predetermined ones of said alternative paths, and means for controlling the trunk selecting operation of said selectors so that the trunks of said one class are seized through said selectors in rotation and the trunks of said other class are seized through said selectors on a preferential basis in accordance with a predetermined preference pattern.

22. In a telephone system, a group of trunks including trunks of two classes, a plurality of directively-controlled selectors each having access to the trunks of one class over paths extending through the outlet contacts thereof and each having access to each of the trunks of the other class over either of two alternative paths both extending through the outlet contacts thereof, means for imposing a restriction on the use of the trunks of said other class when seized through said selectors over predetermined ones of said alternative paths, means for controlling the trunk selecting operation of said selectors so that the trunks of said other class are seized in rotation over said predetermined alternative paths of said selectors, and means for further controlling the trunk selecting operation of said selectors so that the trunks of said one class are seized through said selectors in rotation and the trunks of said other class are seized through the other alternative paths of said selectors on a preferential basis in accordance with a predetermined preference pattern.

23. In a telephone system, a group of trunks including toll trunks and combination toll and free service trunks, a plurality of directively-controlled selectors each having access to said toll trunks over paths extending through the outlet contacts thereof and each having access to each of said combination trunks over toll and free service paths which extend through different sets of outlet contacts of each selector, means for imposing a restriction on the use of said combination trunks and when seized over said free serv-

ice paths, and trunk preselect means for controlling the trunk selecting operation of said selectors so that the toll trunks are seized through said links in rotation and the combination trunks are seized through said selectors on a preferential basis in accordance with a predetermined preference pattern.

24. In a telephone system, a group of trunks including toll trunks and combination toll and free service trunks, a plurality of directively-controlled selectors each having access to said toll trunks over paths extending through the outlet contacts thereof and each having access to each of said combination trunks over toll and free service paths which extend through different sets of outlet contacts of each selector, means for imposing a restriction on the use of said combination trunks and when seized over said free service paths, trunk preselect means for controlling the trunk selecting operation of said selectors so that said combination trunks are seized in rotation over said free service paths, and trunk preselect means for further controlling the trunk selecting operation of said selectors so that the toll trunks are seized through said selectors in rotation and the combination trunks are seized over the toll paths of said selectors on a preferential basis in accordance with a predetermined preference pattern.

25. In a telephone system, a group of trunks including toll trunks and combination toll and free service trunks, a plurality of directively-controlled selectors each including consecutively numbered sets of outlet contacts arranged in groups, all of the trunks of said group being accessible to each of said selectors through consecutively numbered sets of outlet contacts in one group of contacts of the selector and the combination toll and free service trunks being accessible to each of said selectors through consecutively numbered sets of outlet contacts in another group of contacts of the selectors, whereby each of said combination trunks may be seized through each selector over either a toll path or a free service path, means for imposing a restriction on the use of said combination trunks only when seized over said free service paths, and means for controlling the trunk selecting operation of said selectors so that said toll trunks are seized through said links in rotation and said combination trunks are seized through said selectors on a preferential basis in the order of increasing numbers of the corresponding contact sets.

26. In a telephone system, a group of trunks including toll trunks and combination toll and free service trunks, a plurality of directively-controlled selectors each including consecutively numbered sets of outlet contacts arranged in groups, all of the trunks of said group being accessible to each of said selectors through consectively numbered sets of outlet contacts in one group of contacts of the selector and the combination toll and free service trunks being accessible to each of said selectors through consecutively numbered sets of outlet contacts in another group of contacts of the selectors, whereby each of said combination trunks may be seized through each selector over either a toll path or a free service path, means for imposing a restriction on the use of said combination trunks only when seized over said free service paths, and means for controlling the trunk selecting operation of said selectors so that said toll trunks are seized through said links in rotation and said combination trunks are seized over the toll paths of said selectors on a preferential basis in the order of increasing numbers of the corresponding contact sets, and means for further controlling the trunk selecting operation of said selectors so that combination trunks are seized in rotation over the free service paths of said selectors.

27. In a telephone system, a plurality of trunks, a plurality of directively-controlled selectors each having access to each of said trunks over either of two paths, and means for controlling the trunk selecting operation of said selectors so that said trunks are seized through said selectors on a preferential basis in accordance with a predetermined preference pattern or in rotation depending upon the paths of said selectors over which the trunks are seized.

28. In a telephone system, a plurality of trunks, a plurality of directively-controlled selectors each having access to each of said trunks over either of two paths, means for imposing a restriction on the use of said trunks when seized over predetermined ones of said paths, means for controlling the trunk selecting operation of said selectors so that said trunks are seized over said predetermined paths of said selectors in rotation, and means for further controlling the trunk selecting operation of said selectors so that said trunks are seized over the other paths of said selectors on a preferential basis in accordance with a predetermined preference pattern.

29. In a telephone system, a plurality of trunks, a plurality of directively-controlled selectors each having access to each of said trunks over either of two paths and each including unit relays individually corresponding to said trunks, and means for controlling the unit relays of said selectors so that said trunks are seized through said selectors on a preferential basis in accordance with a predetermined preference pattern or in rotation depending upon the paths of said selectors over which the trunks are seized.

30. In a telephone system, a plurality of trunks, a plurality of directively-controlled selectors each having access to each of said trunks over either of two paths and each including unit relays individually corresponding to said trunks, means for imposing a restriction on the use of said trunks when seized over predetermined ones of said paths, means for controlling the unit relays of said selectors so that said trunks are seized over said predetermined paths in rotation, and means for further controlling the unit relays of said selectors so that said trunks are seized over the other paths of said selectors on a preferential basis in accordance with a predetermined preference pattern.

31. In a telephone system, a group of trunks including trunks of two different classes, a plurality of selectors having access to said trunks and each including unit relays individually corresponding to said trunks, each of the trunks of one class being accessible to each selector over either of two paths, means for controlling the unit relays of said selectors so that the trunks of said one class are seized through said selectors on a preferential basis in accordance with a predetermined preference pattern or in rotation depending upon the paths over which the trunks are seized, and means for further controlling the unit relays of said selectors so that the trunks of the other class are seized through said selectors in rotation.

32. In a telephone system, a group of trunks, a plurality of overflow trunks, a plurality of selec-

tors having access to said trunks and each including unit relays individually corresponding to said trunks, means for controlling the unit relays of said selectors so that the trunks of said group are seized through said selectors in rotation, and means for controlling the unit relays of said selectors so that said overflow trunks are seized through said selectors on a preferential basis in accordance with a predetermined preference pattern.

33. In a telephone system, a group of trunks including trunks of two different classes, a plurality of selectors each including unit relays corresponding to said trunks and a pair of group relays, one of the group relays of each selector including consecutively numbered sets of contacts individually corresponding to said trunks and through which all of the trunks of said group may be seized, the other group relay of each selector including consecutively numbered sets of contacts individually corresponding to the trunks of one class in said group and through which only the trunks of said one class may be seized, means for imposing a restriction on the use of the trunks of said one class when seized through the contacts of said other group relays, means for controlling the unit relays of said selectors so that the trunks of said one class are seized through said selectors in the order of increasing numbers of the corresponding contact sets, and means for controlling the unit relays of said selectors so that the trunks of the other class are seized through said selectors in rotation.

34. In a telephone system, a group of trunks including trunks of two different classes, a plurality of selectors each including unit relays corresponding to said trunks and a pair of group relays, one of the group relays of each selector including consecutively numbered sets of contacts individually corresponding to said trunks and through which all of the trunks of said group may be seized, the other group relay of each selector including consecutively numbered sets of contacts individually corresponding to the trunks of one class in said group and through which only the trunks of said one class may be seized, means for imposing a restriction on the use of the trunks of said one class, means operative to prevent the operation of said last-named means when the trunks of said one class are seized through the contacts of said one group relays, means for controlling the unit relays of said selectors so that the trunks of said one class are seized through the contacts of said one group relays of said selectors in the order of increasing numbers of the corresponding contact sets and are seized in rotation through the contacts of said other group relays of said selectors, and means for controlling the unit relays of said selectors so that the trunks of the other class are seized through said selectors in rotation.

35. In a telephone system a group of trunks including toll trunks and combination toll and free service trunks, a plurality of selectors each including unit relays corresponding to said trunks and a pair of group relays, one of the group relays of each selector including consecutively numbered sets of contacts individually corresponding to said trunks and through which all of the trunks of said group may be seized, the other group relay of each selector including consecutively numbered sets of contacts individually corresponding to said combination trunks and through which said combination trunks may be seized, means for restricting the use of said combination trunks to a predetermined time interval when seized through the contacts of said other group relays, means for controlling the unit relays of said selectors so that said combination trunks are seized through the contacts of said one group relays of said selectors in the order of increasing numbers of the corresponding contact sets and are seized in rotation through the contacts of said other group relays of said selectors, and means for controlling the unit relays of said selectors so that the trunks of the toll trunks are seized through said selectors in rotation.

36. In a telephone system, a trunk, a selector including outlet contacts and having access to said trunk over either of two different paths which respectively include different sets of said outlet contacts, and means for imposing a restriction on the use of said trunk when seized through said selector over one of said paths.

37. In a telephone system, a trunk, a selector including outlet contacts and having access to said trunk over either of two different paths which respectively include different sets of said outlet contacts, and means for restricting the use of said trunk to a predetermined time interval when said trunk is seized through said selector over one of said paths.

38. In a telephone system, a trunk, a selector including outlet contacts and having access to said trunk over either of two different paths which respectively include different sets of said outlet contacts, means for imposing a restriction on the use of said trunk when seized through said selector over one of said paths, and means responsive to the seizure of said trunk over the other of said paths for preventing the operation of said last-named means.

39. In a telephone system, a trunk, a selector including outlet contacts and having access to said trunk over either of two different paths which respectively include different sets of said outlet contacts, means for restricting the use of said trunk to a predetermined time interval when said trunk is seized through said selector over one of said paths and means responsive to the seizure of said trunk over the other of said paths for preventing the operation of said last-named means.

40. In a telephone system, an operator's position, a trunk extending to said operator's position, a directively-controlled selector including outlet contacts and having access to said trunk over either of two different paths which respectively include different sets of said outlet contacts, means for imposing a restriction on the use of said trunk when said trunk is seized over one of said paths, and means controllable over said trunk from said operator's position for rendering said last-named means ineffective to impose said restriction on the use of said trunk.

41. In a telephone system, an operator's position, a trunk extending to said operator's position, a directively-controlled selector including outlet contacts and having access to said trunk over either of two different paths which respectively include different sets of said outlet contacts, means for limiting the use of said trunk to a predetermined time interval when seized over one of said paths, and means controllable over said trunk from said operator's position for rendering said last-named means ineffective to limit the use of said trunk.

42. In a telephone system, an operator's position, a two-way trunk extending to said opera-

tor's position, a directively-controlled selector including outlet contacts and having access to said trunk over either of two different paths which respectively include different sets of said outlet contacts, control means for imposing a restriction on the use of said trunk when seized over one of said paths or from said operator's position, means controllable from said operator's position for preventing said control means from imposing said restriction on the use of said trunk, and means responsive to the seizure of said trunk over the other of said paths for preventing said control means from imposing said restriction on the use of said trunk.

43. In a telephone system, an operator's position, a two-way trunk extending to said operator's position, a directively-controlled selector including outlet contacts and having access to said trunk over either of two different paths which respectively include different sets of said outlet contacts, control means for restricting the use of said trunk to a predetermined time interval when said trunk is seized over one of said paths or from said operator's position, means controllable from said operator's position for preventing said control means from imposing said timing restriction on the use of said trunk, and means responsive to the seizure of said trunk over the other of said paths for preventing said control means from imposing said timing restriction on the use of said trunk.

44. In a telephone system, an automatic exchange, an operator's position, means for establishing a connection which extends through said exchange and said operator's position, means for automatically disabling said connection a predetermined time interval after it is completed regardless of the direction of routing thereof, and means controllable from said operator's position for rendering said last-named means inoperative to disable said connection.

45. In a telephone system, an automatic exchange, lines extending to said exchange, an operator's position, means for extending a connection from said operator's position through said exchange to one of said lines, means operative automatically to disable said connection a predetermined time interval after it is completed, and means controllable from said operator's position for rendering said last-named means inoperative to disable said connection.

46. In a telephone system, an automatic exchange, lines extending to said exchange, a second exchange including an operator's position, a trunk extending from said operator's position to said automatic exchange, a repeater terminating said trunk in said automatic exchange, means including said trunk and said repeater for extending a connection from said operator's position through said automatic exchange to one of said lines, means for controlling said repeater to disable said connection a predetermined time interval after it is completed, and means in said repeater controllable over said trunk from said operator's position for rendering said last-named means inoperative to disable said connection.

47. In a telephone system, an automatic exchange, lines extending to said exchange, a second exchange including an operator's position, a trunk extending from said operator's position to said automatic exchange, a repeater terminating said trunk in said automatic exchange, means including said trunk and said repeater for establishing a connection which extends between said operator's position and one of said lines, said connection including a loop circuit which extends between said operator's position and said repeater, means at said operator's position for unbalancing said loop circuit, means for controlling said repeater to disable said connection a predetermined time interval after it is completed, and means in said repeater operative in response to an unbalanced condition of said loop circuit for rendering said last-named means inoperative to disable said connection.

48. In a telephone system, an automatic exchange, lines extending to said exchange, a second exchange including an operator's position, a trunk extending from said operator's position to said automatic exchange, a repeater terminating said trunk in said automatic exchange, means including said trunk and said repeater for extending a connection from said operator's position through said automatic exchange to one of said lines, said connection, when extended to said repeater, including a loop circuit which extends between said operator's position and said repeater, means at said operator's position for unbalancing said loop circuit, means for controlling said repeater to disable said connection a predetermined time interval after it is completed, and means comprising a differentially wound relay energized in said loop circuit and operative in response to an unbalanced condition of said loop circuit for rendering said last-named means inoperative to disable said connection.

49. In a telephone system, an automatic exchange including a plurality of switching links, lines extending to said exchange, an operator's position, a trunk extending from said operator's position to said exchange, a repeater terminating said trunk in said exchange, means including one of said links and said repeater for setting up a connection including said trunk and extending between one of said lines and said operator's position, a timing device, and means included in said repeater and controlled by said timing device for releasing said one link, locking said one line out of service and for transmitting a disconnect supervisory signal to said operator's position.

50. In a telephone system, an automatic exchange including a plurality of switching links, lines extending to said exchange, an operator's position, a trunk extending from said operator's position to said exchange, a repeater terminating said trunk in said exchange, means including one of said links and said repeater for setting up a connection including said trunk and extending between one of said lines and said operator's position, a timing device, means included in said repeater and controlled by said timing device for releasing said one link, locking said one line out of service and for transmitting a disconnect supervisory signal to said operator's position, and means controllable over said trunk from said operator's position for rendering said last-named means inoperative to perform the functions indicated.

51. In a telephone system, an automatic exchange including a plurality of switching links, lines extending to said exchange, an operator's position, a trunk extending from said operator's position to said exchange, a repeater terminating said trunk in said exchange, a line circuit individual to said repeater and having a setting in which said repeater is locked out of service, means including said repeater, said line circuit and one of said links for extending a connection from said operator's position to one of said lines,

timing means for controlling said repeater to release said link, lock said one line out of service and transmit a disconnect supervisory signal to said operator's position a predetermined time interval after said connection is established, and means operative incident to the release of said link for causing said line circuit to assume its lockout setting.

52. In a telephone system, an automatic exchange including a plurality of switching links, lines extending to said exchange, an operator's position, a trunk extending from said operator's position to said exchange, a repeater terminating said trunk in said exchange, a line circuit individual to said repeater and having a setting in which said repeater is locked out of service, means including said repeater, said line circuit and one of said links for extending a connection from said operator's position to one of said lines, timing means for controlling said repeater to release said link, lock said one line out of service and transmit a disconnect supervisory signal to said operator's position a predetermined time interval after said connection is established, means operative incident to the release of said link for causing said line circuit to assume its lockout setting, and means controllable from said operator's position over said trunk for rendering said timing means inoperative to perform the functions indicated.

53. In a telephone system, a pair of offices each including an operator's position, a tandem automatic exchange including links and inter-office trunk repeaters, means including one of said links connected between two of said repeaters for setting up a connection between said operators' positions, a release circuit extending through said one link between said two repeaters and including parallel branches which are respectively completed in said two repeaters, thereby to permit two-way supervisory signaling between said operator's positions without releasing the connection, means responsive to a connection release operation performed at one of said operators' positions for opening one of the branches of said circuit, and means responsive to a connection release operation performed at the other of said operators' positions for opening the other branch of said circuit, whereby said connection is only released when cleared out at both of said operators' positions.

54. In a telephone system, a pair of offices each including an operator's position, a tandem automatic exchange including links and inter-office trunk repeaters, means including one of said links connected between two of said repeaters for setting up a connection between said operators' positions, said connection comprising a plurality of tandem connected and reactively coupled loop circuits, a release circuit extending through said one link between said two repeaters and including two parallel branches, means individual to said two repeaters for respectively completing the parallel branches of said release circuit incident to the setting up of said connection, thereby to permit two-way open-loop closed-loop supervisory signaling between said operators' positions without releasing the connection, means responsive to the opening of one of said loop circuits at one of said positions for opening one branch of said release circuit, and means responsive to the opening of another of said loop circuits at the other of said positions for opening the other branch of said release circuit, whereby said connection is only released when cleared out at both of said operators' positions.

55. In a telephone system, a circuit for intercepting calls intended for predetermined lines of the system, said circuit comprising relays individually corresponding to said lines and energized by ringing current transmitted therethrough, means including an automatic switch having access to said circuit for extending a connection from a calling substation of the system to said circuit and for transmitting ringing current through one of said relays, means responsive to the operation of said one relay for guarding said circuit against seizure until released and for arresting the transmission of ringing current through said one relay, and means responsive to the operation of said one relay for transmitting a signal from said circuit to the calling substation.

56. In a telephone system, a circuit for intercepting calls intended for predetermined lines of the system, said circuit comprising relays individually corresponding to said lines, means including an automatic switch having access to said circuit for extending a connection from a calling substation of the system to said circuit and for transmitting ringing current to said circuit, means responsive to the transmission of ringing current to said circuit for energizing one of said relays, means responsive to the operation of said one relay for arresting the transmission of ringing current to said circuit and for preventing the other relays from operating until said circuit is released, and means responsive to the operation of said one relay for transmitting a signal from said circuit to said calling substation.

57. In a telephone system, a circuit for intercepting calls intended for predetermined lines of the system, said circuit comprising relays individually corresponding to said lines, means including an automatic switch having access to said circuit for extending a connection from a calling substation of the system to said circuit and for transmitting ringing current to said circuit, means responsive to the transmission of ringing current to said circuit for energizing one of said relays, means responsive to the operation of said one relay for arresting the transmission of ringing current to said circuit and for preventing the other relays from operating until said circuit is released, a signal current generator operative to transmit signaling current from said circuit to said calling substantion, means responsive to the operation of said one relay for initiating the operation of said generator, and means responsive to the release of said connection for deenergizing said one relay, thereby to cause the release of said circuit.

58. In a telephone system, a circuit for intercepting calls intended for predetermined lines of the system, said circuit comprising relays individually corresponding to said lines, operating circuits for said relays, said operating circuits comprising a common portion which includes chain-connected contacts individually controlled by said relays, whereby only one of said relays can be energized at a time, means including an automatic switch having access to said circuit for extending a connection from a calling substation of the system to said circuit and for energizing one of said relays, and means responsive to the operation of said one relay for arresting the transmission of ringing current to said circuit and for transmitting a signal from said circuit to the calling substation.

59. In a telephone system, a circuit for intercepting calls intended for a predetermined line of the system, said circuit comprising a signal current generator operative to transmit signal current to a calling substation of the system, and means including an automatic switch for extending a connection from a calling substation of the system to said circuit and for initiating the operation of said generator.

60. In a telephone system, a circuit for intercepting calls intended for a predetermined line of the system, said circuit comprising a signal current generator operative to transmit signal current to a calling substation of the system, means including an automatic switch for extending a connection from a calling substation of the system to said circuit and for transmitting ringing current to said circuit, a relay energized by the ringing current transmitted to said circuit, and means responsive to the operation of said relay for arresting the transmission of ringing current to said circuit and for initiating the operation of said generator.

EDWARD S. PETERSON.