Jan. 7, 1941. R. E. COLLIS ET AL 2,227,488

TELEPHONE SYSTEM

Filed June 17, 1938 9 Sheets-Sheet 1

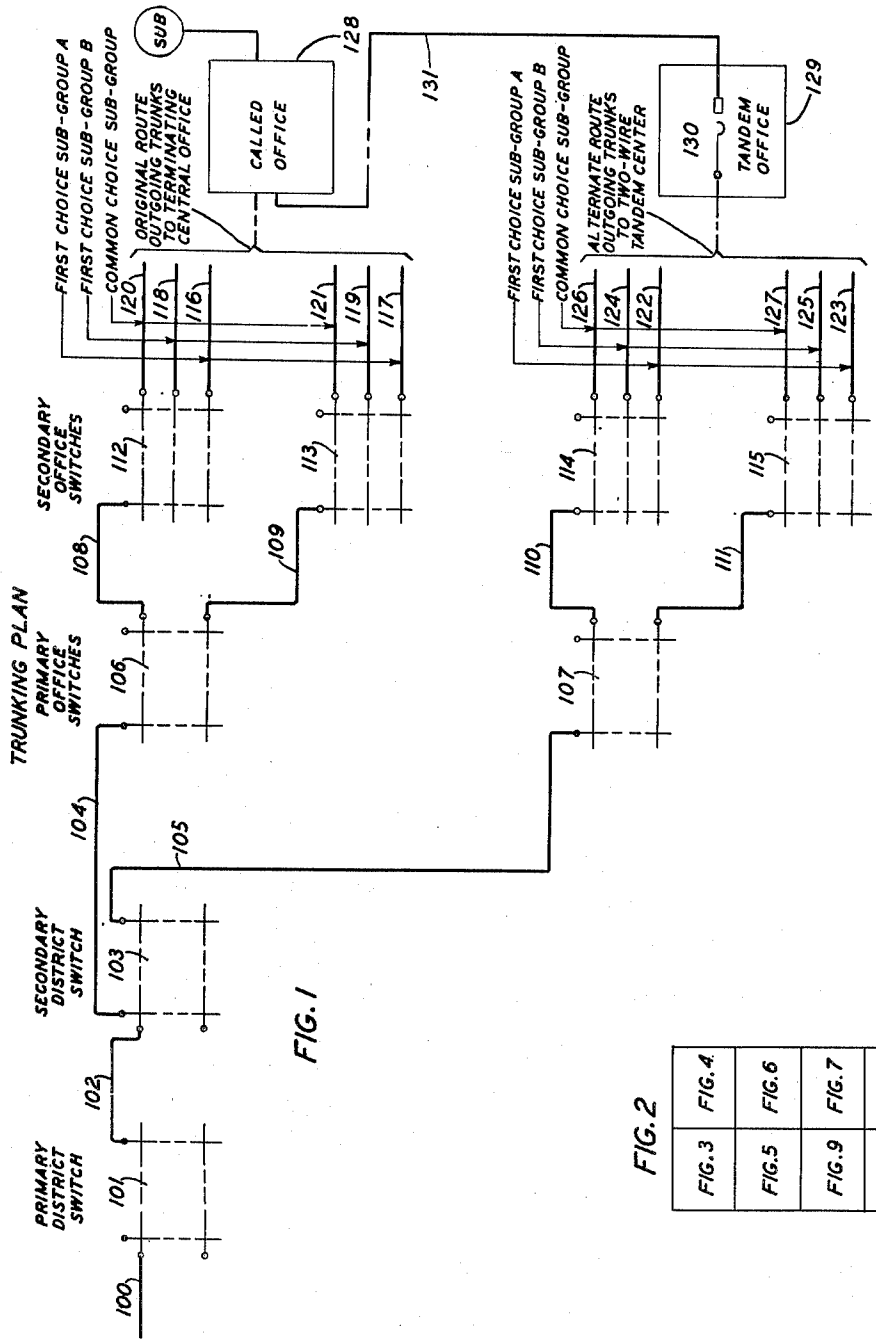

FIG. 1

FIG. 2

FIG. 3	FIG. 4
FIG. 5	FIG. 6
FIG. 9	FIG. 7
FIG. 10	FIG. 8

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TELEPHONE SYSTEM

Filed June 17, 1938 9 Sheets-Sheet 2

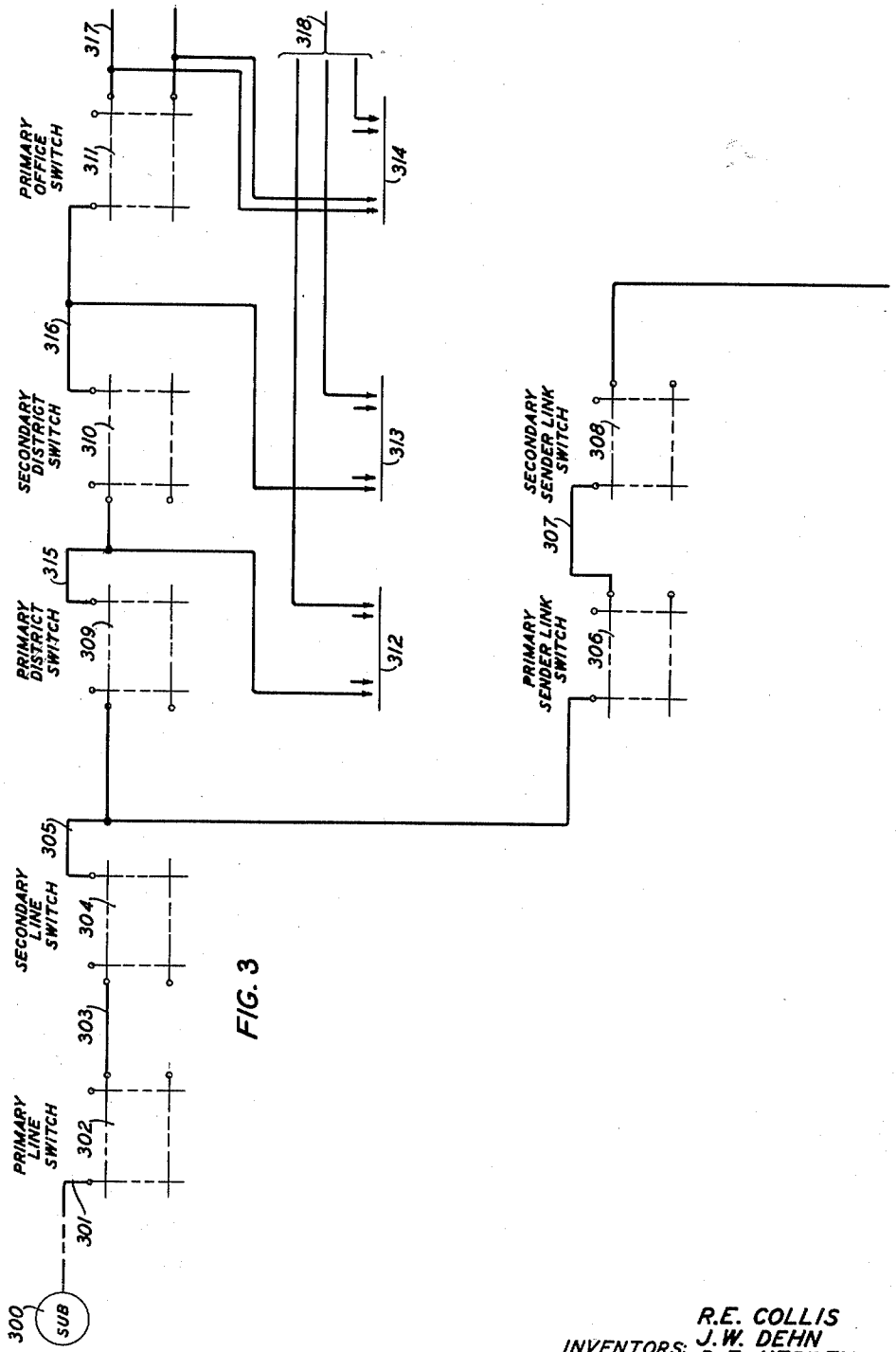

FIG. 3

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TELEPHONE SYSTEM

Filed June 17, 1938 9 Sheets-Sheet 3

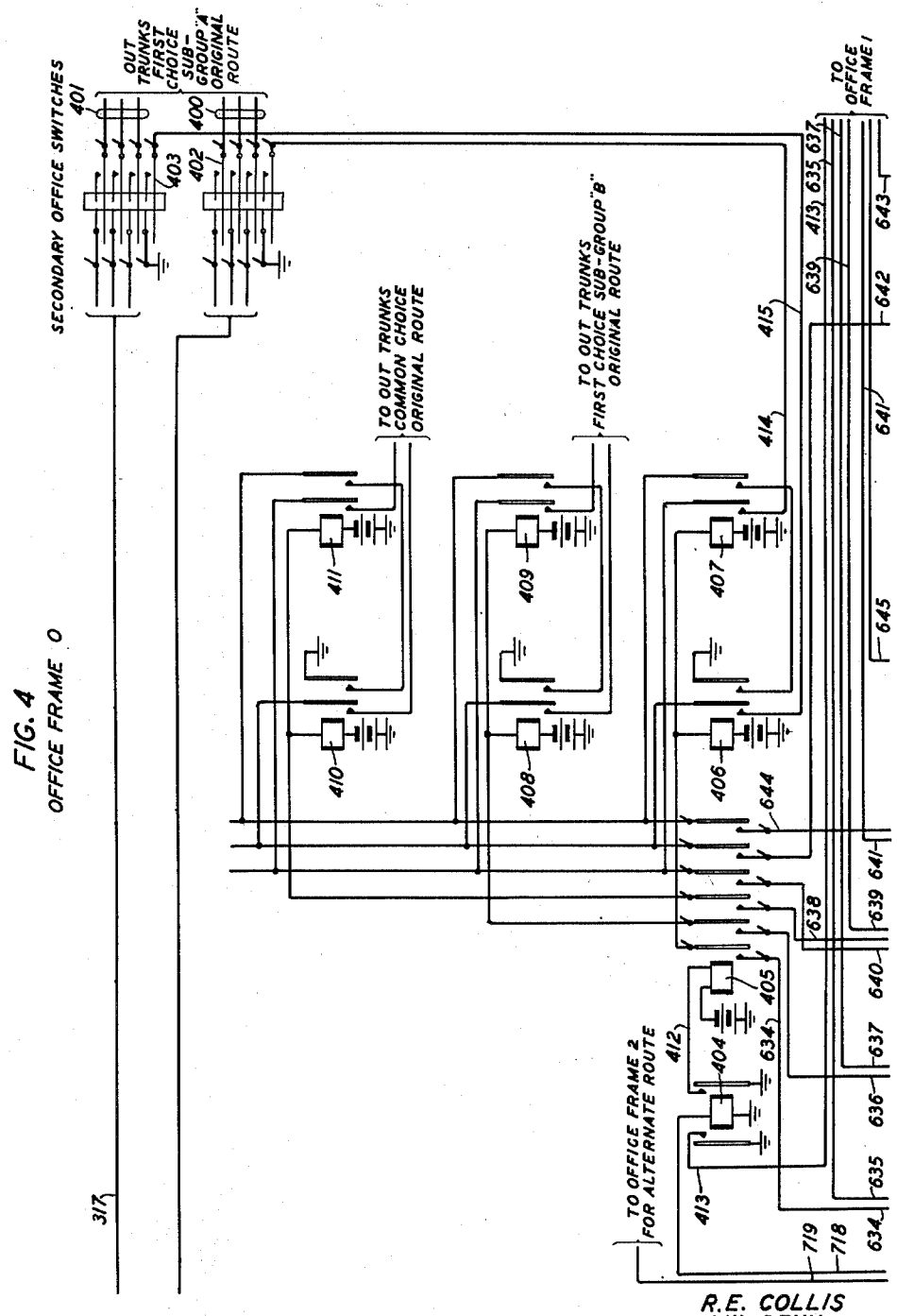

FIG. 4

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TELEPHONE SYSTEM

Filed June 17, 1938 9 Sheets-Sheet 4

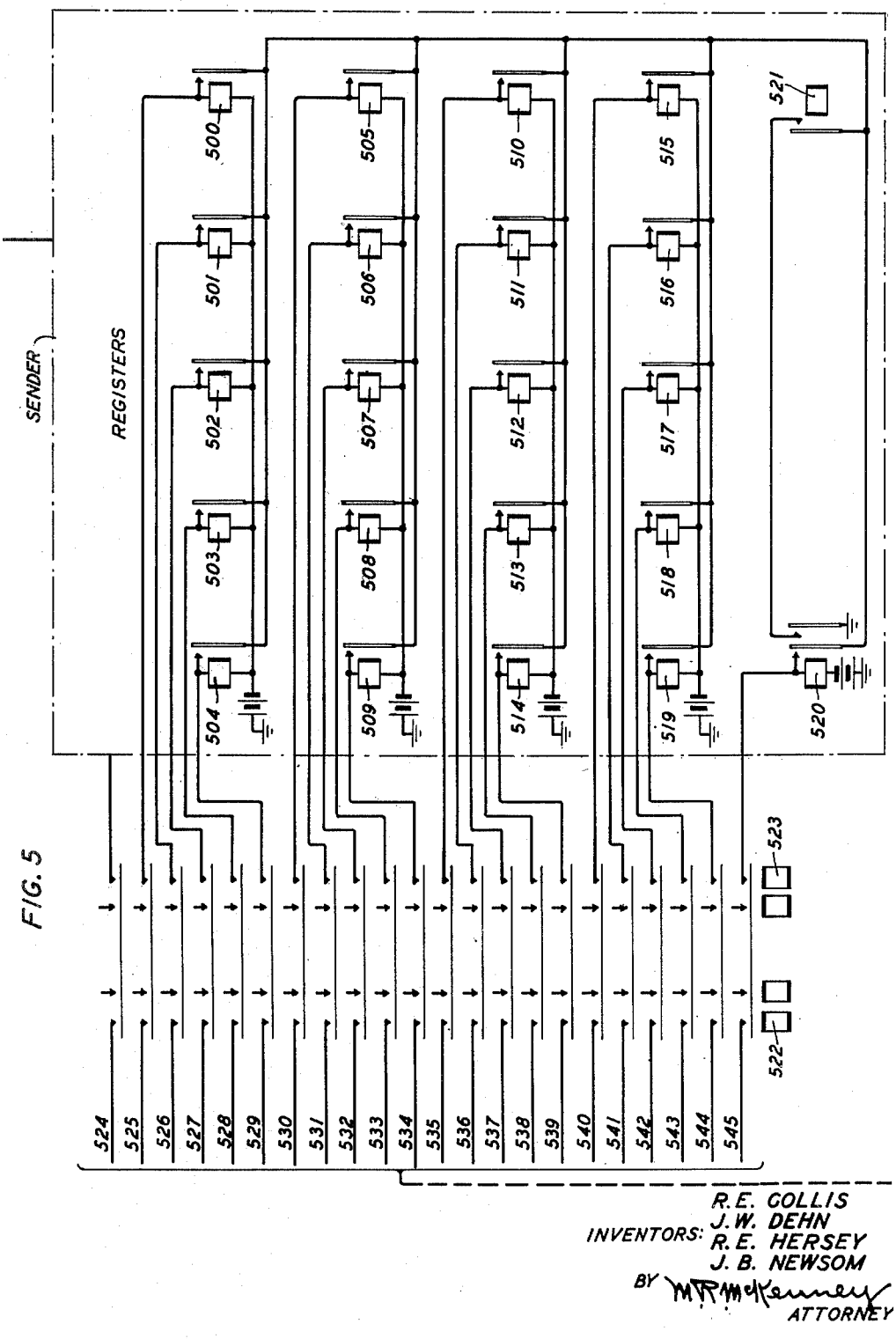

FIG. 5

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TELEPHONE SYSTEM

Filed June 17, 1938 9 Sheets-Sheet 5

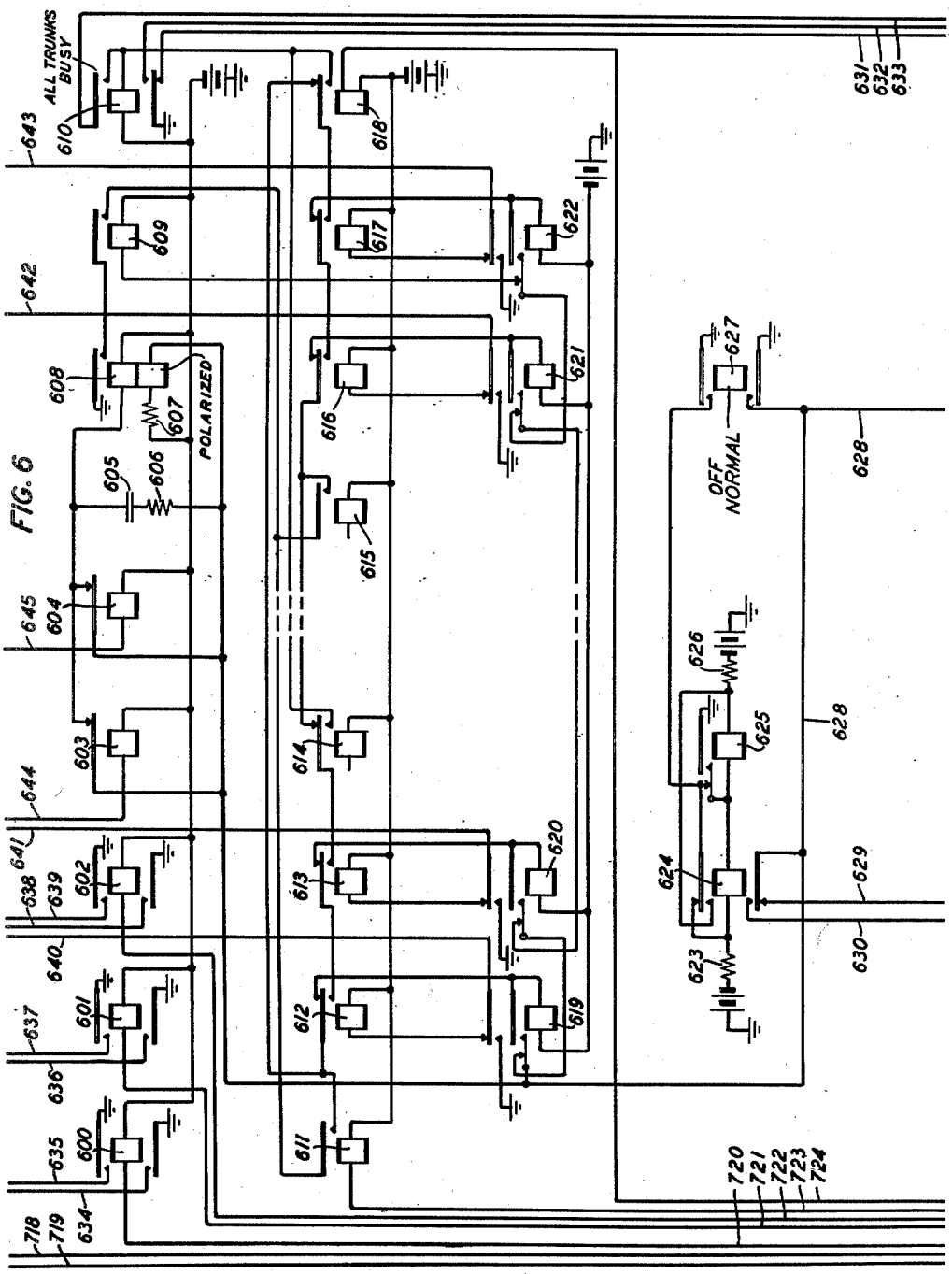

FIG. 6

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TELEPHONE SYSTEM

Filed June 17, 1938 9 Sheets-Sheet 6

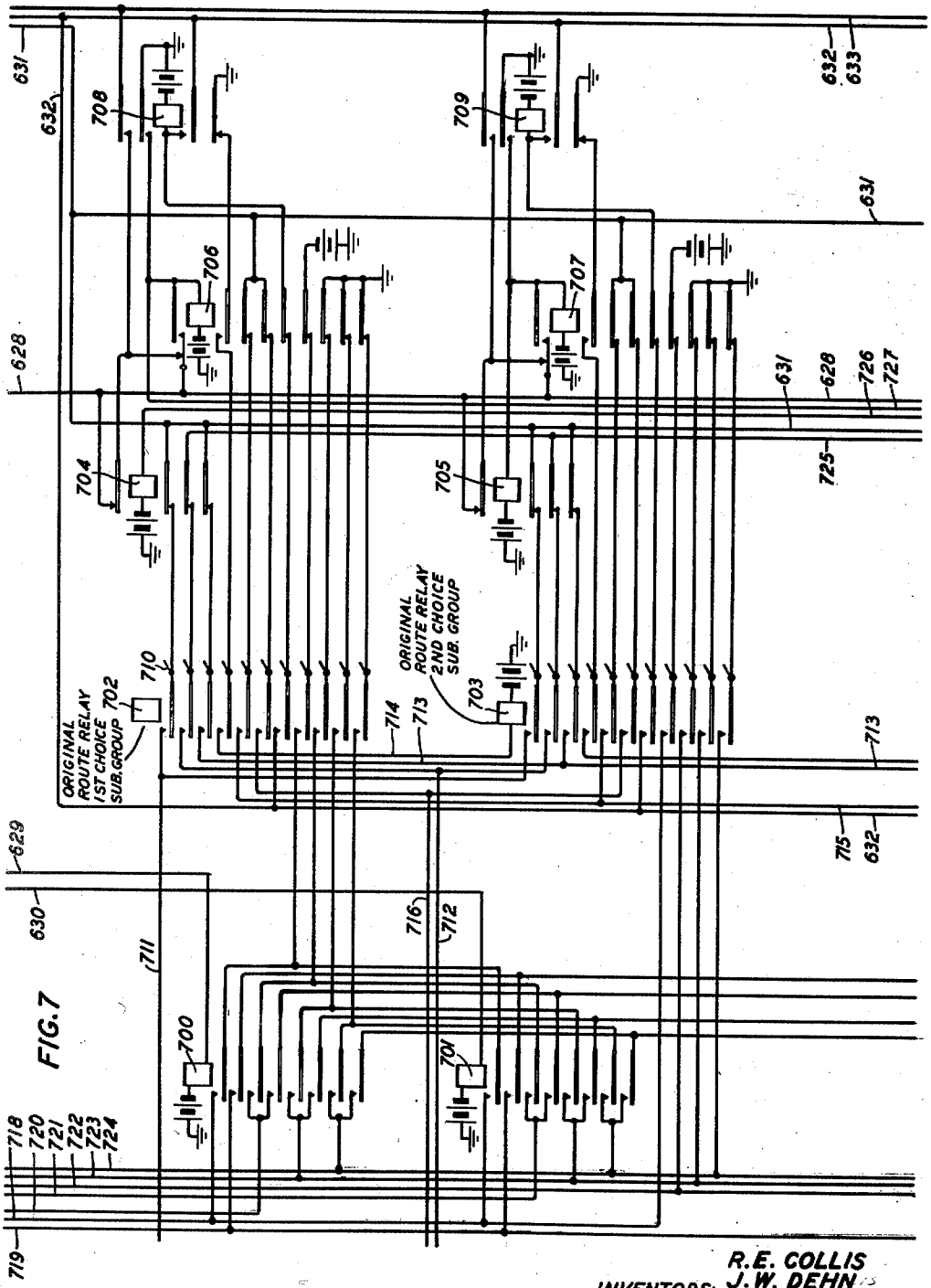

FIG. 7

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TELEPHONE SYSTEM

Filed June 17, 1938 9 Sheets-Sheet 7

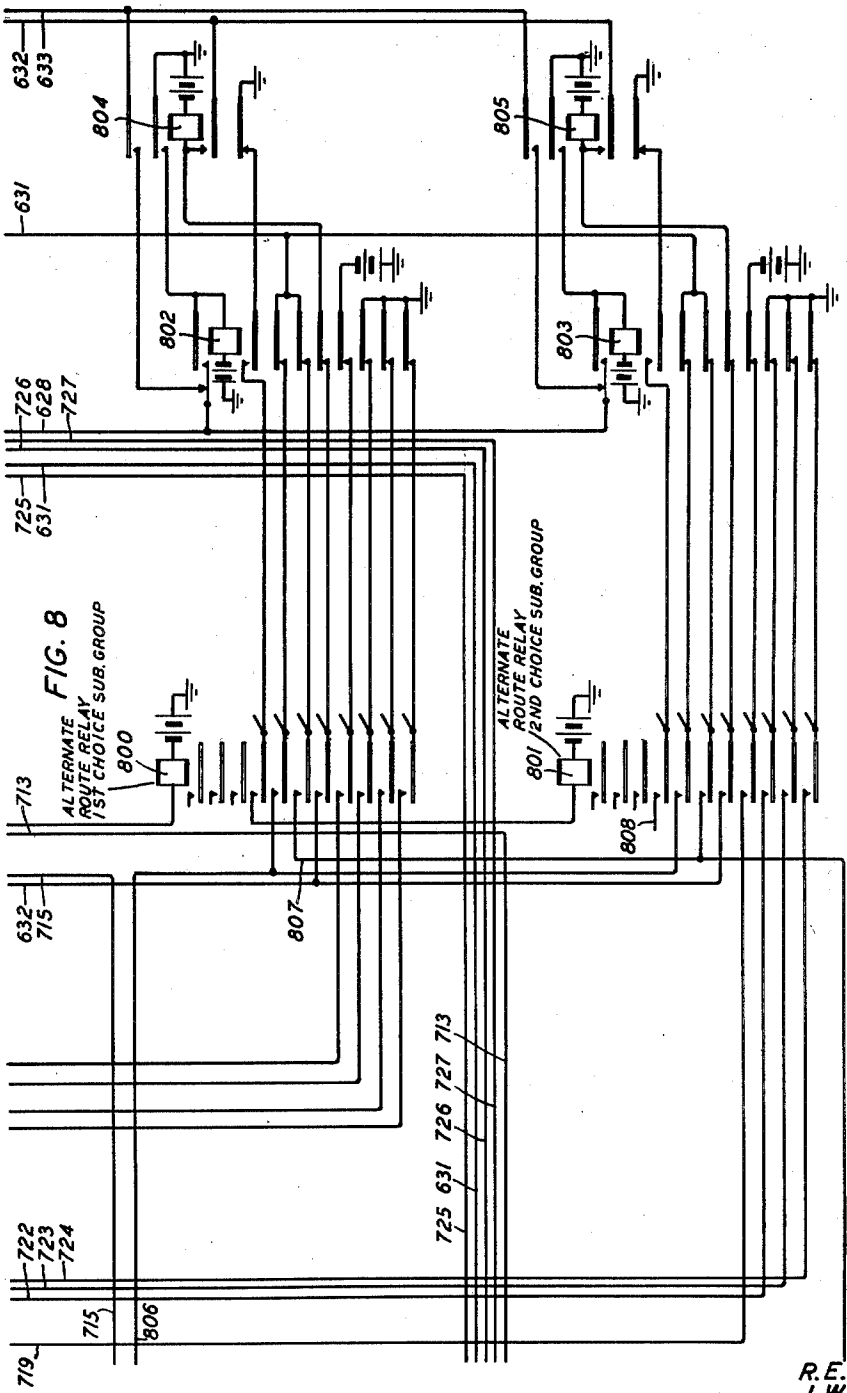

FIG. 8

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TELEPHONE SYSTEM

Filed June 17, 1938 9 Sheets-Sheet 8

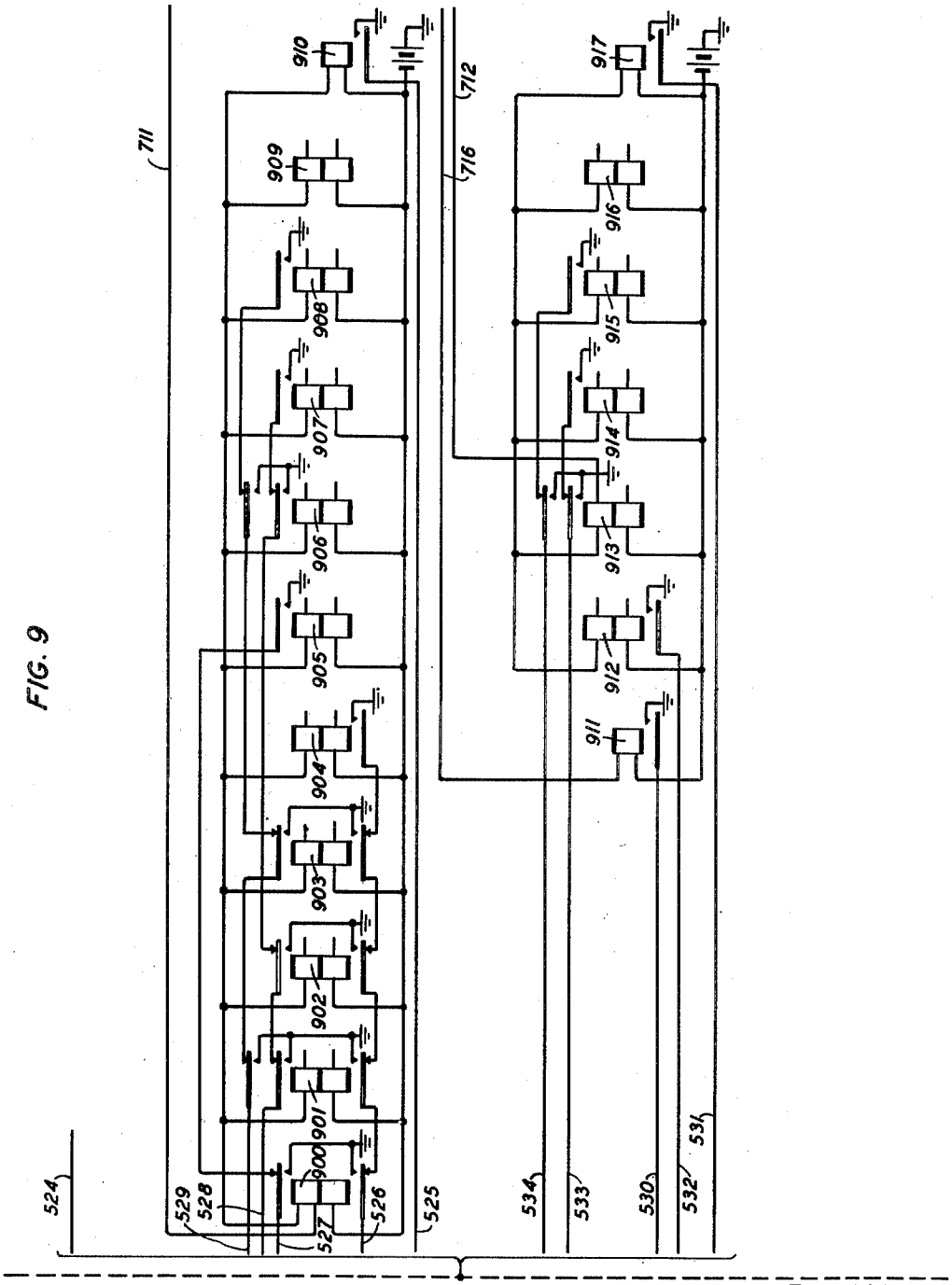

FIG. 9

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TELEPHONE SYSTEM

Filed June 17, 1938 9 Sheets-Sheet 9

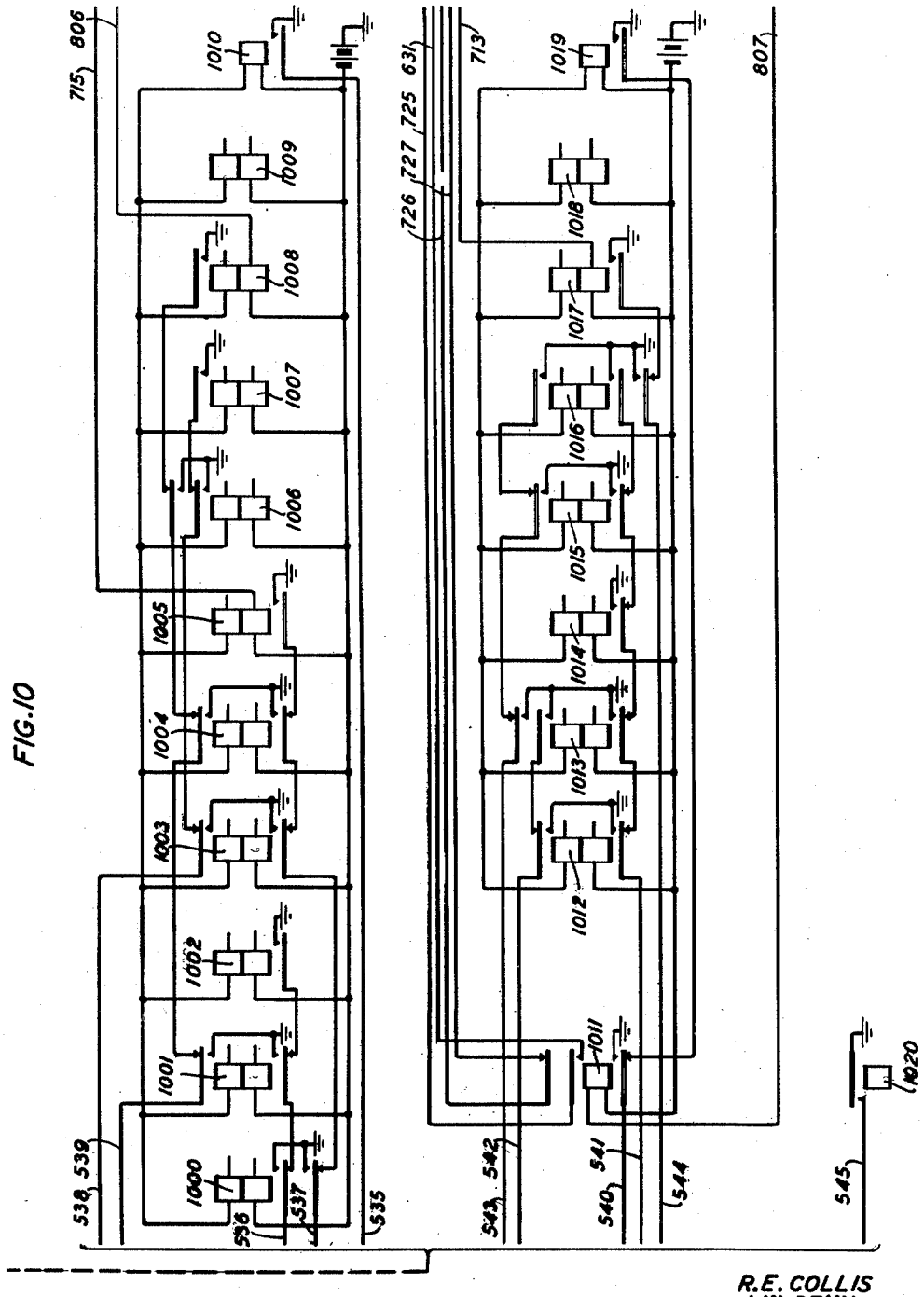

FIG. 10

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Patented Jan. 7, 1941 2,227,488

UNITED STATES PATENT OFFICE

2,227,488

TELEPHONE SYSTEM

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Application June 17, 1938, Serial No. 214,354

6 Claims. (Cl. 179—18)

This invention relates to telephone systems and particularly to those in which automatic selector switches controlled by central-office register mechanisms are employed for establishing conversational connections.

It has been proposed heretofore, in systems using central-office register senders and common switch controlling markers, to extend calls over alternate route groups of trunks through a tandem office to the called office in the event that all direct trunks from the calling office to the called office are busy at the time they are tested. In these prior systems the common switch controlling marker in the originating or calling office is provided with individual route relays for the several groups of direct trunks to called offices, these relays serving to cause the connection of the marker to the proper frames of the switches for testing the desired trunk groups and also serving to establish in the sender the information needed thereby in the further extension of the call. Where an alternate route group of trunks is provided to the tandem office it has been necessary in these prior systems to provide the route relay of the alternate group with the necessary information for causing the marker to establish the connection in the originating office to trunks of such alternate route group and also to provide this relay with means for giving the sender the routing information necessary for it to control the extension of the connection over the alternate route group and through the tandem office to the trunk group outgoing from the tandem office to the called office. In effect this requirement necessitated the provision of a direct route relay for each direct trunk group and also an alternate route relay or the equivalent thereof for each direct trunk group that had an alternate route through the tandem office.

It is, therefore, an object of the present invention to simplify the routing equipment in the central office, to reduce the number of routing relays or equivalent mechanisms required therein, and otherwise to improve the operation of these devices and the systems in which they are utilized.

According to a feature of the invention, these objects are attained by means of a system in which the marker is equipped with individual route relays for each of the direct trunk groups outgoing to called or terminating offices and with a single route relay individual to an alternate group of trunks which serve as an alternate route through the tandem office for a plurality of the direct trunk groups. This simplification of the routing equipment in the marker is made possible by providing the direct trunk group relay with contact means for transferring to the sender the routing information for routing the call through the tandem office in case that becomes necessary. When the marker tests the direct trunks to the called office, the routing information is transferred from the direct group route relay to the sender. If all the direct trunks are found busy by the marker, it cancels the route information which was transferred to the sender by the direct route relay and proceeds to operate the route relay individual to the alternate route trunks serving as an alternate route for the direct group. Since this alternate route relay is common to a number of direct route relays, it cannot furnish the sender with information individual to any one of the direct groups. Therefore, this information, which will now be needed for extending the connection through the tandem office, is again transferred to the sender by the direct route relay, which is still in its operated condition. After the idle trunk has been found in the alternate route group extending to the tandem office, the routing information transferred to the sender under the control of the direct route relay is utilized by the sender for controlling the switches in the tandem office to select a trunk extending from the tandem office to the terminating office in which the called line appears.

Another feature of the invention is a routing system of the kind above described in which the direct trunk groups are divided into first choice subgroups and a second choice subgroup, a routing relay being provided for each such subgroup, and in which the alternate route trunks to the tandem office are likewise divided into first choice subgroups and a second choice subgroup, each such subgroup being equipped with an individual route relay in the marker. The marker in testing for an idle trunk to extend a call to a particular terminating office will cause the operation of a first choice direct route relay, then the second choice direct route relay, then a first choice alternate route relay, and finally the second choice alternate route relay, testing the corresponding subgroups of trunks in succession until an idle one is found in some one of the four subgroups thus available. The routing information for the called office is, as above explained, transferred to the sender under the control of the routing relay of the first direct subgroup. If all of the trunks of this subgroup are

busy and it is necessary to test the three successive subgroups, the routing information is canceled from the sender as soon as it is determined that the first choice direct subgroup is busy. Upon the succeeding operation of the second choice direct route relay the same routing information is again transmitted to the sender under the control of the contacts of the latter relay. If all of the trunks in this second direct subgroup are busy, the routing information is again canceled, and the marker proceeds to operate the route relay of the first alternate subgroup. Upon the operation of this relay the routing information is restored to the sender under the control of the contacts of the routing relay of the first direct subgroup. If all trunks of the first alternate subgroup are busy, the routing information in the sender is again canceled, and finally the alternate route relay of the second choice alternate group is operated, and once more the routing information is reestablished in the sender under the control of the contacts of the first choice direct subgroup route relay. Thus the marker is capable of testing a succession of subgroups of trunks, some of which are direct route trunks and others of which extend over a common alternate route through the tandem office. And as it performs these tests it establishes in the sender the information which will be necessary for the sender to control the further extension of the call in the event that an idle trunk in the subgroup undergoing test is found.

These and other features of the invention will be described more fully in detail in the following specification.

The detailed specification should be considered in connection with the accompanying drawings in which:

Fig. 1 is a diagram of the trunking plan showing how a calling line may be extended through an originating office over the direct trunks or over alternate route trunks;

Figs. 3 to 10, inclusive, when taken in the order illustrated in Fig. 2, show in detail those portions of the circuits in the originating office which are necessary to a complete understanding of the invention;

Fig. 3 shows in simplified form a subscriber station, primary and secondary cross-bar line switches, primary and secondary district switches, primary and secondary sender link switches, a primary office switch, links and trunks for connecting the subscriber's line through the switches to a sender, and connectors for connecting the district and office switches to originating markers;

Fig. 4 shows in more detail one cross-point each of two secondary office switches on office frame No. 0, office links connecting them to the primary office switch shown on Fig. 3, two outgoing trunks connected to the two cross-points and belonging to first choice subgroup A of the original route, and parts of the office frame connector for connecting the test leads of outgoing trunks to markers;

Fig. 5 shows that part of the subscriber sender which registers information supplied it by a marker, and which it requires to extend a connection forward over an outgoing trunk and to a terminating office. It also shows diagrammatically a connector for connecting senders to markers as required; and

Figs. 6 to 10, inclusive, show in detail those parts of a marker which are involved in this invention.

General Description of Circuits and Equipment

The invention is illustrated in an automatic telephone system in which automatic switches of the cross-bar type are used as the medium for extending connections from subscribers' lines over trunks to other subscribers' lines. These cross-bar switching mechanisms are controlled by register senders at the central office, which receive the designations from the calling subscribers' dials, and by decoder markers, which are connectable to the senders for receiving information from the senders, and which are connectable to the proper switch frames for the purpose of testing the outgoing trunks and for testing the connecting links and for operating the magnets of the cross-bar switches to establish the connections.

While the system disclosed is not limited to the use of cross-bar switches of any particular type, reference may be had to the patent to Reynolds 2,021,329 of November 19, 1935, for an understanding of the construction and operation of a switch suitable for use in such systems. Because of the complicated nature of these systems, and since it is not necessary to an understanding of the invention that the system in all of its details be disclosed, much of the circuits and equipment has been eliminated in the present disclosure for the sake of simplicity. And in the following descriptions reference will be made to numerous operations which are not fully disclosed in all of their details. Wherever such references occur it will be understood that the circuits and equipment so referred to are already old in the prior art, and in particular reference is here made to the following for a detailed disclosure of all operations and equipment referred to herein but not specifically disclosed: Carpenter Patent No. 2,093,117 of September 14, 1937; and Carpenter application Serial No. 214,356, filed June 17, 1938.

General description of trunking plan

Referring to Fig. 1, and assuming that the line of a subscriber originating a call has been connected through line switches to district junctor **100**, and that the subscriber has dialed an office code calling for connection to the terminating office **128** reached over the original route or over the alternate route outgoing trunks shown on the figure, the first preferred path is over either first choice subgroup A or first choice subgroup B of the original route, the selection between those two subgroups being predetermined by a condition set up in the marker on its preceding engagement. The second preferred path is over the common choice subgroup of the original route. The third preferred path is over either first choice subgroup A or first choice subgroup B of the alternate route, and the fourth preferred path is over the common choice subgroup of the alternate route.

A connection over the first preferred path may be established by closing a cross-point in each switch mentioned, from district junctor **100**, through primary district switch **101**, district link **102**, secondary district switch **103**, office junctor **104**, primary office switch **106**, office link **108**, and secondary office switch **112** to outgoing trunk **116** in subgroup A or outgoing trunk **118** in subgroup B. Or a connection may be made over the same path to one more trunk in each subgroup, connected to the same secondary office switch **112**;

or through the same primary office switch 106 but other office links such as 109 and to other secondary office switches such as 113 to other outgoing trunks such as 117 in subgroup A or 119 in subgroup B, there being ten secondary office switches in all on this office frame No. 0, with twenty trunks in each subgroup. The same secondary office switches and outgoing trunks may be reached through other primary office switches on the same office frame No. 0, or through other secondary district switches and the same primary office switches. The twenty other outgoing trunks of each subgroup are connected to the secondary office switches of office frame No. 1, equipped and arranged just like office frame No. 0, and are reached through the same secondary district switches.

A connection over the second preferred path may be established over the same paths to the same secondary office switches, where different cross-points are closed to connect to the forty outgoing trunks of the common choice subgroup, such as trunks 120 and 121.

Connections over the third and fourth preferred paths are established in precisely the same manner, except that the outgoing trunks of the alternate route are connected to secondary offices switches on office frames No. 1 and No. 2. For example, a connection may be made from district junctor 100, through primary district switch 101, district link 102, secondary district switch 103, office junctor 105, primary office switch 107, office link 110 and secondary office switch 114, to outgoing trunk 122 in first choice subgroup A, or outgoing trunk 124 in first choice subgroup B, or outgoing trunk 126 in the common choice subgroup. The alternate route trunk group, which may serve a number of direct route groups, extends to the tandem office 129. At the tandem office switches 130 are controlled from the originating offices to extend the calls over trunks 131 to the called offices, such as office 128.

Detailed Description

In the following detailed description, and in the accompanying drawings a certain grouping of outgoing trunks is arbitrarily assumed for the purpose of illustrating this invention. The extension of a connection is traced from a calling subscriber to another central office than the one to which his line is connected, and the assumptions made are as follows: The direct or original route used by preferance, consists of one-hundred and twenty trunks extending directly to the terminating office, and divided into three subgroups of forty trunks each, known as first choice subgroup A, first choice subgroup B and the common choice subgroup. The alternate route, used when for any reason the original route is not immediately available, consists of one-hundred and twenty trunks extending direct to a two-wire tandem center, whence calls may be extended to any one of a number of terminating offices, and is divided into three subgroups of forty trunks each, known as first choice subgroup A, first choice subgroup B, and the common choice subgroup. Each outgoing trunk connects to one whole level of a secondary office switch, and the forty trunks of any one subgroup occupy the same two adjacent levels in each of the ten switches on two adjacent office frames. The three subgroups of the original route occupy three pairs of levels in office frames No. 0 and No. 1, and the three subgroups of the alternate group occupy the same three pairs of levels in office frames No. 2 and No. 3. These assumptions, as stated above, are made for illustrative purposes only, and in practice would vary to meet local conditions. The alternate route could be through any type of tandem center, either route could have more or less than two first choice subgroups, any subgroup could have less than forty trunks, the six subgroups could all appear on one pair of office frames or on any number up to six pairs, the alternate route subgroups could appear on different levels from the original route subgroups, and any or all subgroups could occupy half levels instead of whole levels in the switches.

Referring now to the drawings, Fig. 1 shows in skeleton form the assumed trunking plan as described above. Figs. 3 to 10, inclusive, when taken in the order shown in Fig. 2, show in detail those portions of the circuits which are necessary for a complete description of the functions comprised in this invention, namely, the manner in which successive attempts are made to establish a connection to a certain terminating office over as many as four separate subgroups of trunks, and how on each attempt an appropriate record is set up in the sender to guide it in extending the connection to the terminating office.

Detailed description of a call

Assuming that a call is originated by the subscriber at station 300, whose line 301 terminates on primary line switch 302, a train of operations is started which selects an available path to an idle sender, and operates select and hold magnets on the primary and secondary line switches and sender link switches to close that path from the subscriber's line to the sender. This connection is shown through line link 303, secondary line switch 304, district junctor 305, primary sender link switch 306, sender link 307, and secondary sender link switch 308 to the sender partly shown on Fig. 5. District junctor 305 also terminates on primary district switch 309.

The subscriber dials the office code of the desired terminating office, and when the code is registered in the sender, relay 521 operates and causes the sender to be connected to an idle originating marker through the connector shown at the left of Fig. 5, as for example by operating relays 522 and 523 the sender is connected to the marker partly shown in Figs. 6 to 10, inclusive, over a plurality of conductors of which conductors 525 to 545 are shown separately, and the remaining conductors are represented by the single line 524.

The office code is transmitted from the sender to the marker, resulting in the operation of off-normal relay 627 to supply certain operating and locking ground connections in the marker while it is engaged on this call, and of a certain route relay, such as relay 702. Following relay 627, either relay 700 or relay 701 operates by a circuit from ground through bottom contact of relay 627, off-normal ground conductor 628, bottom break or make contact of relay 624, conductor 629 or 630, and winding of relay 700 or 701 to battery. Whether relay 700 or 701 operates depends upon whether relay 624 is normal or operated during the marker engagement, a condition which alternates from engagement to engagement, as follows. If when relay 627 operates on a particular engagement it finds

relays 624 and 625 normal, ground through its top contact will cause relay 625 to operate, but by shunting out the battery supply through resistance 623 to the winding of relay 624 will prevent the latter from operating through the make contact of relay 625. Then when relay 627 releases at the end of the marker engagement it will break that shunt and relay 624 will operate through the make contact of relay 625, through which contact relay 625 itself is also holding operated. Relays 624 and 625 will hold up while the marker is disengaged. When relay 627 operates on the following engagement its top contact will shunt out the battery supply through resistance 626 to the winding of relay 625, which will thereupon release, but relay 624 will not release because it is held through top make contact of relay 627 and break contact of relay 625. Then when relay 627 releases at the end of the marker engagement it will break the holding circuit for relay 624 and that will release. Relays 624 and 625 will remain normal while the marker is disengaged.

Four route relays, 702, 703, 800 and 801, may be used in completing this call to its destination. Relay 702 is definitely assigned to the particular office code which was dialed and no other; it operates when the office code has been received in the marker; it remains operated throughout this engagement of the marker; it controls the testing of one of the first choice subgroups of trunks of the original route to the terminating office; and it transmits to the sender information required for the extension of the call to the terminating office in case the original route is used, and some other information required in case the alternate route is used. Route relay 703 is also definitely assigned to the particular office code and to no other; it operates in case no idle trunk is found in the original route first choice subgroup tested; it then remains operated throughout the engagement of the marker; it controls the testing of the common choice subgroup of the original route; and it transmits to the sender the same information as route relay 702. Route relay 800 may be assigned to several office codes for terminating offices reached by alternate route through the same tandem center; it operates in case no idle trunk is found in the original route common choice subgroup; it then remains operated throughout the engagement of the marker; it controls the testing of one of the first choice subgroups of trunks of the alternate route; and it transmits to the sender some information required for the extension of the call to the terminating office, additional to that transmitted by route relay 702. Route relay 801 is assigned to the same office codes as route relay 800; it operates in case no idle trunk is found in the alternate route first choice subgroup tested; it then remains operated throughout the engagement of the marker; it controls the testing of the common choice subgroup of trunks of the alternate route; and it transmits to the sender the same information as route relay 800.

All corresponding armature springs of all route relays controlling first preferred paths for other office codes are multipled to those of relay 702, as indicated by the multiple strap 710, for example. Similarly the armature springs of all route relays controlling second preferred paths are multipled together, and so for those controlling third preferred paths and for those controlling fourth preferred paths. The contact springs of the route relays are wired for flexible cross-connection according to the route and the trunks it controls, and so also are the contact springs of relays 700 and 701.

When route relay 702 operates it causes a subgroup of trunks to be tested and at the same time it transmits information to the sender. The latter function will be described first.

Information to sender for first preferred path

Conductor 711 is grounded from conductor 631 through a break contact of relay 704 and make contact of relay 702, conductor 631 being grounded through a break contact of relay 610. It may be connected to either winding of any one of relays 900 to 909, thereby causing that relay to operate, and if to its upper winding also causing relay 910 to operate in series. According to the relay or two relays operated, some or none of conductors 525 to 529 are grounded in one of twenty combinations, setting up sender relays 500 and 501 in one of four combinations, and relays 502, 503 and 504 in one of five combinations. The record on relays 500 and 501 gives certain information as to the terminating office, which will be the same whatever trunks are used to reach that office. The record on relays 502, 503 and 504 gives the office brush selection in the two-wire tandem center in case the alternate route is employed, and although registered in the sender will not be used by it in case the original route is employed. As shown for an example in the drawings, conductor 711 is connected to the upper winding of relay 900, so relays 910 and 900 operate and ground conductors 525, 526 and 527, operating relays 500, 501 and 502, and leaving relays 503 and 504 normal.

Conductor 712 is not grounded at this time because its connection from conductor 631 is not closed at the top make contact of relay 1011.

Conductor 713 is grounded from conductor 631 through a break contact of relay 704 and make contact of relay 702. It may be connected to either winding of any one of relays 1012 to 1018, thereby causing that relay to operate, and if to its upper winding also causing relay 1019 to operate in series. According to the relay or two relays operated, some or none of conductors 540 to 544 are grounded in one of fourteen combinations, setting up sender relays 516 to 519 in one of seven combinations, with relay 515 either operated or not operated. The record on relays 516 to 519 gives certain information as to the terminating office which will be the same whatever trunks are used to reach that office. Relay 515 operated indicates a route through a tandem center. As shown for an example in the drawings, conductor 713 is connected to the lower winding of relay 1017, so that relay operates and grounds conductor 544, operating relay 519 and leaving relays 516 to 518 normal. Relay 515 is also left normal because the original route is not through a tandem center.

Conductor 714 is not grounded at this time because its connection from conductor 631 is not closed at the bottom make contact of relay 706.

Conductor 715 is grounded from conductor 631 through a break contact of relay 706 and make contact of relay 702. It may be connected to either winding of any one of relays 1000 to 1009, thereby causing that relay to operate, and if to its upper winding also causing relay 1010 to operate in series. According to the relay or two relays operated, some or none of conductors 535 to 539 are grounded in one of twenty combinations, setting up sender relays 511 to 514 in

one of ten combinations, with relay 510 either operated or not operated. The record on relays 511 to 514 gives information as to the resistances which the sender is to insert in the trunk to compensate for short trunks to the two-wire tandem center, if any, and again to compensate for short direct trunks or tandem circuits to the terminating office. The set-up at this time is appropriate to the original route only. Relay 510 operated gives certain information as to the terminating office. As shown for an example in the drawings, conductor 715 is connected to the lower winding of relay 1005, so that relay operates and grounds conductor 537, operating relay 512 and leaving relays 510, 511, 513 and 514 normal.

Conductor 716 is grounded from conductor 631 through a break contact of relay 706 and make contact of relay 702. It is connected to the winding of relay 911, thereby causing that relay to operate, which in turn grounds conductor 530, operating sender relay 505, which records the fact that there is no office selector in the original route, and therefore the sender is to skip over the office selections when a connection has been established over that route.

If an idle trunk is found in that one of the original route first choice subgroups which is tested, then shortly thereafter relay 1020 operates. That by grounding conductor 545 operates sender relay 520, the right-hand contact of which connects ground through a make contact of relay 521 to lock up both itself and those sender relays which were operated as described above, namely relays 500, 501, 502, 505, 512 and 519. The operation of relay 520 also causes the release of the connector relays 522 and 523, thereby breaking down the direct connection between the sender and the marker.

Testing outgoing trunks for first preferred path

For the purpose of determining the idle or busy state of each of the trunks of a test group of forty, which may include trunk groups to several destinations, but which in the conditions assumed herein include just one subgroup of trunks to a single destination in each case, the marker has forty trunk test relays, of which only the first two and the last two are shown, namely relays 612, 613, 616 and 617. There are also forty relays, one of which will be operated to designate the trunk selected for use, and of these also only the four are shown which correspond with the four trunk test relays shown, namely relays 619, 620, 621 and 622. Supposing that relay 700 operates as described above on this engagement of the marker, then upon the operation of route relay 702, conductor 718 is connected to battery, and conductors 720, 723 and 724 to ground, through break contacts of relay 706 and make contacts of relays 702 and 700. Battery on conductor 718 operates relay 404, which is common to the pair of office frames numbered 0 and 1, and individual to the particular marker. The operating circuits of the similar relays for the several markers, associated with one pair of office frames, are wired in a preference chain which is not shown, to prevent any two operating together, so that at any one time only one marker can deal with a particular pair of office frames. By grounding conductors 412 and 413, relay 404 operates relay 405 for office frame No. 0 which is partly shown in Fig. 4, and a similar relay for office frame No. 1, these relays also being individual to the particular marker.

Ground on conductor 720 operates relay 600, which is associated with the particular pair of levels to which the trunks of subgroup A of the original route are connected. The bottom contact of relay 600 connects ground through conductor 634, a contact of relay 405, and the windings of relays 406 and 407 in parallel to battery, operating relays 406 and 407, which are associated respectively with the two levels in all the secondary switches of frame No. 0. The top contact of relay 600 connects ground through conductor 635 to frame No. 1, where it operates relays corresponding to 406 and 407. Relays 405, 406, 407 and the corresponding relays in frame No. 1 connect the windings of the forty trunk test relays to the test conductors of the forty trunks of subgroup A of the original route, which trunks are connected to the two levels on each of the ten secondary switches on each of frames No. 0 and No. 1. Thus the winding of relay 612 is connected through break contacts of relay 619, conductor 640 and make contacts of relays 405 and 407 to test conductor 414 of outgoing trunk 400, which is the first of the group of forty. This trunk is connected to cross-point 402 and multiplied to the other cross-points in the same level of the same switch, that is, in the first of the two levels in the first of the ten switches on frame No. 0. The winding of relay 613 is connected through break contact of relay 620, conductor 641 and make contacts of relays corresponding to 405 and 407 in frame No. 1 to the test conductor of the next higher numbered trunk, which is connected to the first of the two levels in the first of the ten switches on frame No. 1. The winding of relay 616 is connected through break contact of relay 621, conductor 642 and make contacts of relays 405 and 406 to test conductor 415 of outgoing trunk 401, connected to cross-point 403 and multipled to the other cross-points in the same level of the same switch, that is, in the second of the two levels in the last of the ten switches on frame No. 0. The winding of relay 617 is similarly connected through break contact of relay 622, conductor 643 and make contacts of relays corresponding to relays 405 and 406 in frame No. 1, to the test conductor of the last of the group of forty trunks, which is connected to the second of the two levels in the last of the ten switches on frame No. 1. There are sufficient contacts on relays 405, 406 and 407, besides those shown, to accommodate the full set of twenty trunks per frame. The multiple straps shown connected to the contact springs of relay 405 indicate that the connected conductors multiple to corresponding relays associated with the same marker but other even-numbered office frames. Those shown connected to the armature springs of relay 405 indicate multipling to corresponding relays in the same frame but associated with other markers. If outgoing trunk 400 is busy on a connection previously established, it is made so by cross-point 402, or one of the others on the same level in the same switch, being closed. That grounds the test conductor 414 and causes trunk test relay 612 to operate, it having battery connected to the other end of its winding. In the same way all of the forty test relays which are connected to busy trunks will operate.

Conductors 723 and 724 are so connected as to block out of the forty trunks tested those which constitute the trunk group to the desired destination. Such a trunk group may contain any even number of trunks from two to forty. There are

twenty relays similar to relays 611 and 615, and by connecting conductor 723 to the winding of one of them and thereby causing it to operate when the route relay operates, the first trunk of the group is marked. There are also twenty relays similar to relays 614 and 618, and by connecting conductor 724 to the winding of one of them and thereby causing it to operate when the route relay operates, the last trunk of the group is marked. Connecting conductor 723 to relay 611, and conductor 724 to relay 618, as shown, identifies the trunk group as consisting of the entire forty trunks which have been tested.

The next step is to operate one of the forty relays like relays 619 to 622 to select for use the first one of the forty trunks which happens to be idle. When relays 406, 407 and the corresponding relay in frame No. 1 have operated to connect the forty test relays to the forty trunks, a circuit is closed from ground through front contacts of relays 406, 407 and 405, conductor 644 and the winding of relay 603 to battery, and the similar circuit from frame No. 1 over conductor 645 to the winding of relay 604. Relays 603 and 604 thereupon operate. Up to this time condenser 605 and resistance 606 in series have been short-circuited and the condenser-timed polarized relay 608 has had opposing currents through its two windings, and the upper winding being stronger has held the armature on its back contact. One circuit is from off-normal ground conductor 628 through break contacts of relays 603 and 604 in parallel, and the upper winding of relay 608 to battery. The other circuit is from off-normal ground conductor 628 through the lower winding of relay 608 and resistance 607 to battery. When relays 603 and 604 have both operated, the direct ground connection to the upper winding of relay 608 is broken, but current continues to flow through it for a time, charging condenser 605. As the condenser charges, this current dies down, until the lower winding overpowers the upper and the relay operates. This slow operation allows time for the trunk test relays, such as relay 621, to operate. Relay 609 has been operated from the beginning by a circuit from off-normal ground conductor 628 through break contacts of the forty trunk selecting relays, including relays 619 to 622, and winding of relay 609 to battery. If out trunk 401, for example, happens to be the first trunk of the subgroup which is idle, trunk test relay 616 will be the first one normal, counting from the left, and its associated trunk selecting relay 621 will operate by a circuit from ground through make contacts of relays 608, 609, 611, 612 and 613, break contact of relay 614, make contacts of intermediate trunk test relays, not shown, and break contacts of intermediate relays, not shown, but similar to relay 614, break contact of relay 616 and winding of relay 621 to battery.

Relay 621 operating locks up through the back contact chain to its left, and at the same time breaks the back contact chain to its right, thereby releasing relay 609. This breaks the circuit which operated relay 621 and thereby prevents the operation of any earlier relay of the same kind, such as 619 or 620, in case an earlier trunk test relay, such as 612 or 613, should release upon its trunk becoming idle.

Relay 621 operating also transfers the connection of the test conductor 415 from the winding of trunk test relay 616 to ground, thus immediately marking the trunk as busy.

Relay 621 operating also starts a chain of operations involving the operation of district and office frame connectors 312, 313 and 314 to connect the marker to various parts of the district and office switches; the testing of all possible paths from primary district switch 309 to the secondary office switch to which is connected outgoing trunk 401; the selection of an available path such as the one shown through district links 315, secondary district switch 310, office junctor 316, primary office switch 311 and office link 317; the operation of select and hold magnets in the primary and secondary district and office switches to close through this path, thus completing a connection from subscriber station 300 to outgoing trunk 401; and the release of the marker from service on this call.

If it should happen that relay 701 operates instead of relay 700 on this engagement of the marker, all operations would be as described above except that first choice subgroup B of the original route would be involved instead of first choice subgroup A. The corresponding armature springs of relay 701 are multipled to those of relay 700, and the four contact springs corresponding to those above mentioned on relay 700 are connected according to the pair of office frames and the pair of levels on which subgroup B appears, and to the section of forty trunks occupied by that subgroup. Under the assumptions made herein the office frames are the same for subgroups A and B, and the subgroup occupies the whole forty trunks with the test starting at the first trunk in both cases, but the levels are different. Therefore, in this case battery is connected to conductor 718 and ground to conductors 723 and 724 as in the other case, but ground is connected to conductor 721 instead of to conductor 720. Therefore, all operations are the same except that relays 601, 408 and 409 operate instead of 600, 406 and 407, connecting the marker trunk test relays to the proper pair of levels for subgroup B. Each office link, such as 317, is multipled to the ten cross-points in one vertical file of a particular secondary office switch, so that the only difference in establishing a connection is that the select magnet associated with the proper level is operated.

In case all forty trunks of the first choice subgroup tested are busy, all forty trunk test relays will operate, closing the circuit from contact of relay 608 clear through the chain of relays including 611 to 618, to the winding of relay 610, and that relay will operate instead of relay 621 or a similar relay. Then relay 708 will operate by a circuit from ground through make contact of relay 610, conductor 632, make contact of relay 702, break contact of relay 706, and winding of relay 708 to battery. The inner top make contact of relay 708 operates relay 706 directly and relay 704 through the top break contact of relay 1011 over conductors 727 and 726. Relay 706 operating, breaks the battery and ground connections to conductors 718, 720, 723 and 724, releasing all connections between the marker and the office frames. All operated relays release which are shown on Fig. 4 and Fig. 6 except 609, 627 and 624 and 625 if operated. Relay 708 also released, but relays 700, 702, 704 and 706 remain operated, the two latter locking through top make contact of relay 706 to off-normal ground conductor 628. To prevent relay 610 releasing before relays 704 and 706 operate and lock, it locks through its top contact, conductor 633, outer top contact of relay 708, top break contacts of relays 704 and 706 in parallel, to conductor 628. To

prevent relay 708 releasing before relay 706 is locked up, relay 708 locks through its bottom make contact and conductor 632 to the bottom make contact of relay 610.

When relay 708 releases, it closes a circuit from ground through its break contact, make contacts of relays 706 and 702, conductor 714, and the winding of route relay 703 to battery, causing the last to operate.

Information to sender for second preferred path

The ground connections through break contact of relay 610, conductor 631, break contacts of relay 704 or 706, and make contacts of relay 702, to conductors 711, 713, 715 and 716, and thence to the windings of relays 900, 1017, 1005 and 911, are broken early at the break contact of relay 610 when that operates because all trunks of the original route first choice subgroup tested are found busy, and then permanently at the break contacts of relays 704 and 706. Relays 910, 900, 1017, 1005 and 911 thereupon release, and that causes the release of all the sender relays shown on Fig. 5 which had been operated through their contacts.

The operation of route relay 703 and the release of relay 610 causes these same relays in marker and sender to re-operate, conductors 711, 713, 715 and 716 being grounded again, this time through conductor 631, break contacts of relays 705 and 707, and make contacts of relay 703.

If an idle trunk is found in the original route common choice subgroup, relay 1020 operates, then relay 520, and that locks up, locks the record in the sender, and releases the connection between sender and marker, as described above in connection with the finding of an idle trunk in one of the first choice subgroups.

Testing outgoing trunks for second preferred path

Route relay 703 operating closes circuits from battery and ground through break contacts of relay 707 to seize and test the original route common choice subgroup of out trunks. Since those are assumed to be on the same pair of office frames and to comprise forty trunks with the test starting at the first trunk, as in the case of the first choice subgroups, conductor 718 is connected to battery and conductors 723 and 724 to ground as before. Since this subgroup appears on a different pair of levels, conductor 722 is grounded. As a result of these battery and ground connections, relay 404 operates, causing the operation of relay 405 in frame No. 0 and a similar relay in frame No. 1; relay 602 operates, causing the operation of relays 410 and 411 in frame No. 0 and corresponding relays in frame No. 1; and relays 611 and 618 operate.

The trunks are tested and if an idle one is found a connection is established and the marker disconnected as described above. Otherwise relay 610 operates again, causing relay 709 to operate by a circuit through conductor 632, make contact of relay 703 and break contact of relay 707. The inner top make contact of relay 709 operates relays 705 and 707 in parallel and they lock to off-normal ground conductor 628. Relay 707 operating breaks the battery and ground connections to conductors 718, 722 and 724, releasing all connections between the marker and the office frames. All operated relays release which are shown on Fig. 4 and Fig. 6 except 609, 627 and 624 and 625, if operated. Relay 709 also releases. Similar precautions are taken against the too quick release of relays 610 and 709 as were described above in the case of relays 610 and 708. Relays 700, 702, 703, 704, 705, 706 and 707 remain operated. When relay 709 releases it closes the circuit from ground through its break contact, make contacts of relays 707 and 703, and the winding of route relay 800 to battery, causing the last to operate.

Information to sender for third preferred path

The ground connections through break contact of relay 610, conductor 631, break contacts of relay 705 or 707, and make contacts of relay 703, to conductors 711, 713, 715 and 716, and thence to the windings of relays 900, 1017, 1005 and 911, are broken early at the break contact of relay 610 when that operates because all trunks of the original route common choice subgroup are found busy, and then permanently at the break contacts of relays 705 and 707. Relays 910, 900, 1017, 1005 and 911 thereupon release, and that causes the release of all the sender relays shown on Fig. 5 which had been operated through their contacts.

The operation of route relay 800 and the release of relay 610 connect ground through conductor 631, break contacts of relay 802, and make contacts of relay 800 to conductors 806 and 807.

Conductor 806 may be connected to either winding of any one of relays 1000 to 1009, thereby causing that relay to operate, and if to its upper winding also causing relay 1010 to operate in series. According to the relay or two relays operated, some or none of conductors 535 to 539 are grounded in one of twenty combinations, setting up sender relays 511 to 514 in one of ten combinations, with relay 510 either operated or not operated. The record on relays 511 to 514 gives information as to the resistances which the sender is to insert in the trunk to compensate for short trunks to the two-wire tandem center, and again to compensate for short tandem circuits to the terminating office. The set-up at this time is appropriate to the alternate route. Relay 510 operated gives certain information as to the terminating office as before. As shown for example in the drawings, conductor 806 is connected to the lower winding of relay 1008, so that relay operates and grounds conductor 539, operating relay 514 and leaving relays 510, 511, 512 and 513 normal.

Conductor 807 is connected to the winding of relay 1011, thereby causing that relay to operate, which in turn grounds conductor 540, operating sender relay 515, which establishes certain conditions requisite when a connection is to be made through a two-wire tandem center.

Besides operating sender relay 515, the operation of relay 1011 has two effects in the marker. Its top make contact connects conductor 631 to conductor 725, thus grounding the middle bottom armature spring of relay 704 for the first time, and its top break contact causes relay 704 to release by breaking apart conductors 726 and 727. This release of relay 704 connects ground from conductor 631 through make contacts of relay 702 to conductors 711, 713 and 712. Ground on conductor 711 has the same effect as in its two previous applications, operating relays 910 and 900, which in turn operate sender relays 500, 501 and 502. Since the call is now to be routed through a two-wire tandem center, the information recorded by relay 502 being operated will be made use of this time. Ground on conductor 713 has the same effect as in its two previous applications, operating relay 1017,

which in turn operates sender relay 519. Conductor 712 may be connected to either winding of any one of relays 912 to 916, thereby causing that relay to operate, and if to its upper winding also causing relay 917 to operate. According to the relay or two relays operated, some or none of conductors 531 to 534 are grounded in one of ten combinations, setting up sender relays 506 to 509 in one of ten combinations according to the office group selection in the two-wire tandem center. As shown for example in the drawings, conductor 712 is connected to the upper winding of relay 913, so relays 917 and 913 operate and ground conductors 531, 533, 534, operating relays 506, 508 and 509, and leaving relay 507 normal.

The reason for setting up office brush and office group information through contacts of route relay 702 instead of contact of route relay 800, is that such information is individual to the particular terminating office to which relay 702 is assigned, whereas relay 800 may serve for several terminating offices, each with its own office brush and group selections.

If an idle trunk is found in that one of the alternate route first choice subgroups which is tested, relay 1020 operates, then relay 520, and that locks up, locks the record in the sender, and releases the connection between sender and marker, as described above in connection with finding an idle trunk in an original route first choice subgroup.

Testing outgoing trunks for third preferred group

Route relay 800 operating closes circuits from battery and ground through break contacts of relay 802 and make contacts of relays 800 and 700, assuming as before that relay 700 is operated on this call, to seize and test the alternate route subgroup A of out trunks. Since these are assumed to appear on a different pair of office frames but on the same levels in the switches, and to comprise forty trunks with the test starting at the first trunk as in the case of the original route subgroup A, conductor 719 is connected to battery and conductors 720, 723 and 724 to ground. Battery on conductor 719 operates a relay on office frame No. 2 corresponding to relay 404 on office frame No. 0, and thereafter all operations are the same as described for the first preferred route, using relays on frames No. 2 and No. 3 corresponding in all respects to those on frames No. 0 and No. 1.

If all the trunks of the alternate route first choice subgroup tested are found busy, relay 610 operates a third time, causing relay 804 to operate by a circuit through conductor 632, make contact of relay 800 and break contact of relay 802. The inner top make contact of relay 804 operates relay 802 and that locks to off-normal ground conductor 628. Relay 802 operating breaks the battery and ground connections to conductors 719, 720, 723 and 724, releasing all connections between the marker and the office frames. All operated relays release which are shown on Fig. 6, except 609, 627, 624 and 625 if operated, and also all operated relays corresponding to those shown on Fig. 4, and also relay 804. Similar precautions are taken against too quick release of relays 610 and 804 as were described above in the case of relays 610 and 708. Relays 700, 702, 703, 800, 705, 706, 707 and 802 remain operated. When relay 804 releases, it closes a circuit from ground through its break contact, make contacts of relays 802 and 800, and the winding of route relay 801 to battery, causing the last to operate.

Information to sender for fourth preferred path

When relay 610 operates because all trunks of the alternate route first choice subgroup tested are found busy, it breaks ground from conductor 631 and thereby releases relays 1008, 1001, 917, 913, 910, 900 and 1017, and then all the sender relays release, shown on Fig. 5 and previously operated through their contacts. The release of relay 1011 causes relay 704 to operate through its top break contact, and the action of relay 610 in breaking ground from conductor 631 and thereby from the conductors leading to the windings of relays 1008, 1001, 913, 900 and 1017 is supplemented by break contacts of relays 802 and 704 breaking those conductors.

The operation of route relay 801 and the release of relay 610 connect ground through conductor 631, break contacts of relay 803, and make contacts of relay 801 to conductors 806 and 807. Ground on conductor 806 operates relay 1008, and ground on conductor 807 operates relay 1011. Relay 1011 operating connects conductor 631 to the middle bottom armature spring of relay 704 and causes the same to release. This connects ground from conductor 631 through break contacts of relay 704 and make contacts of relay 702 to conductors 711, 712 and 713, operating relays 910, 900, 917, 913 and 1017. These relays operated in the marker cause the same relays to operate in the sender as were just released, namely, 500, 501, 502, 506, 508, 509, 514, 515, 519.

If an idle trunk is found in the alternate route common choice subgroup, relay 1020 operates, then relay 520, and that locks up, locks the record in the sender, and releases the connection between sender and marker, as described above in connection with finding an idle trunk in an original route first choice subgroup.

Testing outgoing trunks for fourth preferred path

Route relay 801 operating closes circuits from battery and ground through break contacts of relay 803 to seize and test the alternate route common choice subgroup of out trunks. Since these are assumed to be on the same pair of office frames and to comprise forty trunks with the test starting at the first trunk, as in the case of the alternate route first choice subgroup, conductor 719 is connected to battery and conductors 723 and 724 to ground, as before. Since this subgroup appears on the same pair of levels on frames No. 2 and No. 3 as the original route common choice subgroup on frames No. 0 and No. 1, conductor 722 is grounded. Battery on conductor 719 operates a relay on office frame No. 2 corresponding to relay 404 on office frame No. 0, and thenceforth all operations are as described for the second preferred route, using relays on frames No. 2 and No. 3 corresponding in all respects to those on frames No. 0 and No. 1.

If all the trunks of the alternate route common choice subgroup are found busy, relay 610 operates a fourth time, causing relay 805 to operate by a circuit from conductor 632, make contact of relay 801 and break contact of relay 803. The inner top make contact of relay 805 operates relay 803 and that locks to off-normal ground conductor 628. Relay 803 operating breaks the battery and ground connections to conductors 719, 722, 723 and 724, releasing all connections

between the marker and the office frames. All operated relays release which are shown on Fig. 6, except 609, 627 and 624 and 625 if operated, and also all operated relays corresponding to those shown on Fig. 4, and also relay 805. Similar precautions are taken against the too quick release of relays 610 and 805 as were described above in the case of relays 610 and 708. When relay 805 releases it closes a circuit from ground through its break contact and make contacts of relays 803 and 801, to conductor 808, which is connected to the winding of a route relay for overflow trunks, not shown. Similar operations to those described above then ensue in an endeavor to connect the calling line to an overflow trunk and to set up the sender relays shown on Fig. 5 accordingly.

In the foregoing description it is explained how the marker first makes a test of the first and second choice subgroups of trunks extending directly to the called office and, finding these all busy, then tests the first and second choice subgroups of alternate route trunks leading to the tandem office through which access may be had to trunks extending to the called office. Should the marker find an idle trunk in either of the two subgroups of direct route trunks, it proceeds to establish the connection from the calling district trunk 305 through the district and office switches to such idle outgoing trunk. Thereafter the sender acts to control the equipment in the called office to further complete the connection to the wanted subscriber's line. Should, however, all direct group trunks be busy and should the marker locate an idle trunk in one of the two alternate route subgroups of trunks, it likewise proceeds to establish a connection from the calling district trunk 305 through the district and office selectors to the selected idle alternate route trunk which extends to a tandem center. Thereafter the sender, using the information which it has received from the marker in the manner already described, controls the selective switches in the tandem center to choose a trunk in the group extending to the called office. After this trunk has been seized and the connection extended to the called office, the switching equipment therein is further controlled to complete the connection to the wanted subscriber's line.

What is claimed is:

1. In a telephone system, a calling office having automatic switches therein, a plurality of terminating offices, a tandem office having switching means therein, trunk groups extending from said calling office directly to the respective terminating offices, a common group of trunks extending from the calling office to said tandem office and serving as an alternate route for calls from the calling office to said terminating offices, route relays in said calling office individual respectively to the direct trunk groups extending to said terminating offices, circuit means controlled by the contacts of each of said route relays for causing the selective operation of said automatic switches to extend a connection over the corresponding trunk group to the terminating office, a single route relay for said common alternate route group of trunks, circuit means controlled by said common group route relay for causing the selective operation of said automatic switches to extend a connection over the common group to said tandem office, and circuit means controlled by the contacts of each of said direct route relays for controlling the operation of the switching means in said tandem office to cause the further extension of a connection from the tandem office to the corresponding terminating office.

2. In a telephone system, a calling office having automatic switches therein, a plurality of terminating offices, a tandem office having switching means therein, direct trunk groups extending from said calling office to the respective terminating offices, a common group of trunks extending from the calling office to said tandem office and serving as an alternate route for calls to said terminating offices, a marker in the calling office having individual route relays for the respective direct trunk groups to said terminating offices and a single route relay for said alternate route group of trunks, circuit means controlled by the contacts of each of said route relays for causing the marker to selectively control the operation of said automatic switches to extend a connection over the corresponding trunk group, and circuit means controlled by the contacts of each direct route relay for controlling the operation of the switching means in said tandem office.

3. In a telephone system, a calling office having automatic switches therein, a plurality of terminating offices, a tandem office having switches therein, direct trunk groups extending from said calling office to the respective terminating offices, a common trunk group extending from the calling office to said tandem office and serving as an alternate route for calls to said terminating offices, trunks extending from said tandem office to each of said terminating offices, automatic switches in each of said terminating offices, route relays in said calling office individual respectively to the direct trunk groups, a single route relay in said calling office for said alternate route group of trunks, circuit means controlled by the contacts of each of said direct route relays for causing the selective operation of the switches in said calling office to extend a connection over the corresponding direct trunk group to the terminating office, circuit means controlled by the contacts of said alternate route relay for causing the selective operation of the switches in said calling office to extend a connection over the alternate group trunks to said tandem office when all of the trunks of a particular direct route group are found busy, and circuit means controlled by the contacts of any one of said direct route relays when all of the trunks of the corresponding direct group have been found busy for causing the selective operation of the switches in said tandem office to further extend an alternate route connection over one of the trunks leading from the tandem office to the called terminating office.

4. In a telephone system, a plurality of groups of trunks, route relays individual respectively to said trunk groups, automatic switches having access to said trunk groups, means responsive to a call for causing the successive operation of said route relays, means controlled by the operation of each relay for causing a test to be made of the corresponding trunk group in search of an idle trunk to serve the call, means controlled by each operated route relay for causing the selective operation of said switches to extend the call over an idle trunk in the corresponding group, a designation register, means controlled by the contacts of the route relay individual to a particular one of said groups for causing the registration of a designation on said register, means responsive to the subsequent operation of other ones of said route relays for alternately canceling said designation and rendering the contacts of said particular route relay effective to reestablish the

registration of said designation, and switching means controlled by said registered designation for causing the further selective extension of a call over one of said groups of trunks.

5. In a telephone system, a plurality of groups of trunks, automatic switches having access to said trunk groups, a sender having designation registers therein, a marker for controlling said automatic switches, route relays in said marker individual respectively to said trunk groups, means responsive to a call for associating said sender with the marker and for causing the successive operation of said route relays, means controlled by the operation of each relay for causing a test to be made of the corresponding trunk group in search for an idle trunk to serve the call, means responsive to any one of said route relays for causing the marker to selectively control the operation of said switches to extend the call over an idle trunk in the corresponding group, means controlled by the contacts of the route relay individual to a particular one of said groups of trunks for causing the registration of a designation on the registers of said sender, means responsive to the subsequent operation of other ones of said route relays for alternately canceling said designation and for rendering the contacts of said particular route relay effective to reestablish the registration of said designation on the registers of said sender, and switching means controlled by the sender in accordance with the registered designation for causing the further selective extension of a call over one of said trunk groups.

6. In a telephone system, a calling office having automatic switches therein, a called office, a direct group and an alternating route group of trunks for extending calls from the calling office to said called office, switch controlling registers in said calling office, a route relay for said direct trunk group and a route relay for said alternate route group in said calling office, means effective when a call is received for said called office for operating said direct route relay to cause the testing and selection of an idle trunk in said direct group, means controlled by said direct group relay for operating said registers to establish thereon information for use in the event it becomes necessary to extend the call over said alternate route group of trunks, means controlled by said direct route relay for canceling the effect of the information registered on said switch controlling registers, means effective if all of said direct trunks are found busy for operating said alternate route relay and for releasing the operated registers, means controlled by said direct route relay for reoperating said registers without canceling the effect of their operation, and means controlled by the operated alternate route relay and by the operated registers for extending the call over an idle trunk in the alternate route group to the called office.

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