Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 1

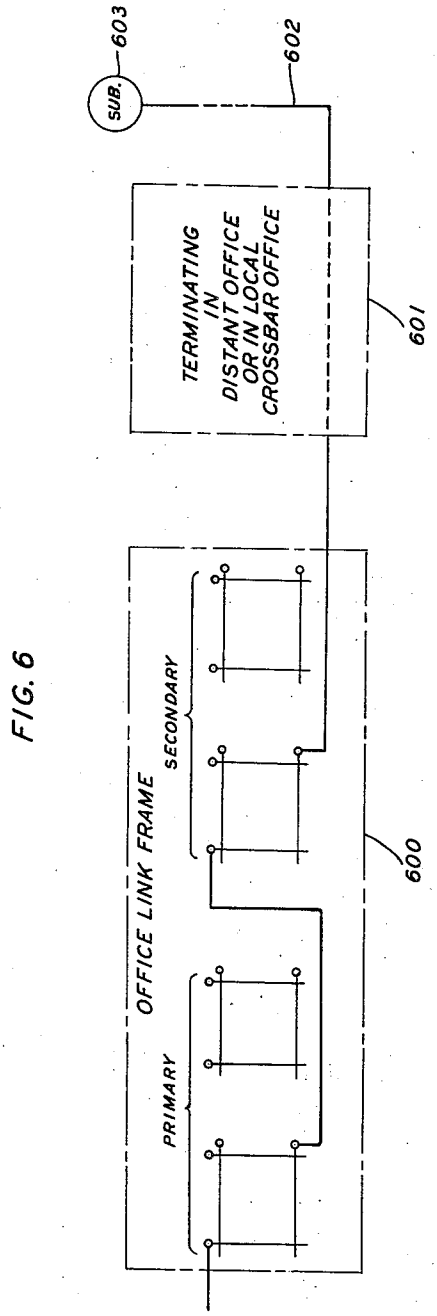


FIG. 6

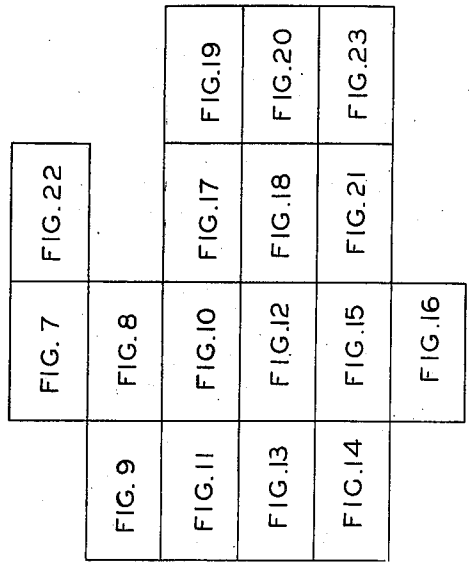


FIG. 2

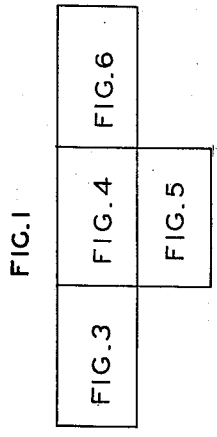


FIG. 1

INVENTORS: A. J. BUSCH
E. L. ERWIN

BY W. T. McTeague

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 2

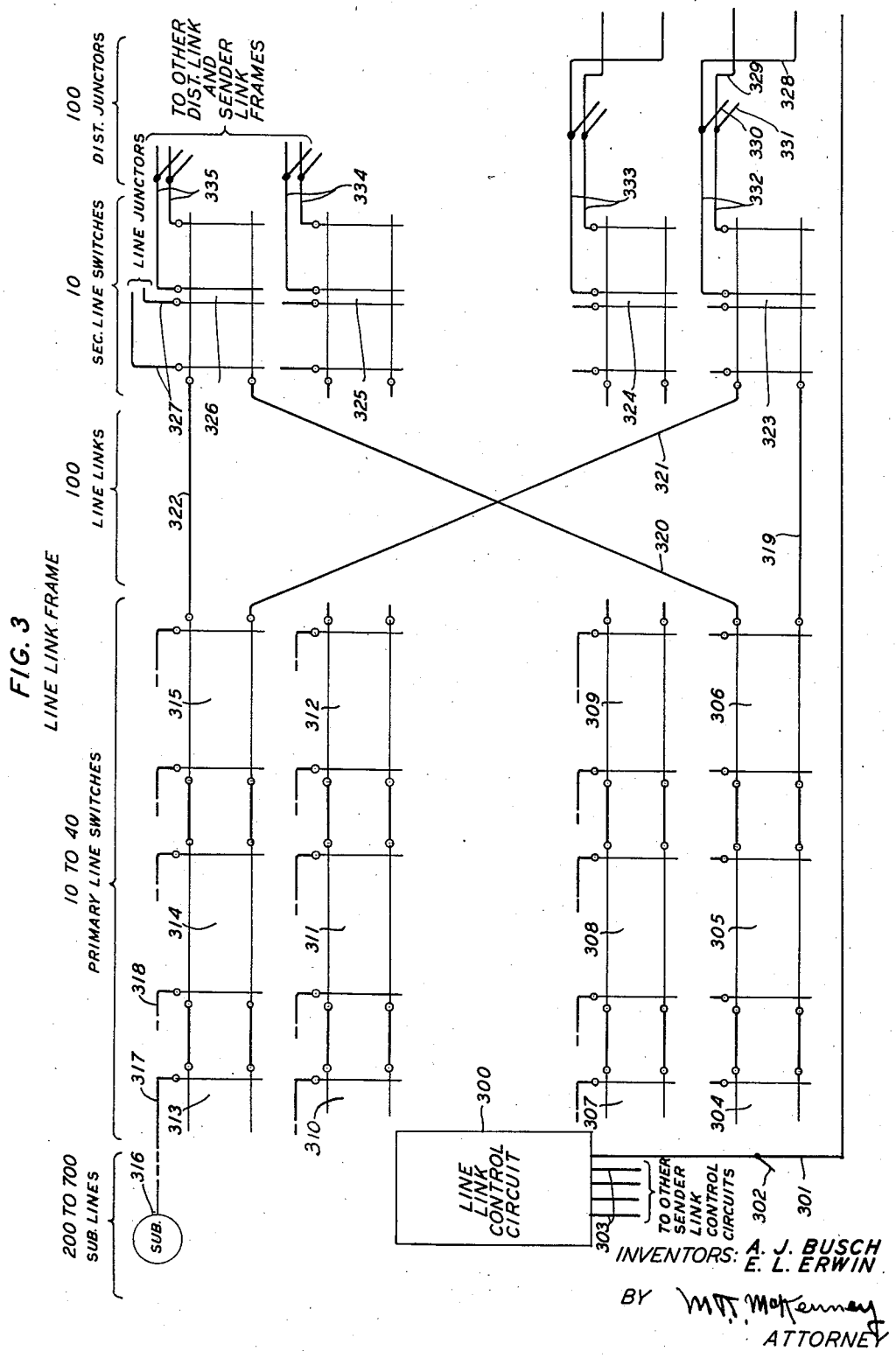


FIG. 3

INVENTORS: A. J. BUSCH
E. L. ERWIN

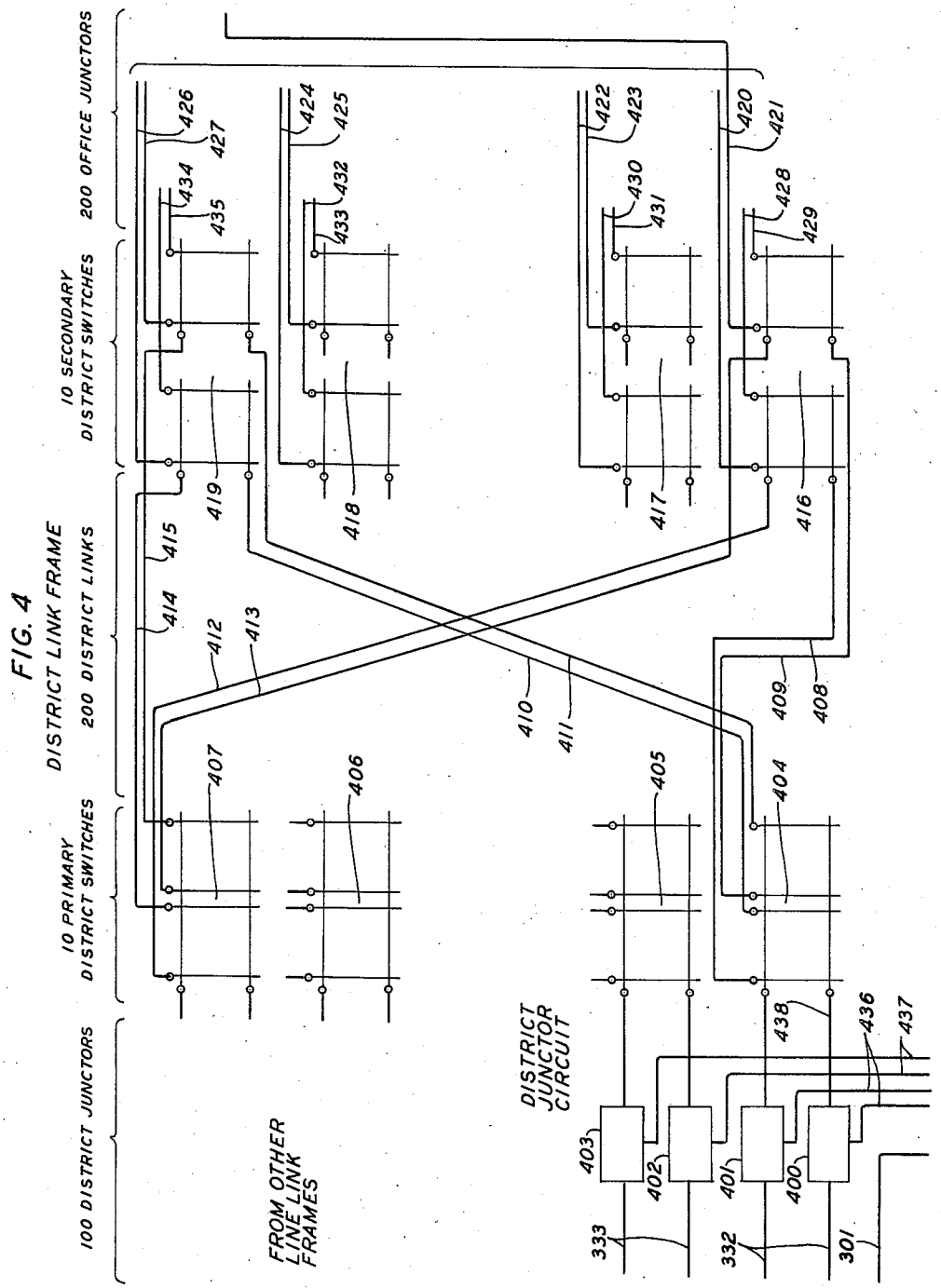
BY W. T. McKenney

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 3



Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 4

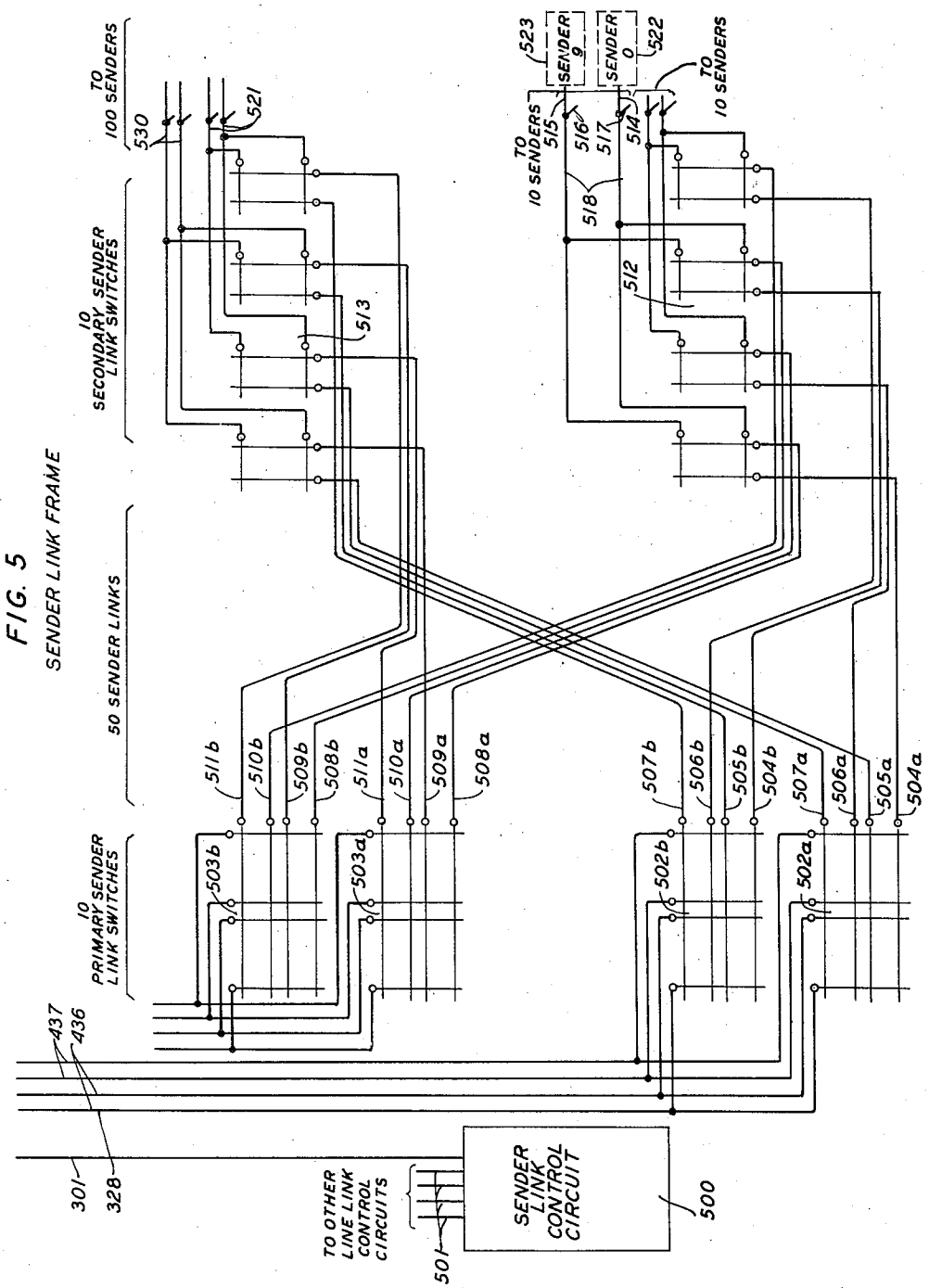


FIG. 5

SENDER LINK FRAME

INVENTORS: A. J. BUSCH
E. L. ERWIN

BY W. T. McTierney

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 5

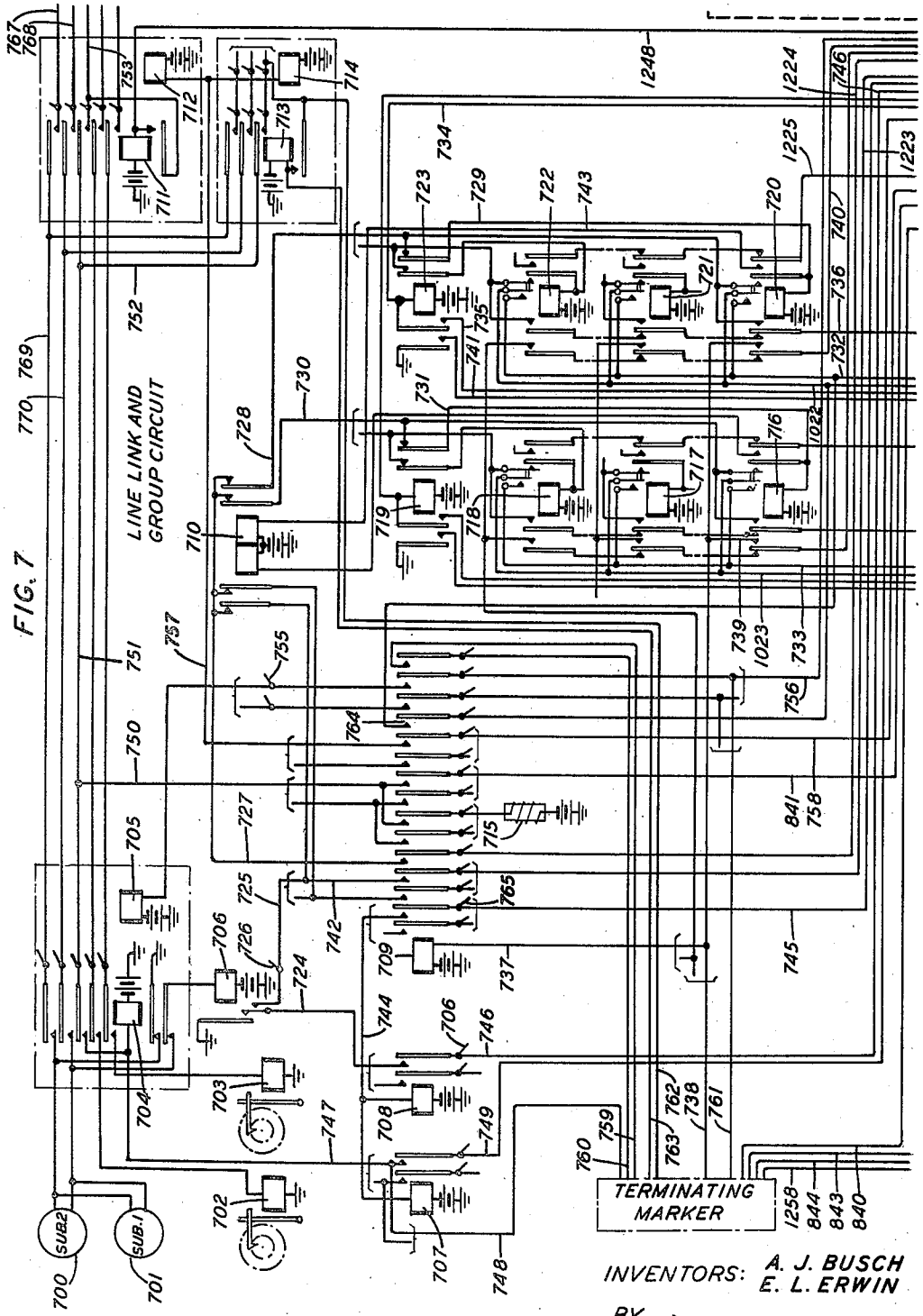


FIG. 7

INVENTORS: A. J. BUSCH
E. L. ERWIN

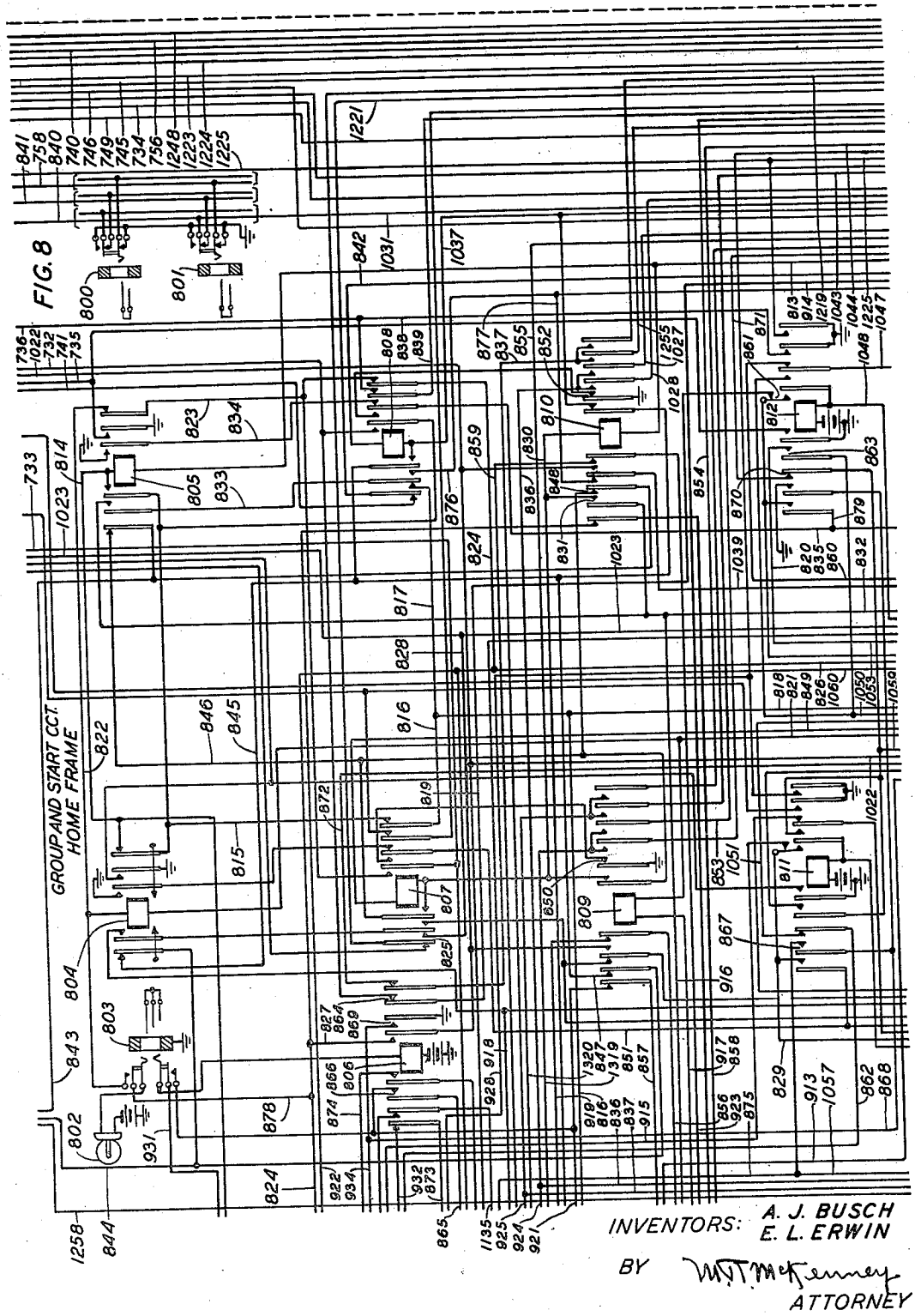
BY

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 6

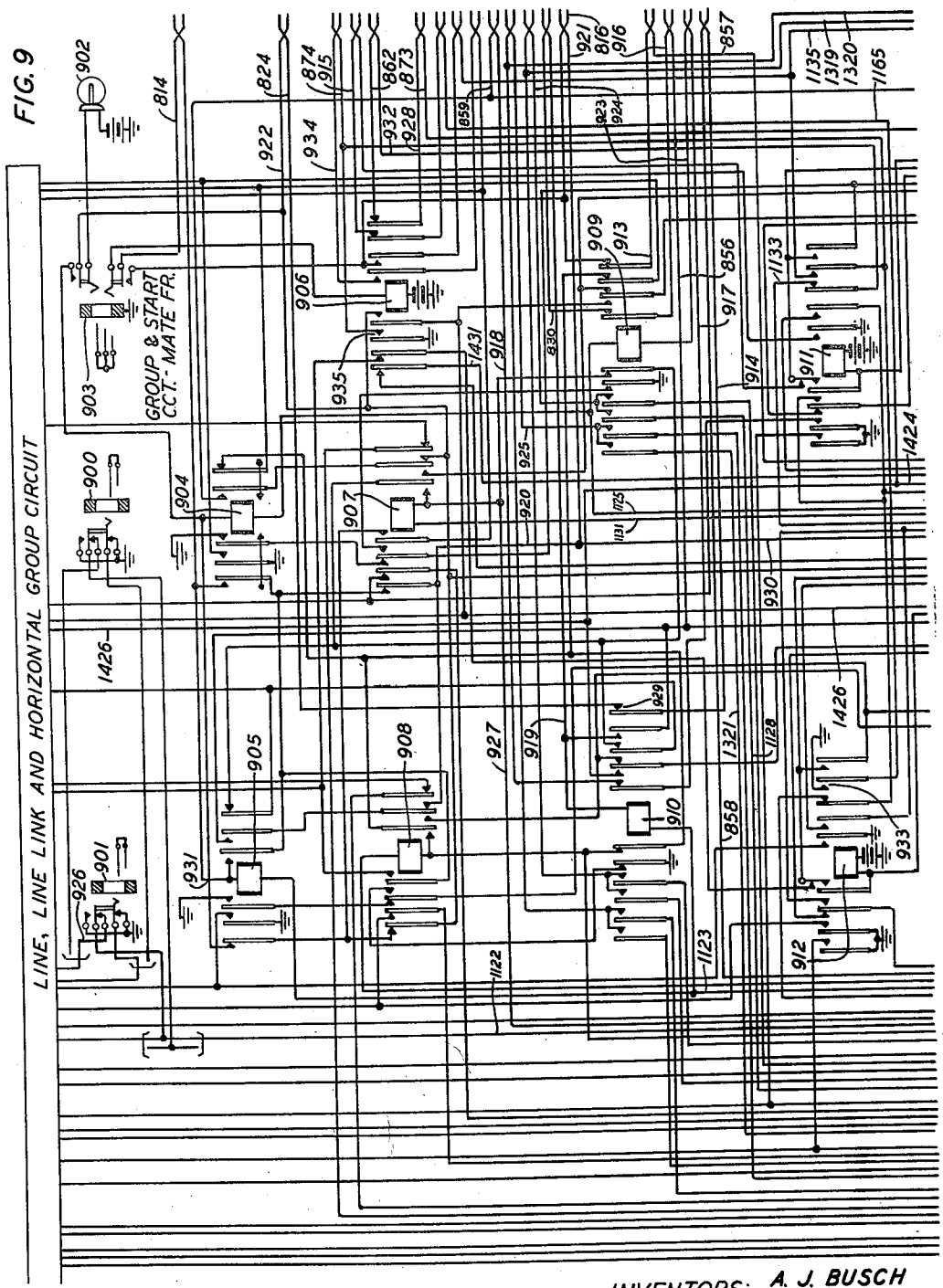


Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 7

FIG. 9



INVENTORS: A. J. BUSCH
E. L. ERWIN

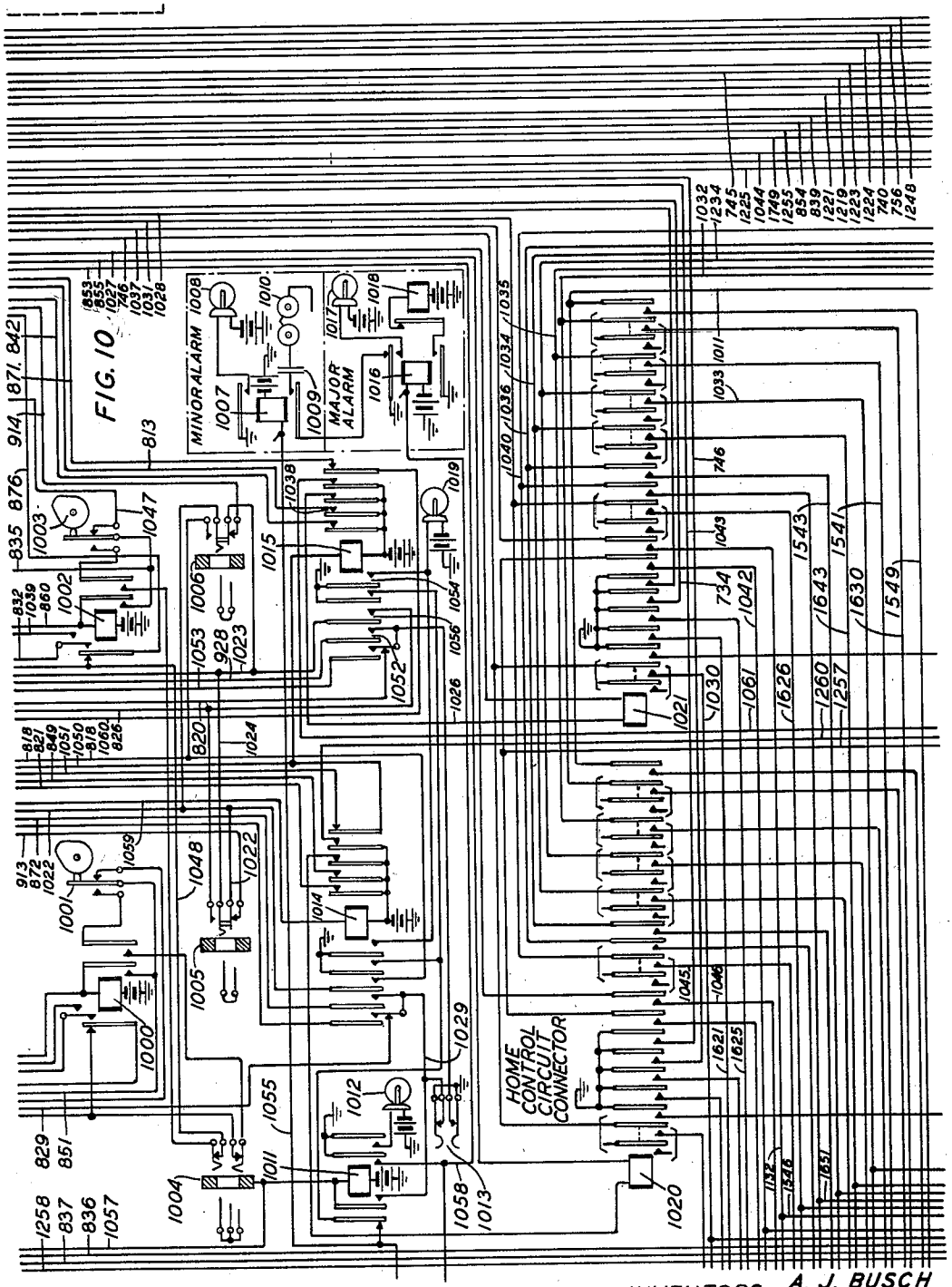
BY M. T. McKenney

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 8



INVENTORS: A. J. BUSCH
E. L. ERWIN

BY W. T. McTierney

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 9

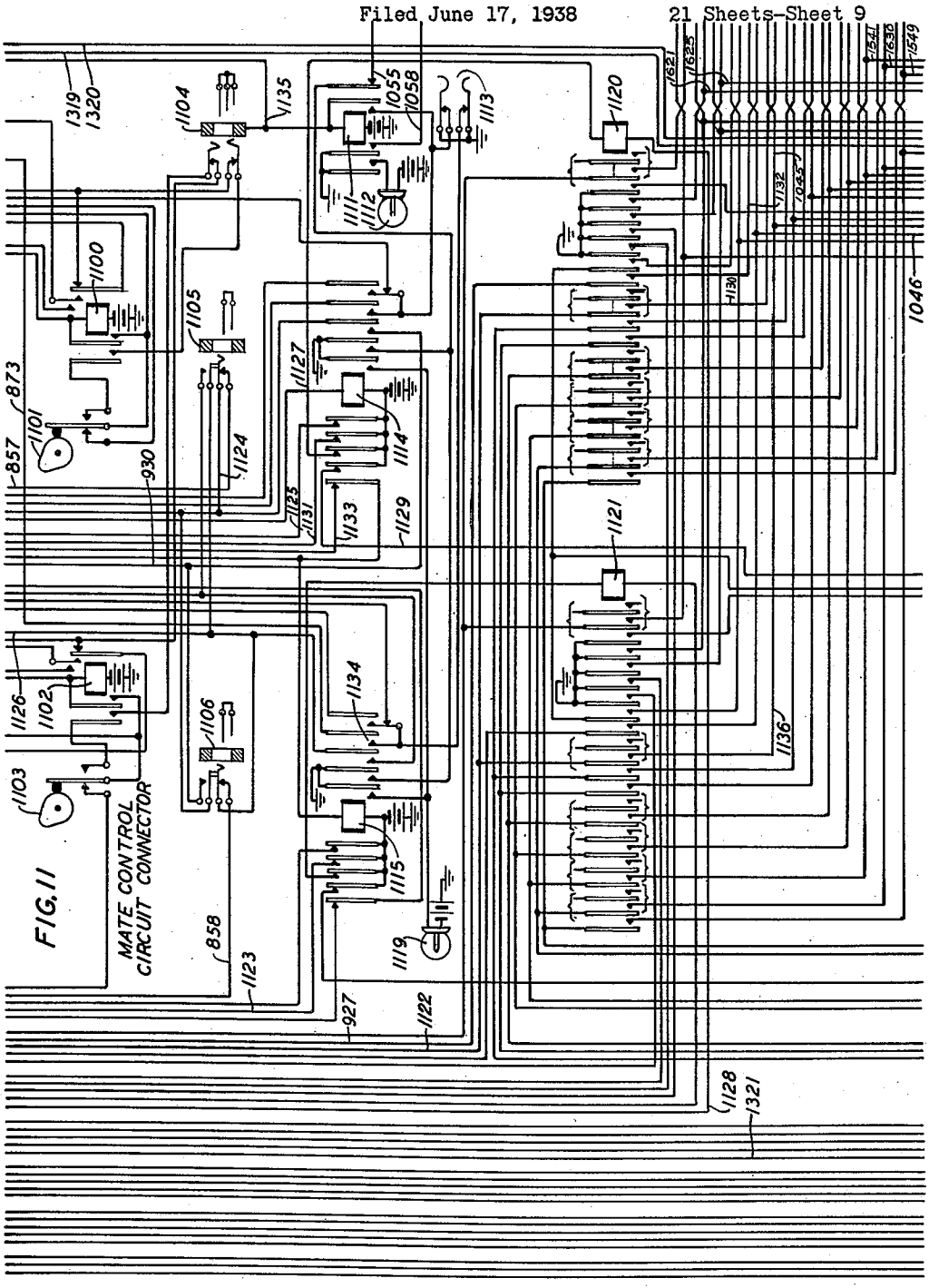


FIG. 11

INVENTORS: A. J. BUSCH
E. L. ERWIN

BY M. T. McKenney

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 10

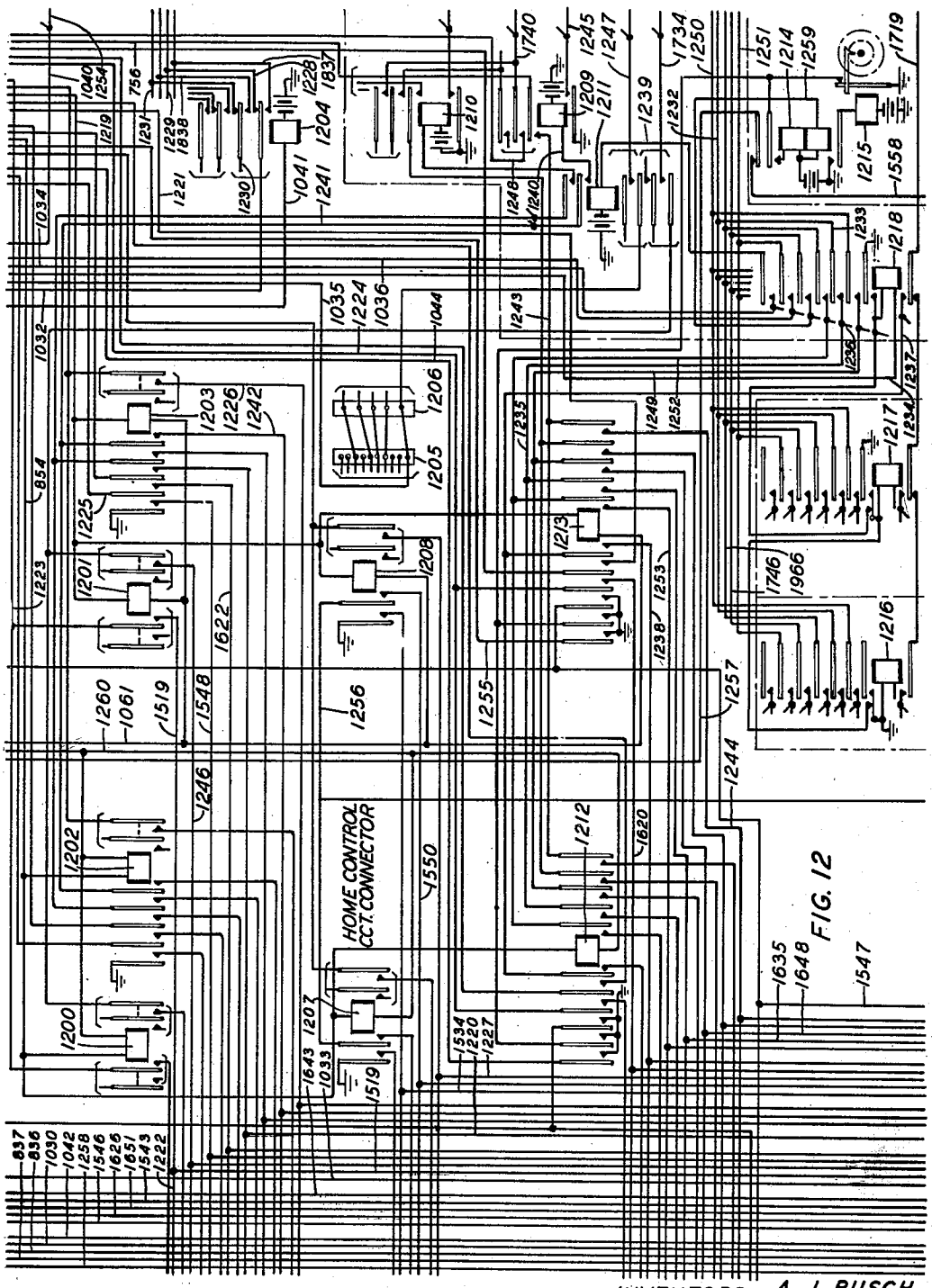


FIG. 12

INVENTORS: A. J. BUSCH
E. L. ERWIN

BY M. F. McKenney

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 11

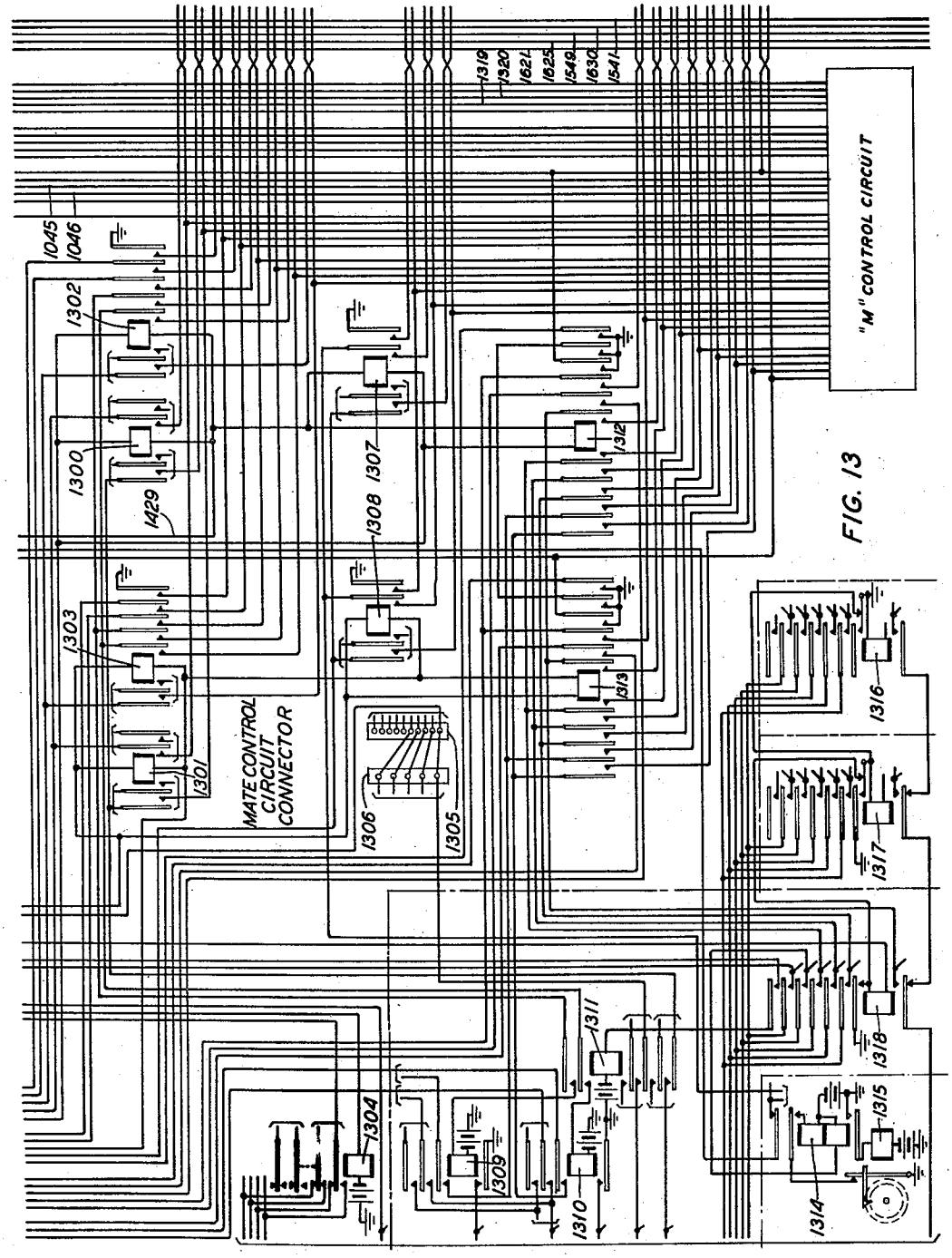


FIG. 13

INVENTORS: A. J. BUSCH
E. L. ERWIN

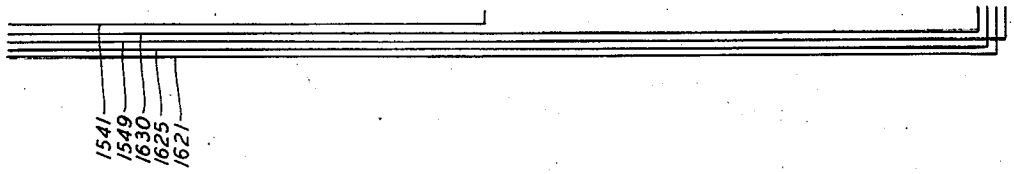
BY W. T. McKinney

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 12



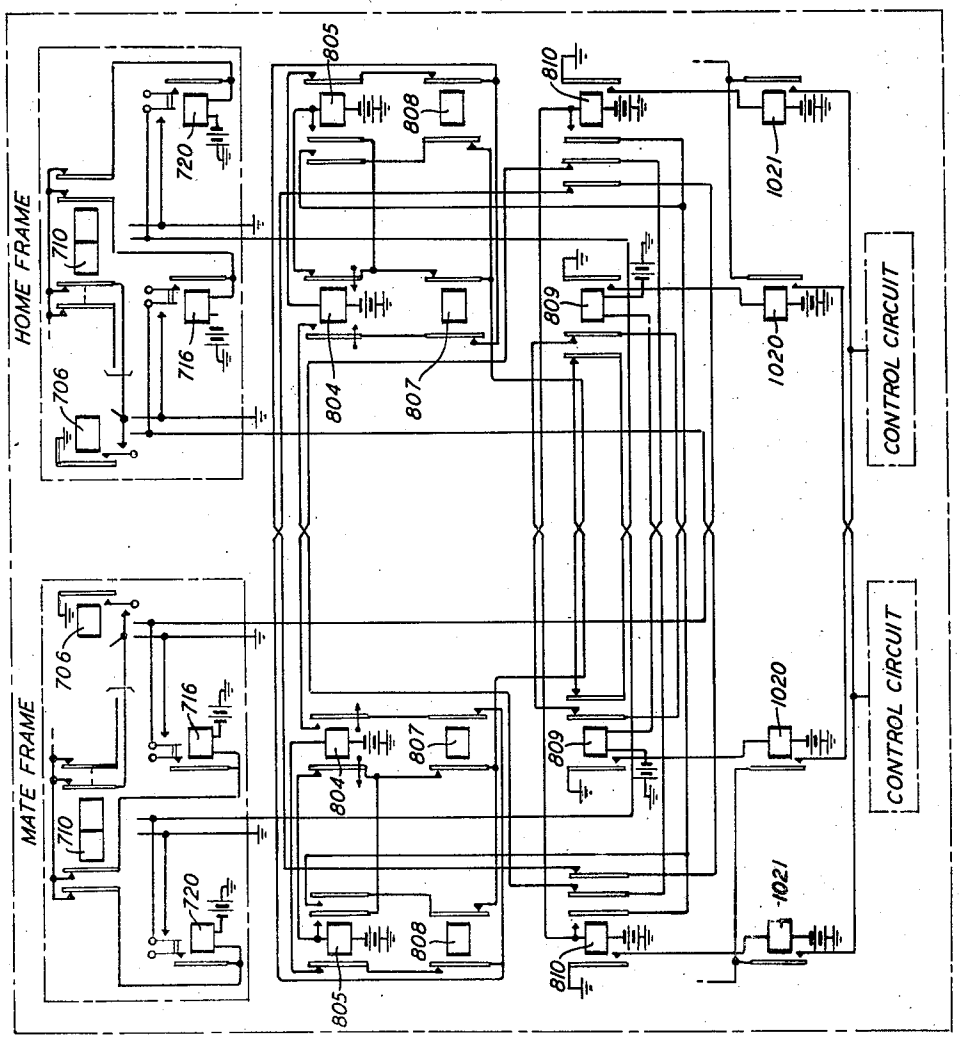


FIG. 14

INVENTORS: A. J. BUSCH
E. L. ERWIN

BY M. T. McKenney

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 13

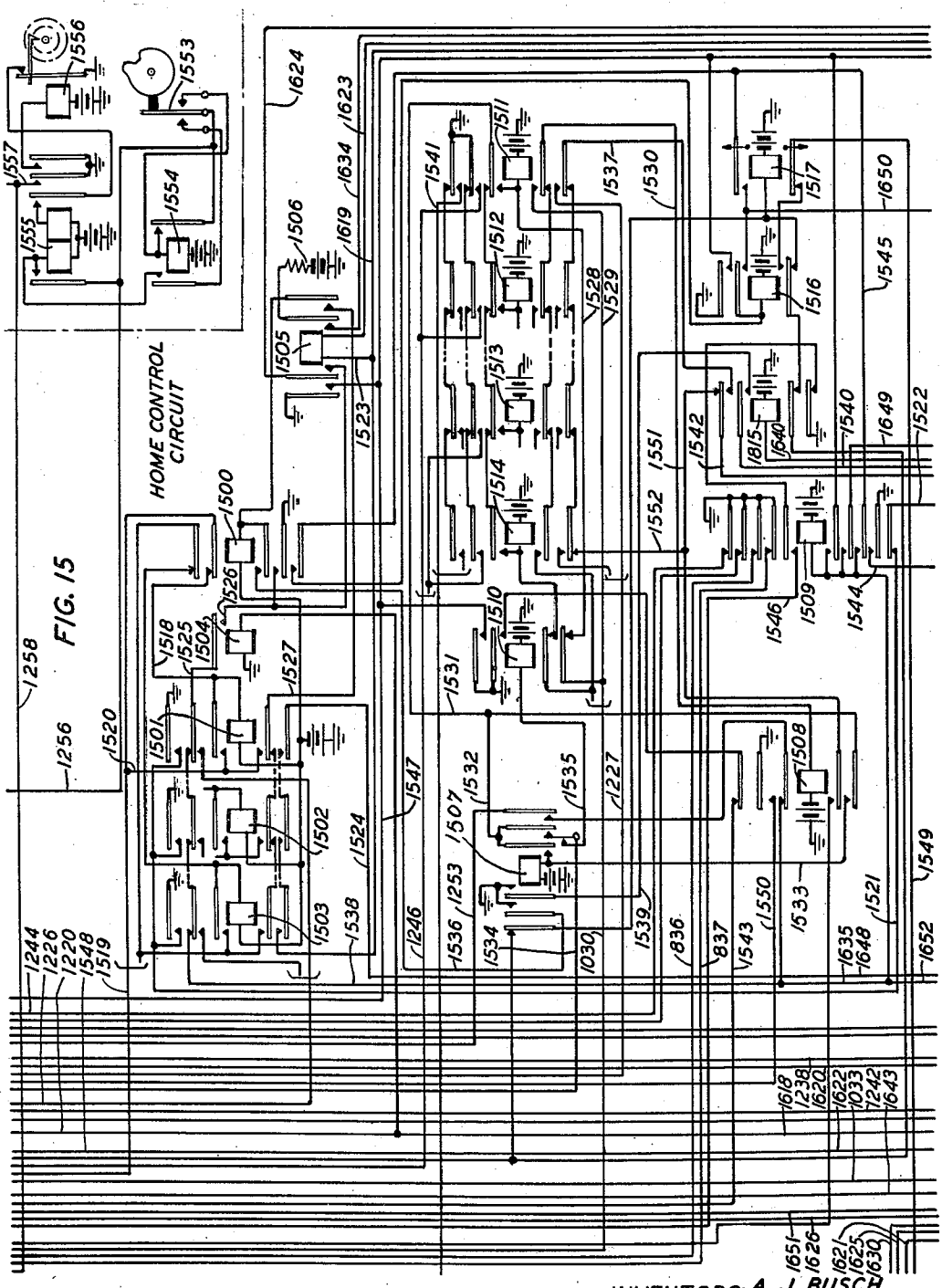


FIG. 15

INVENTORS: A. J. BUSCH
E. L. ERWIN

BY

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 14

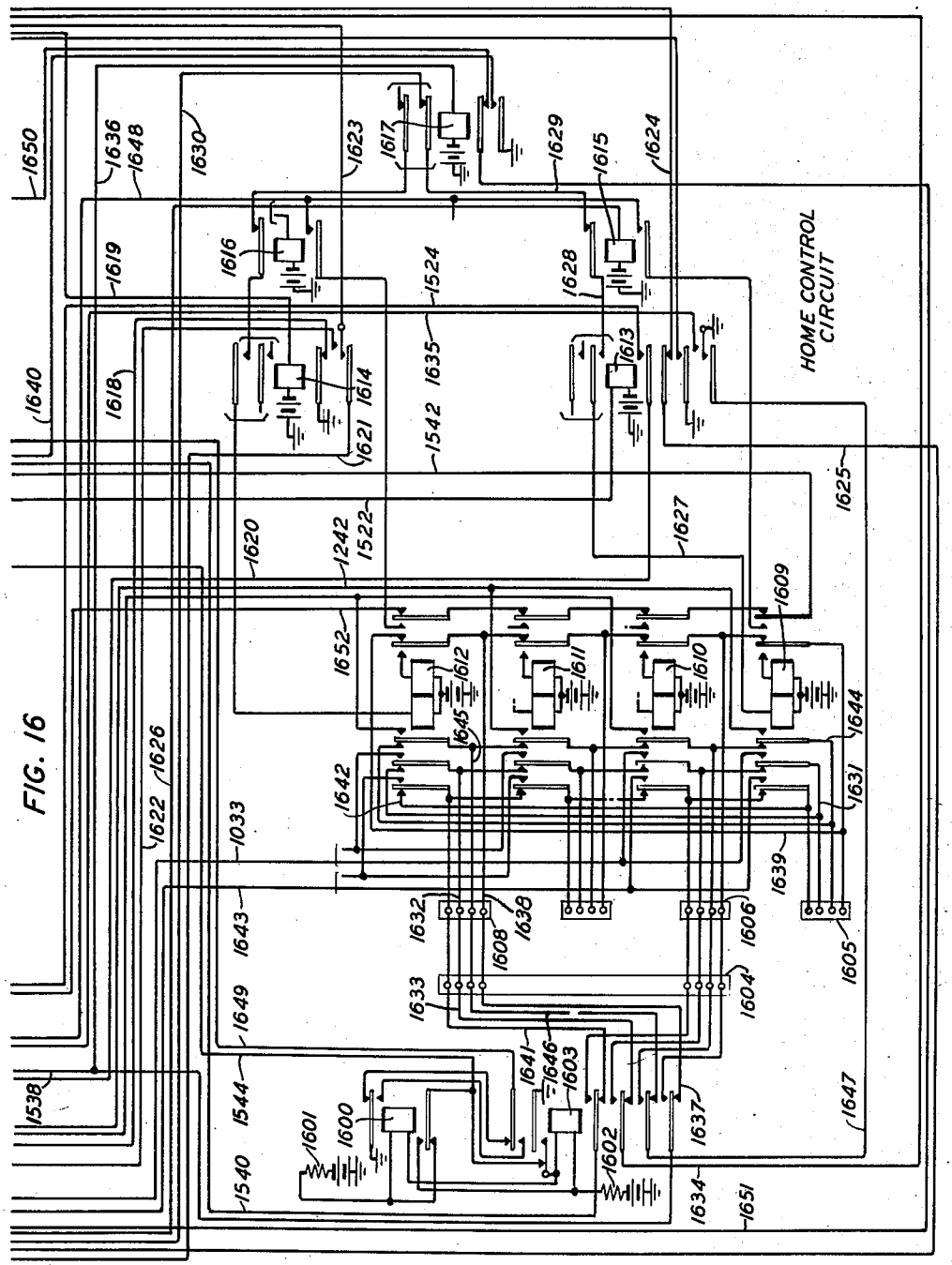


FIG. 16

INVENTORS: A. J. BUSCH
E. L. ERWIN

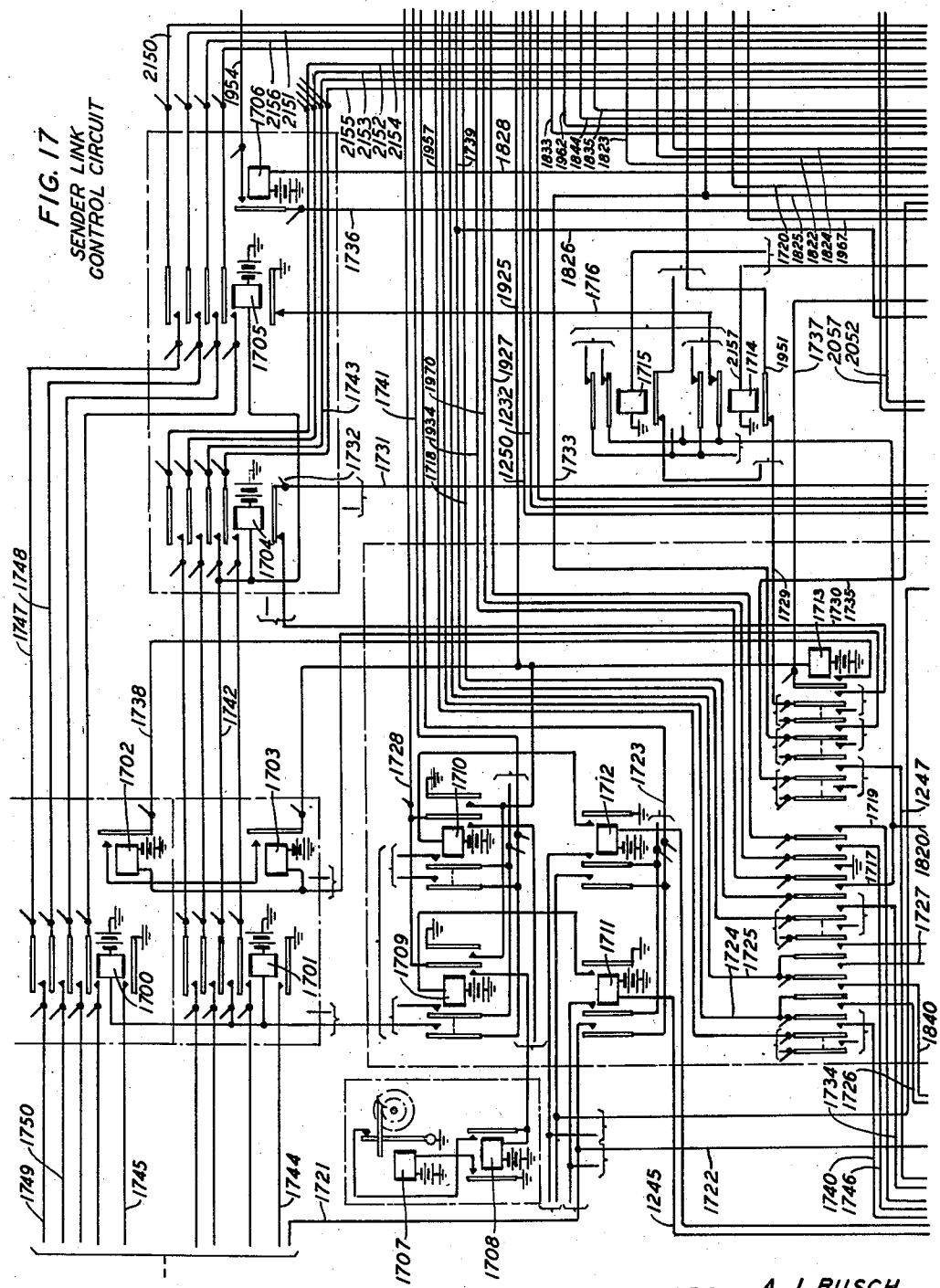
BY M. T. McKenney

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 15



INVENTORS: A. J. BUSCH
E. L. ERWIN

BY M. T. McKenney

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 16

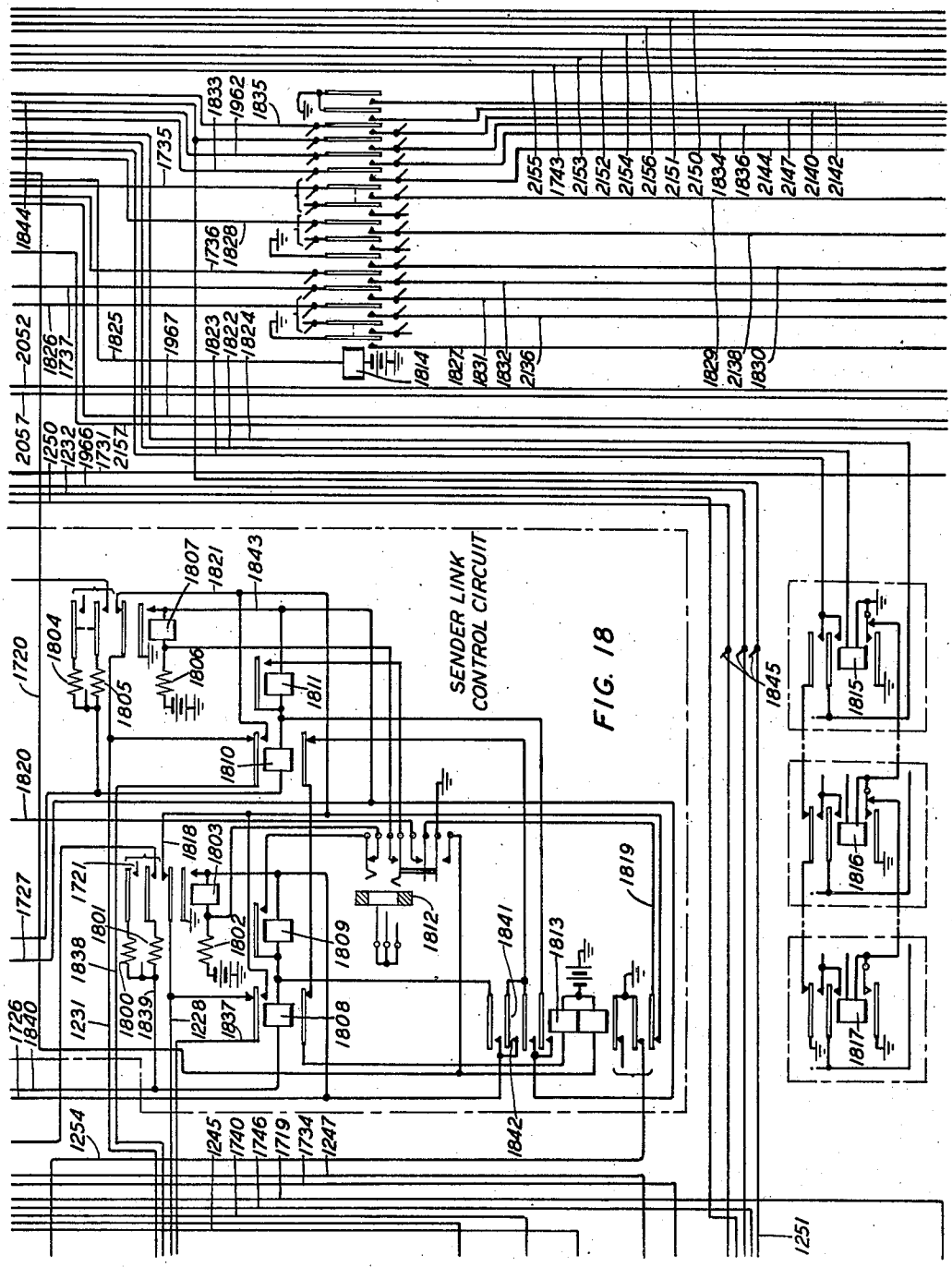


FIG. 18

INVENTORS: A. J. BUSCH
E. L. ERWIN

BY W. T. McKenney

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 17

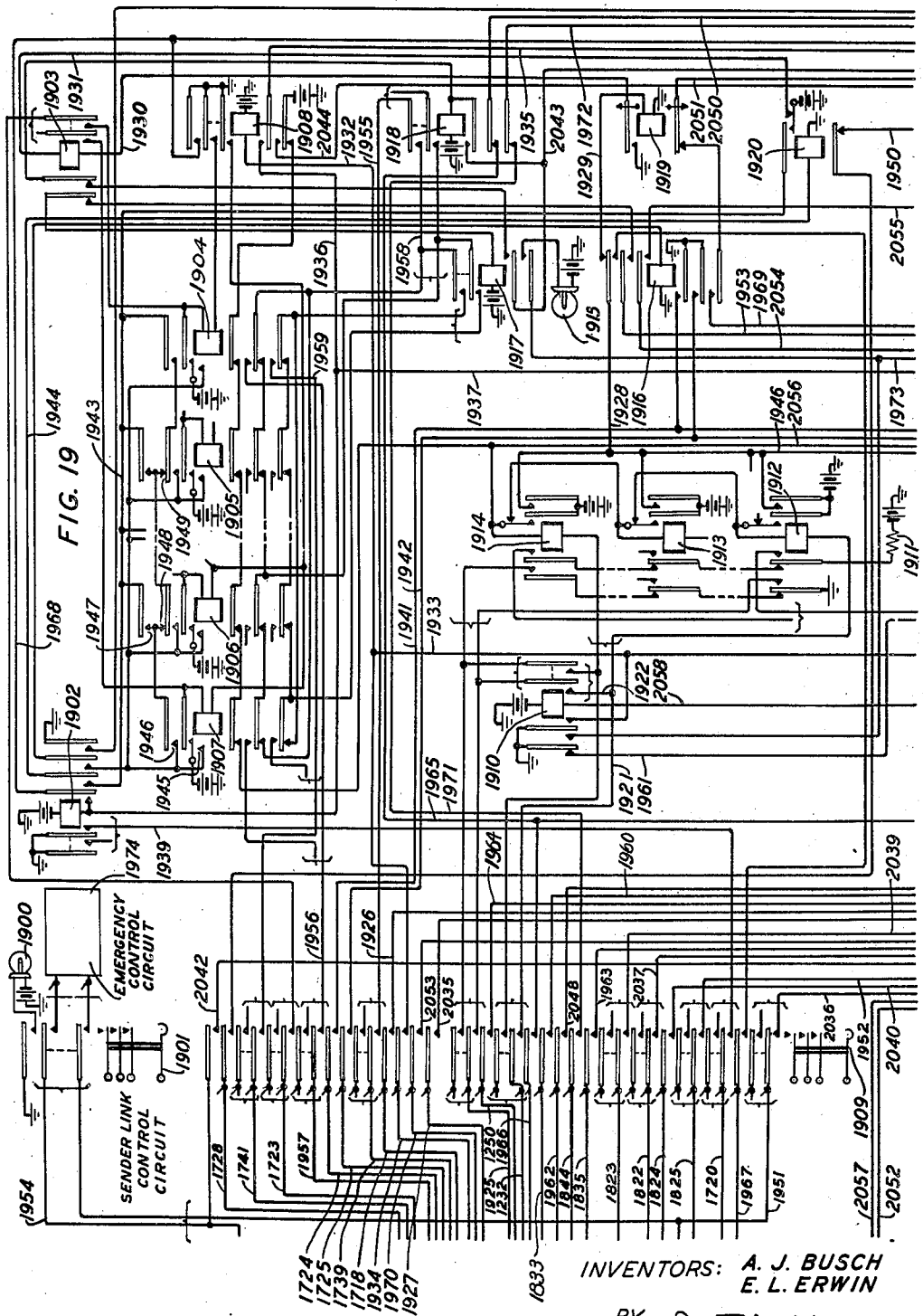


FIG. 19

INVENTORS: A. J. BUSCH
E. L. ERWIN

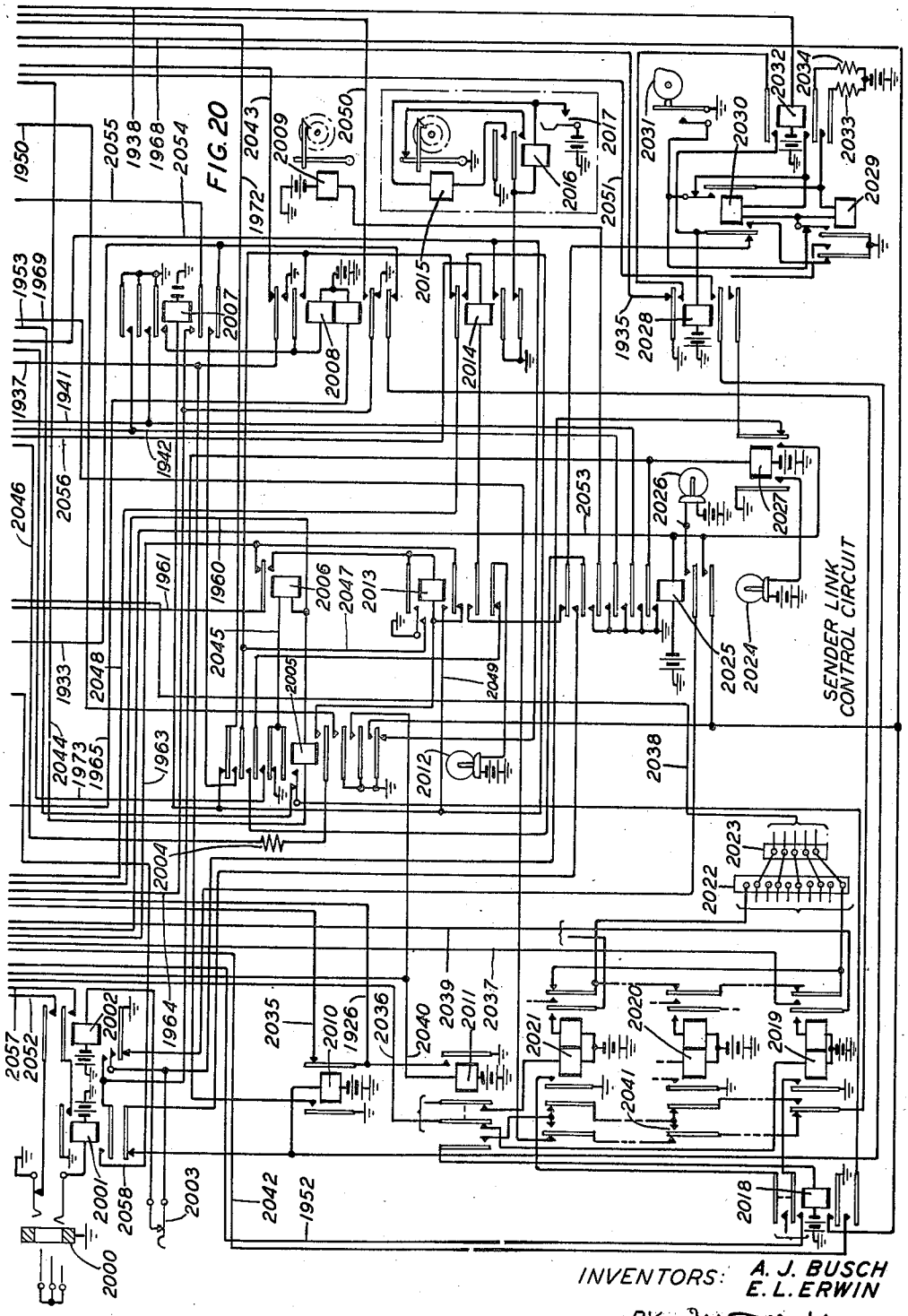
BY M. T. McTierney

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 18



INVENTORS: A. J. BUSCH
E. L. ERWIN

BY M. F. McKenney

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 19

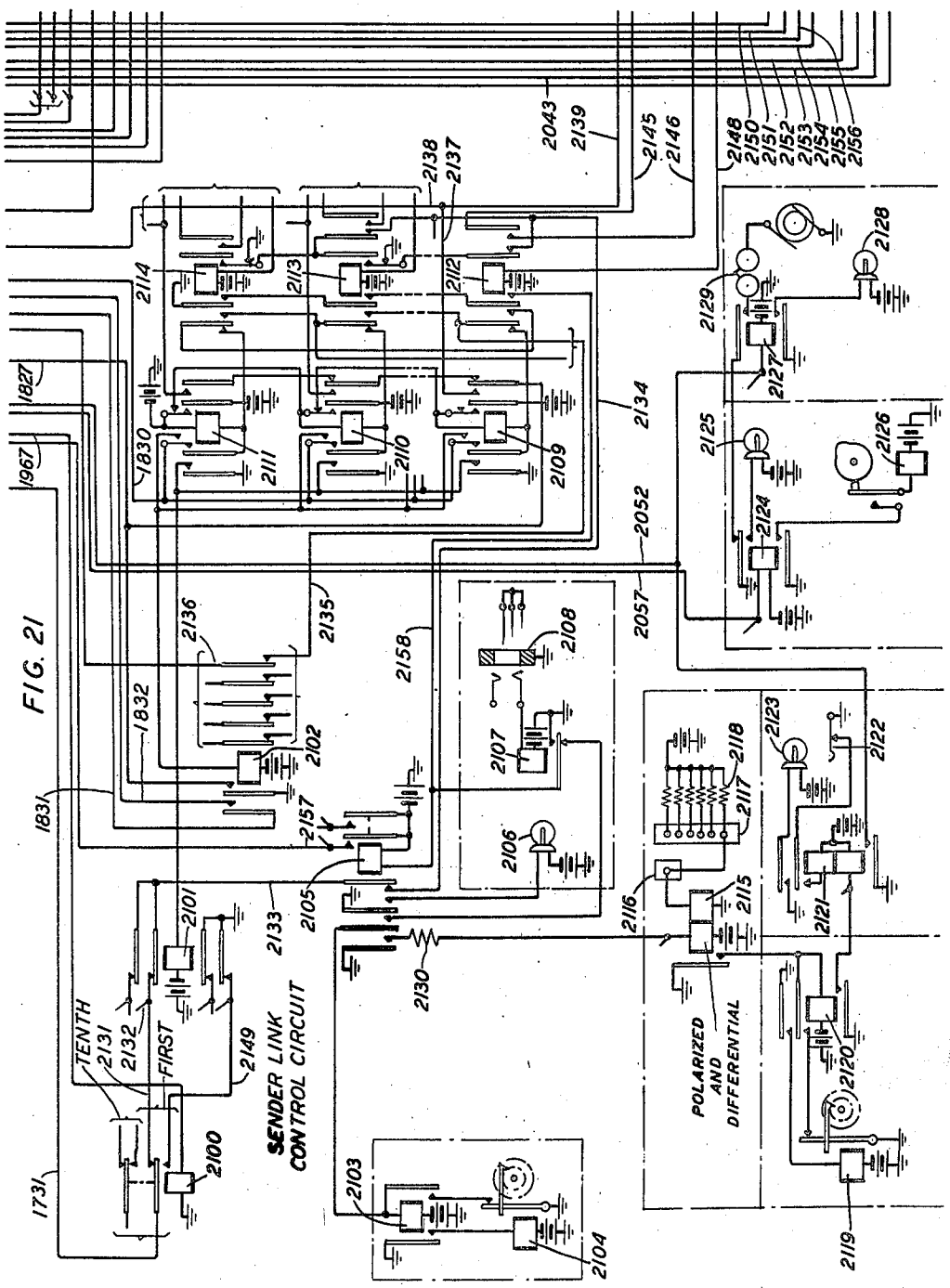


FIG. 21

INVENTORS: A. J. BUSCH
E. L. ERWIN

BY W. J. McTernan

ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 20

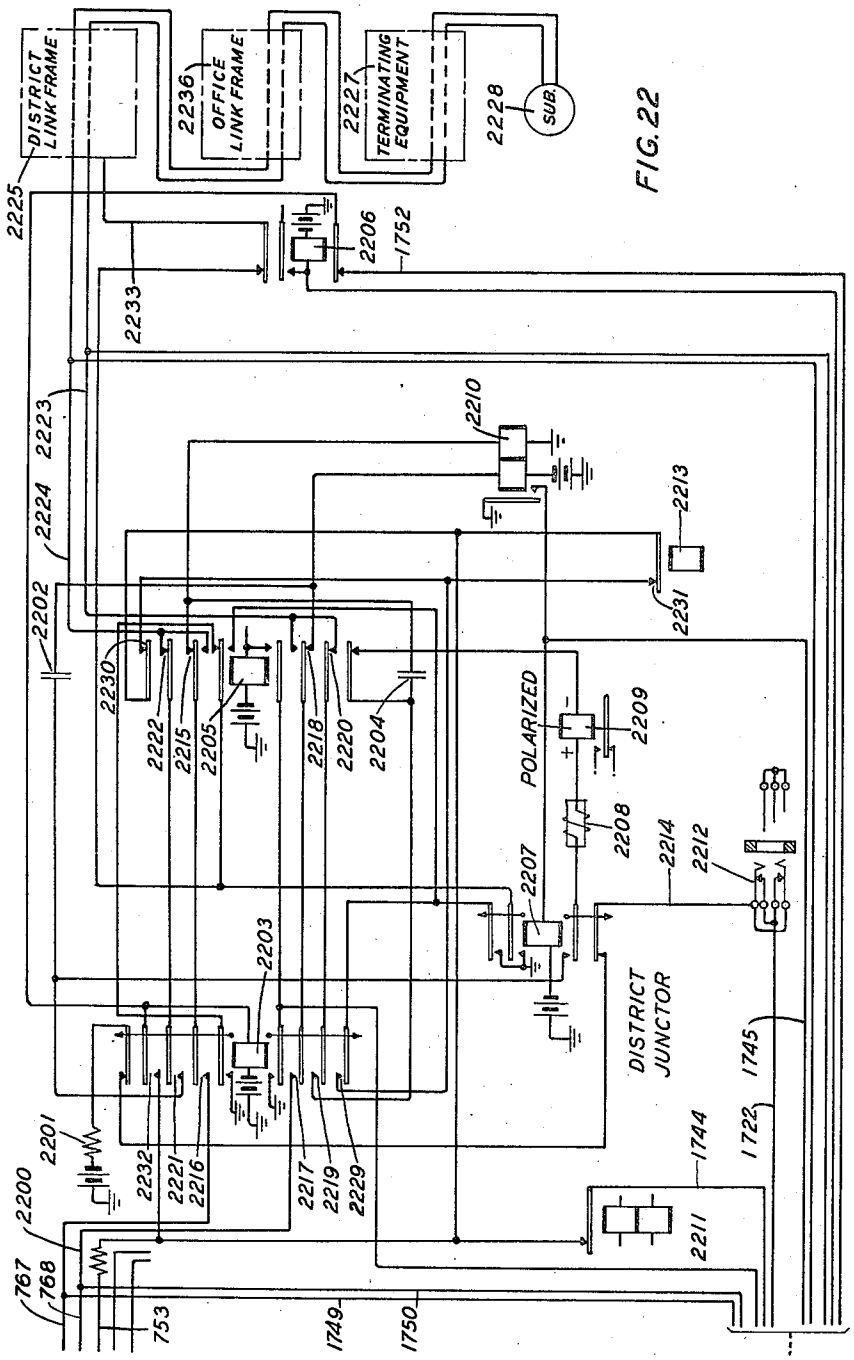


FIG. 22

INVENTORS: A. J. BUSCH
E. L. ERWIN

BY W. T. McKenney

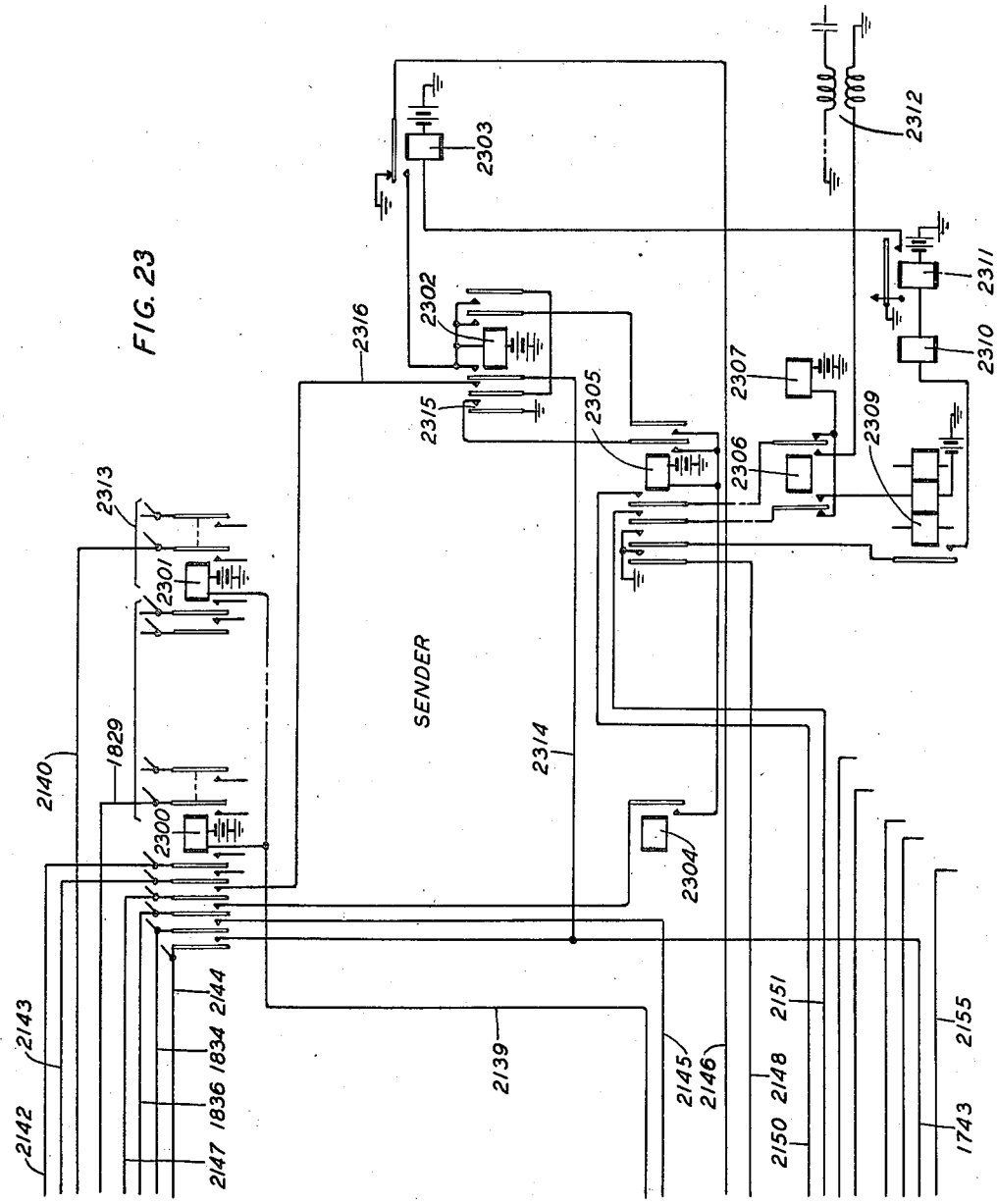
ATTORNEY

Dec. 10, 1940. A. J. BUSCH ET AL 2,224,251

TELEPHONE SYSTEM

Filed June 17, 1938 21 Sheets-Sheet 21

FIG. 23



INVENTORS: A. J. BUSCH
E. L. ERWIN

BY W. T. McKenney

ATTORNEY

Patented Dec. 10, 1940 2,224,251

UNITED STATES PATENT OFFICE

2,224,251

TELEPHONE SYSTEM

Aloysius J. Busch, Madison, and Edson L. Erwin, Towaco, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application June 17, 1938, Serial No. 214,347

13 Claims. (Cl. 179—18)

This invention relates to telephone systems and particularly to those employing automatic switching equipment for the establishment of conversational connections.

The objects of the invention are to enable a more efficient use of the controlling equipment and especially the equipment that serves in common for a number of lines; to expedite the service given to waiting calls by minimizing the delays resulting from an increased demand on the switching facilities or from the existence of trouble conditions; and otherwise to secure improvements in systems of this kind.

Central office exchange systems have been proposed heretofore in which calling subscribers' lines are extended automatically by way of cross-bar line switches to district trunks and district selector switches and in which the district trunks seized for use by the calling lines are also extended automatically by way of cross-bar sender link switches to idle register senders. In such systems it has been the plan to arrange the calling subscribers' lines in groups, each group appearing in a number of cross-bar line switches mounted on a line switch frame and to provide each line group or line switch frame with a controlling equipment for controlling the extension of the calling lines through the line switches to idle district trunks and to idle senders. It has also been the plan to have the district trunks serving a number of groups of lines appear in a number of sender link switches mounted on a single frame. Each of these sender link frames is likewise provided with its individual controlling mechanism, which cooperates with the line controlling mechanism for the purpose of extending calling lines through the sender link switches to the idle register senders. Since a line group control mechanism is common to all the switches and all the lines on the frame to which it is individual, and since the control mechanism must be used for every originating call that is extended through the switches of its frame, any trouble occurring in the common mechanism during the extension of a particular call would, unless provision is otherwise made, prevent all other lines in the group from obtaining service. It is, therefore, desirable to utilize the common controlling equipment on an emergency basis to serve other frames so far as it is feasible to do so. Furthermore, it is desirable to distinguish between conditions which cause delay as a result of fault or trouble in the equipment and conditions causing delay because of an excessive demand upon the switching facilities. And, in accordance with the features of this invention, which are stated more fully below, improvements and advantages are obtained with these systems.

A feature of the invention is a system in which each frame of line switches serving a group of lines is provided with a control mechanism which normally serves the frame as a home control circuit and serves a second frame of switches as a mate control circuit in the event of an emergency, and in which the frame is provided with two start circuits, one serving in the normal operation of the system to cause the connection of the home control circuit to the frame when a call appears, and the other serving in the case of an emergency to cause the connection of the mate control circuit to the frame in response to the appearance of a call therein. Each of these two start circuits serves to record the subgroup or horizontal group location of all calling lines in the line group or frame of switches, and, since the calling condition of any horizontal group is registered in both of the start circuits of the frame, either the home start circuit will summon the home control mechanism to serve the call or the mate start circuit will summon the mate control mechanism depending upon which of the two control mechanisms is at the moment serving the frame. With this arrangement each line switch frame is served normally by its home control mechanism, which is summoned by the home start circuit when a call occurs in the horizontal group, and, whenever a trouble condition occurs, making it impossible for the control mechanism to complete its function in connection with the call it is attempting to serve, the home control mechanism is released, and the mate start circuit of the frame is rendered effective to summon thereafter the control circuit of the mate frame to serve its calls during the emergency. During this emergency period the mate control circuit serves the calls on both frames. Should a second trouble occur while the mate control circuit is serving the frame, a transfer is made back to the home start circuit, and on the next call the frame summons the home control circuit. With each succeeding occurrence of trouble thereafter a transfer is made from one control circuit to the other.

Another feature of the invention is a system in which either the home or the mate control mechanism serves a call in each of the successive groups on the frame having at least one call therein, and in which the group that the control mechanism is serving at the time trouble occurs and causes the transfer from one con-

trol mechanism to the other is held in abeyance and denied service until one call is served in each of all other groups having calls therein.

Another feature of the invention is a system of this character in which each frame of line switches is provided with mechanism for counting two intervals of time, both of which are started when the control mechanism is taken in use to serve a call on the frame. One of these time intervals, which is comparatively long, is selected to measure the time allowable for a control circuit to complete all of its functions in serving a call. Should the control circuit fail to complete its functions and release within this long interval, the indication is that a trouble exists either in the control circuit or in the frame equipment, and the control circuit is automatically released from the frame, and the start circuit transfer is made so that all calls in the frame will thereafter be served by the mate control circuit as above explained. The other time interval, which is comparatively short, is long enough to allow the control mechanism and the associated sender link control mechanism sufficient time in which to determine whether there is available at the moment the necessary idle equipment for extending the calling line over a line link circuit to a district trunk through a sender link circuit to an idle register sender. If this equipment is available, the short time interval expires without affecting the normal procedure of the call, and the functions involved in extending the calling line to the idle sender will continue to progress in their normal manner unless a trouble condition occurs, which will be recognized at the expiration of the long time interval above explained. Should, however, it develop that the necessary switching equipment is unavailable at the time the short time interval expires, the control mechanism is automatically released, and the start circuit of the calling frame proceeds anew to seize the control mechanism for a new trial. However, the release of the control mechanism in response to the expiration of the short time interval is not accompanied by a transfer from one control mechanism to the other. The purpose of this short time interval is to prevent a control mechanism, due to the lack of switching facilities at the moment, from being held until the long interval expires, thereby causing the indication of a trouble condition which does not in reality exist.

A further feature of the invention is a system in which the sender link control mechanism, associated with each one of the sender link frames, is provided with timing mechanism for measuring two separate time intervals. One of these time intervals, which is relatively long, starts when the sender link control mechanism is seized by a line group control mechanism and extends over a period sufficient to enable the sender link control mechanism to perform its functions in connection with the extension of the calling line through to an idle sender. If, however, the sender link control mechanism encounters trouble and fails to complete its functions before the long time expires, the expiration of this interval causes the sender link control mechanism to free the line group control mechanism to which it is locked. Therefore, the line group control mechanism is now free to make another trial, calling in other sender link control mechanisms for this purpose. The second time interval, which is a comparatively short one and which also begins at the time the sender link control mechanism is seized by a line group control mechanism, is of sufficient duration to allow the sender link control mechanism to seize a group of senders having an idle one therein, provided the control mechanism does not encounter competition from other mechanisms for idle sender groups. If, however, the demand for senders is great enough to prevent the control mechanism seizing an idle sender group within the short interval of time allowed, the expiration of this interval causes the sender link control mechanism to free the line group control mechanism, permitting the latter to make another trial.

With the timing periods provided for the line group mechanism and the sender link mechanism it is possible to detect the presence of a trouble condition and to free the line group frame on which the call is present from the line group controlling mechanism that is attempting to serve the call at the time trouble is encountered, provided the trouble is present in the controlling mechanism or in the line switch frame, and to free the line switch frame and its controlling mechanism from the sender link control mechanism with which it is cooperating in the event the trouble is present in the sender link mechanism. In this way a line switch frame is able to continue giving service to the calls appearing thereon and to make further attempts to serve the particular call on which it is working at the time the trouble condition arises. Moreover, the short time intervals safeguard against the possibility that temporary traffic delays may give a false indication that a trouble condition exists in the equipment. If these temporary traffic delays occur, the controlling mechanisms that are attempting to serve a particular call may be released in order that the equipment may make a further trial to complete the desired connection.

The foregoing and other features of the invention will be described more fully in detail in the following specification and will also be set forth in the appended claims. The specification is accompanied by drawings in which:

Fig. 1 is a plan of the arrangement for Figs. 3 to 6, inclusive;

Fig. 2 is a plan of the arrangement for Figs. 7 to 23, inclusive;

Figs. 3 to 6, inclusive, comprise a diagram of the equipment in a dial office which serves to extend calling lines to district selector frames and to idle register senders;

Figs. 7 to 16, inclusive, show in detail a calling subscriber's line, a line link, and the line link control circuit;

Figs. 17 to 21, inclusive, show in detail a sender link and the sender link control circuit;

Fig. 22 shows pertinent details of the district junctor circuit, and a diagrammatic connection through other switching equipment to a called subscriber's line; and

Fig. 23 shows that portion of the sender circuit which affects the operation of the sender link control circuit.

General Description of System

The operation of that part of the cross-bar system embracing the features of this invention, namely the originating portion which connects the calling subscriber's line to a district junctor and to a sender, may be understood in a general way by consideration of the diagram of Figs. 3 to 6, inclusive. The completion of the talking connection to a called subscriber's line is indicated briefly in Figs. 4

and 6 of the diagram. For a more complete disclosure and description of the detailed equipment involved in the completion of calls in a system of this kind, reference may be had to Carpenter Patents 2,093,117 of September 14, 1937, and 2,089,921 of August 10, 1937, and to the copending application of W. W. Carpenter Serial No. 214,356, filed June 17, 1938.

Fig. 3 shows certain primary and secondary line switches and the line link control circuit of one line link frame; line links interconnecting the primary and secondary switches; a subscriber's station and subscriber lines connected to the primary switches; district junctors, extending outward from the secondary switches for use in originating calls; and line junctors incoming to the secondary switches, for use on terminating calls.

Fig. 4 shows certain of the primary and secondary district switches of one district link frame; district links interconnecting the primary and secondary switches; district junctors, incoming from various line link frames, connected to the primary switches and to the associated sender link frame; and office junctors extending outward from the secondary switches.

Fig. 5 shows certain of the primary and secondary sender link switches and the sender link control circuit of the sender link frame which is associated with the above district frame; sender links interconnecting the primary and secondary switches; connecting leads incoming from the district junctors to the primary switches; and common connecting leads outgoing from the secondary switches to various senders.

The switches shown in Figs. 3 to 6, inclusive, are of the cross-bar type and they consist of a plurality of sets of contacts arranged in horizontal levels and vertical rows. Associated with each horizontal level of contact sets is a horizontal operating magnet, not shown, hereinafter referred to as a select magnet, under control of which the contact sets of that level are prepared for operation. Associated with each vertical row of contact sets is a vertical operating magnet, not shown, hereinafter referred to as a hold magnet, under control of which any one set of contacts in that row, after being prepared for operation by the operation of its respective select magnet, is caused to close and remain in the closed position under control of the operated hold magnet. For example, switch 314 in Fig. 3 has two hundred sets of contacts arranged in ten horizontal levels and twenty vertical rows. Each contact set consists of four or five contacts, and each contact consists of two springs of which one may be termed the moving spring and the other the fixed springs. When a contact set is closed each of its moving springs makes electrical contact with its mated fixed spring. Corresponding moving springs in the ten contact sets of the left-hand row of switch 314 are multiplied together and connected to the four or five wires associated with subscriber line 318, and the moving springs of nineteen other rows are similarly connected to nineteen other subscriber lines. Corresponding fixed springs in the twenty contact sets of the top level of switch 314 are multiplied together and connected to the four or five wires associated with line link 322, and the fixed springs of the nine other levels are similarly connected to nine other line links. If the select magnet associated with the top level is operated, and then the hold magnet associated with the left-hand row is operated, the top left-hand contact set will close and connect subscriber line 318 and line link 322 together. The select magnet is then released, but the hold magnet is kept energized as long as it is desired to maintain the connection between the subscriber line and the line link. When the select magnet has been released, the same or another select magnet and another hold magnet may be operated to connect another subscriber line to another line link, and this process may be continued until all ten line links are connected to ten subscriber lines. For a more detailed explanation of the construction and operation of one suitable form of cross-bar switch, reference may be had to the patent of J. N. Reynolds, No. 2,021,329, November 19, 1935.

The subscriber lines are arranged in groups which may vary in size, say, from two hundred to seven hundred lines each, the size of the group depending upon the relative activity of the lines in the group. Each group of lines is served, for the purposes of both originating and terminating calls, by the line switches, line links, and line link control circuit of one line link frame such as shown in Fig. 3. These provide for connecting any line of the group upon the origination of a call over that line, to a district link frame circuit such as shown in Fig. 4 and to a sender link frame circuit such as shown in Fig. 5. They also provide for connecting any line of the group, when that line is called from a distant point, to a line junctor and thence to the distant point.

The primary line switches of a line link frame, such as switches 304 to 315, inclusive, are arranged in ten horizontal groups, of which only the bottom two and top two groups are shown. Each group contains enough primary switches to supply from twenty to seventy vertical groups, so that the ten groups on the frame contain from two hundred to seven hundred rows. Although the drawings show primary switches of twenty vertical row capacity, primary switches of one-half that capacity may be used, or the two sizes may be used in various combinations as required. Each separate row is connected to a subscriber line, such as lines 317 and 318, and each line terminates in one or more subscriber stations such as station 316.

The line link frame has ten secondary line switches, of which the two bottom switches 323 and 324, and the two top switches 325 and 326, are shown. Each secondary switch has twenty vertical rows, of which ten are connected to line junctors such as junctors 327 extending to incoming link frames for terminating calls, and ten are connected to district junctors such as junctors 328 and 329 extending to district link frames and sender link frames for originating calls. The ten district junctors connected to one secondary switch form a subgroup, such as subgroups 332 to 335, inclusive, and the ten subgroups are combined in pairs to make five groups, each group being connected to two adjacent secondary switches and extending to one district link frame and its associated sender link frame, but no two groups from the same line frame extend to the same district link frame and its associated sender link frame. Each group of twenty junctors may be multipled to several line link frames, as indicated by the multiple taps 330 and 331, but the scheme of multiplying is such that not more than two of the five groups appearing on a given line link frame shall appear together elsewhere, on another line link frame; for otherwise, with several frames using more than two junctor groups in common, a temporary overload

occurring on one of the frames might inconvenience the other frames unduly.

Each primary or secondary line switch has ten horizontal levels. Corresponding levels in all primary switches in one horizontal row are multipled together. The levels of the primary and secondary switches are interconnected by one hundred line links such as links 319 to 322, and these are distributed so that there is one link from each horizontal row of primary switches to each secondary switch. Thus primary switches 304, 305, and 306 are connected by link 319 to secondary switch 323, by link 320 to secondary switch 326, and by intermediate links, not shown, to the intermediate secondary switches. By this distribution every subscriber line is given access to every one of the one hundred district junctors connected to the line link frame on which it appears.

The line link control circuit 300 of the line link frame controls the operation of the select and hold magnets of the primary and secondary line switches, acting in conjunction with a sender link control circuit such as 500 in Fig. 5 to establish a connection from a calling subscriber station through an idle line link to an idle district junctor, and so through an idle sender link to an idle sender. To permit this combined action the line link control circuit 300 is connected, as indicated by line 301, to the sender link control circuit 500 of that particular sender link frame to which are connected the group of twenty district junctors 332 and 333 outgoing from the secondary line switches 323 and 324; and, as indicated by the multiple tap 302, the line link control circuits of all other line link frames which multiple to district junctors 332 and 333 also connect to that sender link control circuit. Line link control circuit 300 is also connected as indicated by the four lines 303 to the sender link control circuits of the four other sender link frames to which are connected the four other groups of twenty district junctors outgoing from secondary switches on this line link frame.

A district link frame such as the one shown in Fig. 4 has ten primary and ten secondary cross-bar switches, each with ten horizontal levels and twenty vertical rows of contact sets. The bottom two primary switches 404 and 405, the top two primary switches 406 and 407, the two bottom secondary switches 416 and 417, and the two top secondary switches 418 and 419, are shown.

To the ten levels of each primary district switch are connected the ten district junctors of one subgroup, and to a pair of adjacent switches as 404 and 405 are connected two subgroups such as 332 and 333 forming one group of twenty district junctors extending from a pair of adjacent secondary line switches on each of several line link frames. To the four other pairs of primary switches are connected four other groups of twenty district junctors extended from other line link frames. Each district junctor has transmission and supervisory equipment such as equipments 400 to 403, inclusive.

The twenty vertical rows of each secondary district switch are connected to office junctors such as junctors 420 to 435, inclusive, extending to office link frames. Each secondary switch is divided by its horizontal strapping into a left half and a right half, although so far as the mechanical action of the switch and its magnets is concerned there is no division. The distribution of office junctors varies according to the number of office link frames required, but the arrangement shown is one suitable for ten office link frames. The twenty office junctors connected to the left-hand rows of the twenty half switches, of which junctors 420 to 427, inclusive, are shown, extend to one office link frame such as the one shown in Fig. 6. Similarly each twenty corresponding rows in the twenty half switches are connected to junctors extending to a different office link frame.

The vertical rows of the primary district switches and the levels of the secondary half switches are interconnected by two hundred district links such as links 408 to 415, inclusive, and these are distributed so that there is one link from each primary switch to each secondary half switch. Thus primary switch 404 is connected by links 408 and 409 to the halves of secondary switch 416, by links 410 and 411 to the halves of secondary switch 419, and by intermediate links not shown to the intermediate secondary switches. By this distribution every district junctor is given access to every one of the two hundred office junctors connected to the district link frame on which it appears and so to every office frame.

A sender link frame such as the one shown in Fig. 5 is definitely and exclusively associated with each district link frame such as the one shown in Fig. 4, for the purpose of attaching district junctors to senders. The circuit from district junctor to sender consists of eight wires and it is connected through two sets of contacts, of four contacts per set, on a pair of primary cross-bar switches, and so through two similar sets of contacts in different sections of one secondary switch. A sender link frame has five pairs of primary switches and five secondary switches, each switch with ten horizontal levels and twenty vertical rows of contact sets. The bottom pair of primary switches 502*a* and 502*b*, the top pair of primary switches 503*a* and 503*b*, the bottom secondary switch 512 and the top secondary switch 513, are shown.

To the vertical rows of each pair of primary sender link switches such as switches 502*a* and 502*b* are connected the twenty district junctors of one group such as junctors 436 and 437, the eight wires of a junctor being divided equally between two vertical rows, one row on each switch of the pair.

Each sender link secondary switch is divided by its horizontal strapping into four sections, although so far as the mechanical action of the switch and its magnets is concerned there is no division. The quarter levels are connected to subscriber senders such as sender 522, two quarter levels per sender, there being a total of one hundred senders in the group, divided into ten subgroups of ten senders each. For example, the bottom levels in the first and third sections of switch 512 are connected as indicated by line 514 to sender 522, the top levels in the same sections by line 515 to sender 523, and the intermediate levels in the same sections to eight other senders in the same subgroup of ten. Thus each secondary switch is connected to two subgroups of ten senders as indicated by the lines 518. The entire group of one hundred senders is multipled to all sender link frames associated with the group of senders, as indicated by the multiple taps 516 and 517.

The horizontal levels of the sender link primary switches and the vertical rows of the secondary switches are interconnected by fifty sender links such as links 504*a*—504*b* to 511*a*—511*b*, inclusive, each link consisting of two parts

as 504a and 504b, of four wires each. The links are distributed so that there is one link from each pair of primary switches to each half of each secondary switch. Thus primary switches 502a and 502b are connected by links 504a—504b and 506a—506b to secondary switch 512, by links 505a—505b and 507a—507b to secondary switch 513, and by intermediate links not shown to the intermediate secondary switches. By this distribution every district junctor is given access to every one of the one hundred senders.

The sender link control circuit 500 of the sender link frame controls the operation of the select and hold magnets of the primary and secondary sender link switches, acting in conjunction with a line link control circuit as described above. It is connected as indicated by line 301 with the line link control circuits of all line link frames which connect to the district junctors appearing on the bottom pair of primary switches in its frame, and as indicated by lines 501 to the line link control circuits of all line link frames which connect to the district junctors appearing on the four other pairs of primary switches in its frame.

An explanation will now be given of how an idle district junctor and an idle sender are seized by a calling line for the purpose of recording the number dialed by the subscriber.

Assuming that a call is initiated by the subscriber at station 316, whose line 317 terminates in the right-hand vertical row of primary line switch 313 in the top row of primary line switches in a certain line link frame, the line switch control circuit 300 of that frame starts into action. The control circuit records the position of the calling line in the frame, and thereby directs the operation of connector relays which attach the control circuit itself to the equipment associated with the calling line and its accessible line links, such equipment being represented by primary switch 313, the ten line links including links 321 and 322, and corresponding portions of the ten secondary switches. The control circuit also explores all paths to a sender, to determine which ones are available. For line link 321, for example, to be considered available on this first search, five conditions are essential: First, line link 321 itself must be idle; second, the subgroup 332 of ten district junctors, to which the line link has access through secondary line switch 323, must contain at least two idle junctors; third, the sender link control circuit 500 associated with those district junctors must be idle; fourth, at least one of the ten sender links to which those district junctors have access through primary sender link switches 502a and 502b, such as sender link 504a—504b, must be idle; and fifth, there must be at least one idle sender in the subgroup accessible to the idle line link, such as sender 522, reached by conductors 518 through the first and third sections of switch 512 and through link 504a—504b. If the line link control circuit finds all ten paths unavailable on this basis, it makes a second search, with its requirements relaxed to the extent that it will be satisfied with a subgroup of ten district junctors of which one is idle, instead of two as in the first search. The reason for this procedure is to avoid the complete occupation of a subgroup of ten district junctors except when absolutely necessary, in the interest of a possible succeeding call for which that subgroup may offer the only available path to a sender.

When the line link control circuit finds one or more available line links it chooses one group of twenty district junctors, of which one or both subgroups are reached by available links, and it then signals the associated sender link control circuit. Unless the latter circuit is at the same time receiving a demand from a more favored line link control circuit, in which case the one under consideration is rejected and set to searching again, the line link control circuit and the sender link control circuit are bound together and start setting up the connections. The line link control circuit chooses one of the two subgroups of district junctors if both are available, such as subgroup 332, and signals its choice to the sender link frame.

The sender link control circuit, upon noting the district group and subgroup selected, operates corresponding connector relays and thus attaches itself to the leads and the sender link equipment pertaining to that subgroup, such leads and equipment being represented by conductors 436, primary switches 502a—502b, to ten sender links 504a—504b to 507a—507b, inclusive, and corresponding portions of the five secondary switches 512 to 513, inclusive. Following upon its attachment to the district subgroup, the control circuit selects an individual district from among the idle ones in the subgroup, such as the junctor represented in line 328.

Meanwhile the sender link control circuit tests the ten sender subgroups, and, giving preference to those having two or more senders idle, it selects a sender subgroup, such as that represented by senders 522 and 523. The control circuit operates a corresponding connector relay to attach itself to certain common control leads pertaining to the selected subgroup, and finally the control circuit selects an idle sender in the subgroup, such as sender 522.

By this time the proper select magnets are operated, and the two control circuits proceed to operate the hold magnets of the primary and secondary line link switches and the primary and secondary sender link switches, thus establishing a connection between subscriber's line 317 and sender 522. Control circuits 300 and 500 are released and made available for other calls.

The subscriber at station 316 proceeds to dial the number of the called line, such as line 602, and the number is registered in the sender. The sender attaches itself to a decoder marker, the latter circuit itself to the district and office link frames, and the two circuits cooperate to complete a path through the district link frame, by way of district junctor 400, path 438, primary switch 404, a district link such as 409, secondary switch 416, an office junctor such as 421, office link frame 600, terminating equipment 601, to line 602 and subscriber station 603. Full details of the sender and marker operation will be found in the above-mentioned Carpenter application Serial No. 214,356, filed June 17, 1938.

Upon completing their tests the sender and the marker are disconnected, and with them the sender link path through primary switch 502a—502b, link 504a—504b and secondary switch 512. The two subscribers' lines are left connected through the medium of the line link frame, district junctor equipment 400, the district link frame, and the remainder of the terminating path traced.

Detailed Description

The detailed operation of the system will now

be discussed, and for this purpose reference is made particularly to Figs. 7 to 23, inclusive.

Initiation of a call

Each line is provided with a line relay 706, a combined cut-off relay and hold magnet 704, and, in the case of two-party message rate lines, two message registers 702 and 703. For each group of ten lines there is provided a pair of connector relays 707 and 708 whose function is to associate certain individual leads of the line circuit with corresponding common leads to the control connector circuit, as will be explained later. Each horizontal group, consisting of from 20 to 70 lines, is provided with a horizontal group circuit comprising a start lead control relay 710 and a multicontact relay 709, the latter relay serving to associate various leads pertaining to the horizontal group with corresponding common leads to the control connector circuit.

The start circuit, which is common to the line link frame, comprises the pairs of duplicate start relays 720 and 716, etc., together with the gate relays 723 and 719, all shown in Fig. 7, and the duplicate start equipment shown in Fig. 8 and the upper portion of Fig. 10. Figs. 9 and 11 show the mate frame start circuit corresponding to Figs. 8 and 10, respectively, while the connecting leads between the two circuits show how the frames are interlocked to prevent interference when the control circuit of one frame is serving both in an emergency.

The control connector, which connects the various frame leads either into the home control circuit of Figs. 15 and 16 or into the control circuit of the mate frame, is shown partly in Fig. 10 and partly in Fig. 12. Corresponding portions of the mate frame circuit are shown in Figs. 11 and 13, respectively.

The initial steps in connection with an originating call are briefly as follows: The group start circuit, acting through the common start circuit, causes various common or frame leads to be switched through the connector relays to the control circuit. The common leads, with one end thus attached to the control circuit, must now have their other end switched through additional connector relays to appropriate points in the equipment associated with the horizontal group, the tens-group, and the line itself. These latter switching operations are governed in each case by relays which record the position or location of the calling line.

Start of originating call

When the subscriber at substation 700 initiates a call, the removal of the receiver from the switchhook operates line relay 706 over a circuit from battery, through the winding of relay 706, outer break contact of hold magnet 704, through the substation circuit, inner break contact of magnet 704, to ground. Relay 706 grounds individual lead 724 which later serves to identify the calling line in the group of ten, and also grounds start lead 725 which is multipled by way of straps 726 to a corresponding contact on the other line relays in the same group of ten. The start leads 725, one of which is provided for each of the two to seven line groups in the horizontal group, are initially tied together at break contacts of relay 710, and from the junction point two branch paths diverge for operating the duplicate start relays 720 and 716, etc. This start circuit may be traced from ground on the armature and make contact of one or more line relays 706, conductor 725, left-hand break contacts of relay 710 to a junction point on conductor 727; thence over one branch through a break contact of relay 710, conductor 728, right outer break contact of gate relay 723, conductor 729, to the winding of start relay 720; and over the other branch through a break contact of relay 710, conductor 730, right outer break contact of gate relay 719, conductor 731 to the winding of start relay 716.

Relay 720 energizes the master start relay 805 in a circuit extending from battery on a break contact of relay 1015, conductor 813, winding of relay 805, conductor 814, right outer break contact of relay 804, conductor 815, right outer break contacts of relay 807, conductor 816, right outer break contact of relay 909, conductor 913, break contact of jack 1005, conductor 1022, right inner make contact of relay 720, conductor 732, break contact 864, relay 806, conductor 819, break contact of continuity springs on relay 812, conductor 820, break contact of continuity springs on relay 1015, break contact of key 1013, to ground. Similarly, relay 716 energizes relay 804 over a path from battery on a break contact of relay 1014, conductor 821, winding of relay 804, conductor 822, right break contact of relay 805, conductor 823, right outer break contact of relay 808, conductor 824, right outer break contact of relay 910, conductor 914, break contacts of jack 1006, conductor 1023, right inner make contact of relay 716, conductor 733, right break contact of relay 906, conductor 915, break contact of continuity springs on relay 811, conductor 829, break contact of continuity springs on relay 1014, break contact of key 1013 to ground. Relay 804, however, is made slow operating so that although it is energized at the same instant as relay 805, its operation will under normal conditions be prevented by the speedier movement of the latter relay. Relay 805 locks itself around the right outer break contact of relay 804, in order to prevent the possibility of buzzing action between the two relays. Relay 805 also starts the time alarm circuit and operates relay 810. The time alarm circuit extends from ground at the right inner make contact of relay 805, by way of conductor 834, right inner break contact of relay 808, conductor 835 to interrupter 1003. The circuit for relay 810 extends from battery on a break contact of relay 1015, over conductor 813, winding of relay 810, conductor 830, right inner break contact of relay 909, conductor 916, left outer make contact of relay 805, left inner break contact of relay 808, conductor 835, conductor 817, to the same ground path just traced for the operation of relay 805.

Relay 810 now operates the control connector relays to bring into use the link control circuit of Figs. 15 and 16. Control connector relay 1021 operates in a circuit from battery at a break contact of relay 1015, over conductor 1026, winding of relay 1021, conductor 1027, a right front contact of relay 810, conductor 836, to ground at a break contact of release relay 1509 in the control circuit. Relay 1021 locks itself with ground from its own front contact, over conductor 1028, make contacts of relay 810 in series, conductor 1027, back to its own winding. Control connector relays 1201, 1203, 1208 and 1213 operate in parallel from battery at a break contact of relay 1015, conductor 1061, windings of the four relays in parallel, conductor 1219, make contact of relay 810, conductor 837, to ground at a break contact of release relay 1509 in the control circuit. A locking circuit for the four relays just mentioned is provided by ground at the left outer make contact of relay

1213, over conductor 1255, right outer pair of make contacts on relay 810, conductor 1219, to the windings of the four relays.

Control connector relay 1021 operates gate relay 723 in a circuit from battery, winding of relay 723, conductor 734, to ground at a make contact of relay 1021. Relay 723 locks over conductor 735 to ground at a make contact of relay 805, and opens the operating paths of all ten of the start relays 720, etc., so as to prevent interference from calls originated subsequently in other horizontal groups. The start relays 720, etc., which have been simultaneously operated, remain locked to their respective start leads, the locking path for relay 720, for example, being traced from its own winding and right middle make contact and over lead 728 to start ground. A supplementary locking path for relay 720 is provided through the right inner and left inner make contacts of the relay in series, over conductor 736, right middle break contact of relay 808, conductor 839, a make contact of relay 1203, conductor 1220, to ground through the winding of relay 1504 and also to direct ground over the shunt path including conductor 1618 and the grounded lower break contact of relay 1614. The supplementary locking path just traced for relay 720 is wired in a series chain through transfer springs of the ten start relays. This chain and the two other chain circuits provided on the start relays serve to give preference to the lowest numbered start relay which is operated, and hence to the lowest numbered horizontal group which is calling.

The horizontal group relay 709 corresponding to the preferred start relay is now operated from ground supplied by the operated gate relay 723. This circuit may be traced from battery, winding of horizontal group relay 709, conductor 737, left outer make contact of relay 720, conductor 740, a make contact of control connector relay 1213, conductor 1221, left outer break contact of relay 808, conductor 741, left outer make contact of gate relay 723, to ground. The ten line links accessible to the horizontal group represented by relay 709 are now put in readiness by the operation of their secondary select magnets. Relay 709 closes these paths, one of which may be traced from battery, winding of line link secondary select magnets 712, and 714 in parallel, conductor 757, make contact of relay 709, conductor 758, to ground at the break contact of the make-busy jack 801. Also various individual leads pertaining to the horizontal group under consideration are connected through the make springs of relay 709 to corresponding common leads, which at one end are multipled to all ten of the relays 709 over strap wires such as 765 on conductor 745, and at the other end terminate on contacts of control connector relays 1021, 1201, etc.

In this way, the seven start leads 725 associated respectively with the seven ten-line groups composing the horizontal group are connected over a corresponding number of common leads, through the control connector relays to the control circuit, and so to the windings, respectively, of the seven chain relays represented by relays 1501, 1502 and 1503. These seven relays serve to make a record of whatever ones of the seven ten-line groups are attempting to originate calls at the moment, and by their chain arrangement these relays give preference to the lowest numbered group. All seven of the relays 1501, etc., operate initially, since the seven start leads 725 are for the time being tied together at break contacts of relay 710. The path for operating relay 1501 may be traced from battery, winding of relay 1501, conductor 1518, upper inner break contact of relay 1500, conductor 1519, left inner make contact of control connector relay 1201, conductor 1223, a make contact of relay 709, conductor 742, start lead 725, to ground at the right make contact of line relay 706. All other relays of the chain such as 1502, etc., operate over a similar path, through the left break contacts of relay 710 and the multiple point on lead 727, to start lead 725. These relays do not depend wholly for their operation upon start lead ground supplied from the line relay, since an auxiliary ground for the start lead is supplied by the locking path for start relay 720 previously traced. The use of this auxiliary ground and the reason for operating the entire group of seven relays 1501, etc., will be explained presently.

Relays 1501, etc., close a path from ground, through their upper outer make contacts, conductor 1521, bottom outer break springs of relay 1509, conductor 1522, to the winding of relay 1613, to battery, operating that relay. Relay 1613 completes a path for operating relay 1614 in a series circuit carried through make contacts of the seven relays 1501, etc., so as to check the operation of the latter relays. This path extends from battery, winding of relay 1614, conductor 1619, make contacts of relays 1503, 1502, etc., in series, conductor 1524, lower inner make contact of relay 1613, conductor 1620, a make contact of relay 1213, conductor 1324, a make contact of horizontal group relay 709, to the common point on conductor 727, left break springs of relay 710, to start leads 725 and ground on line relay 706. Relay 1614 in operating removes ground from conductor 1618 to open the shunt around relay 1504, grounds a path for operating relay 710, and prepares a locking path for itself in series with relay 1505. The path for operating relay 710 extends from ground through a make contact of relay 1021, conductor 1621, lower make contacts of relay 1614, conductor 1622, a left make contact of relay 1203, conductor 1225, right outer make contact of relay 720, conductor 743, winding of relay 710 to battery. The locking path for relay 1614 extends from ground on conductor 1621 just traced, through a lower make contact on relay 1614, conductor 1623, winding of relay 1505, conductor 1523, to a junction point on lead 1619, and by way of that lead to the winding of relay 1614 and battery. Relay 1505 remains normal for the moment, since its winding is shunted by the ground present on conductor 1619.

Relay 710 upon operating opens the operating paths for relays 716 and 720, restoring the former and leaving the latter locked in series with relay 1504. Relay 1504 with its second shunt removed in this manner, now operates in series with relay 720. Relay 710 also separates the seven start leads from each other, thus removing ground from the start leads of all non-calling tens-groups and restoring the corresponding chain relays 1501, etc. The chain relays corresponding to calling tens-groups remain operated, and they lock themselves in obvious manner around the break contacts of gate relay 1500 through which their respective operating circuits pass. Relay 710 also removes ground from lead 727 which has been connected through series contacts of relays 1501, etc., to the winding of relay 1614, as already shown. The shunt is thus removed from around relay 1505, which now operates in series with the locking circuit

of relay 1514 in a path just traced above. Relay 1505 closes the circuit for operating gate relay 1509, in a path extending from battery, winding of relay 1509, right outer make contact of relay 1505, conductor 1527, chain circuit extending through lower inner transfer springs of relays 1501, etc., make contacts of these transfer springs, conductor 1520, conductor 1519, and the same circuit used for operating relay 1501 to start ground.

Selection of the tens-group first to be served is governed by the series wiring on chain relays 1501, etc. Preference is given to the lowest numbered group and the selection is completed by operating the corresponding line connector relays 707 and 708, a pair of which are furnished for each tens-group in the horizontal group. The operating circuit for this pair of relays is closed by relay 1500, the path being traced from battery, windings of relays 707 and 708 in parallel, conductor 744, a make contact of relay 709, lead 745, right make contact of relay 1203, conductor 1226, make contact of upper transfer springs on relays 1501, etc., the chain circuit wired through these transfer springs, conductor 1525, make contact of relay 1504, conductor 1526, lower middle make contact of relay 1500 to ground. Connection is thus established between the selected tens-group and the control circuit in preparation for the next step, namely that of recording the calling lines in the group and of selecting the line to be served. Relay 708 connects the individual contacts of the ten line relays 706 to the windings, respectively, of the ten control circuit relays represented by 1511, 1512, etc. A typical path may be traced from ground, make contact of relay 706, common conductor 746, a make contact of relay 1021, conductor 1030, lower break contact of relay 1510, conductor 1528, winding of relay 1511, to battery. Common conductor 746 and others of the kind on relays 707 and 708 are multiplied over conductors such as 766 to all other pairs of these relays on the frame. As many of the ten relays 1511, etc., operate as there are lines calling, and the lowest numbered relay in the group operates relay 1508 in a circuit from battery, winding of relay 1508, conductor 1530, lower inner series chain and make contact of relay 1511, etc., conductor 1529, to conductor 1030 and the path already traced to ground at the left make contact of line relay 706. Relay 1508 closes the operating circuit of relay 1507 from ground on the conductor used in operating relay 1511, etc., lock contact of the latter, upper inner series chain, conductor 1531, lower outer make contact of relay 1508, conductor 1533, winding of relay 1507, to battery. Relay 1507 locks itself through its right inner make contact, and its right middle make contact, conductor 1534, left outer make contact of relay 1208, to ground. This locking ground for relay 1507 is passed back over conductors 1532 and 1531 to lock the lowest numbered relay in the group 1511, 1512, etc., and the same ground is also carried through the right middle double make contact of relay 1507, over conductor 1535, winding of relay 1510 to battery, operating the latter relay. Relay 1510 serves as a gate relay for the ten relays 1511, etc., to prevent interference from lines of lower number than the one receiving preference and to release all relays in the group of higher number than the relay locked as already described. Relay 1508 continues to hold over its energizing path, already traced, to the individual contact of line relay 706. The selection of the line to be served has now been accomplished, since this line is the one whose hold magnet derives its energizing path from the only chain relay 1511, etc., left operated, namely the lowest numbered one of these relays. The hold magnet path may be traced from battery, winding of hold magnet 704, conductor 747, a make contact of relay 707, common lead 749, a right make contact of relay 1208, conductor 1227, make contact of transfer springs on operated chain relay 1511, for example, chain wiring, conductor 1537, to a ground path to be traced later.

The holding control over the connection undergoes a change following the operation of relay 1507, as will now be shown. Up to this time, with the exception of the brief interval required for checking the seven start leads, holding control has rested with the calling subscriber, since the line relay has controlled the locking circuit of the lowest numbered chain relay such as 1501, together with its associated gate relay 1500. If the call is abandoned at this stage, line relay 706 and relays 1501 and 1500 will restore, followed by relay 1613, assuming that the last-named relay is not held operated by some other operated chain relay such as 1502. With relays 1501 and 1613 restored, release relay 1509 operates in a circuit from battery, winding of relay 1509, conductor 1538, upper break contact of relay 1503 and the chain circuit of other relays in the chain, conductor 1525, make contact of relay 1504, conductor 1526, left inner make contact of relay 1505, conductor 1624, lower break contact of relay 1613, conductor 1625, a make contact of relay 1021, to ground. With release relay 1509 operated, the line link equipment is disconnected in a manner to be described later. Assuming that other tens groups have initiated calls simultaneously with the preferred one, so that some other chain relay such as 1502 is operated, then relay 1613 will be held operated by relay 1502 after the release of relays 1500 and 1501, and so release relay 1509 cannot operate to cause disconnection. Relay 1502 now becomes the preferred relay, and it supplies a ground through the lower chain circuit to reoperate gate relay 1500. A new pair of line connector relays 707 and 708, corresponding to relay 1502 and to the waiting tens-group, are operated, and the line recording relays 1511, etc., are reset in the usual manner. Thus one tens-group can relinquish its hold on the control circuit in favor of another tens-group in the same horizontal group, provided the call is abandoned early enough. However, if the operations have reached the stage where all registration has been completed and relay 1507 operated, the line link circuit becomes self-locked and remains so either until the time alarm operates or until the connection reaches the sender, from which latter point a disconnection signal is passed back to the link frame. Relay 1507 establishes this self-locking condition by connecting ground from its left middle make contact, over conductor 1536, to lock relay 1500 and the operated chain relay 1501, etc. Thus the calling line ceases to control the release relay 1509 directly and is deprived of immediate control over disconnection of the link. If the lock-in were delayed until the connection had reached the sender, the line link circuit could be abandoned by the first line and seized by a second line, the transfer taking place at a time when the sender had already received

certain information regarding the first line, such as class of service. On the other hand, if the line link were locked-in immediately after starting, a complete link connection to the sender would result from every transient starting impulse, such as that caused by a line surge. Hence the lock-in is set at a compromise point; early enough to avoid the possibility of giving false information to the sender, and yet not so early as to require complete link operation on every momentary starting impulse.

At this point it can be made clear why a continuity check is provided for in connection with the seven leads used to operate the vertical group recording relays **1501**, etc. The need for making the check arises out of the use of a single line relay contact to perform two functions; namely, starting and tens-group selection. Assuming that the check were not provided, a call could be initiated over any start path that was intact as far as the group start relay, whereas the start lead extension or branch used for tens-group selection would, if open, block the call until the time alarm caused throw-over to the mate frame. Likewise, with the assumed circuit in good working order, a call abandoned before tens-group selection would result in throw-over. In short, a circuit lacking the check feature would be incapable of distinguishing between an abandoned call and a trouble condition which warranted throw-over. In the circuit as actually arranged, however, the branch path in question is first checked as intact, and then the subsequent disappearance of ground from that path is a sure indication of an abandoned call. Another part of this checking feature which has already been mentioned is the auxiliary or back-up ground supplied to the start lead from the locking contact of the group start relay such as **720**, etc., during the checking process. The purpose of the auxiliary ground is to insure that the checking is completed and an opening in any of the branch paths detected, regardless of any action on the part of the subscriber. With the auxiliary ground omitted, switchhook flashing might pump the start circuit and thus delay the alarm and the throw-over.

District group test and selection

While the operations of selecting, recording and connecting to the calling line are still under way, steps are taken to select a group of ten district junctors from among the one hundred which are accessible to the line link and which run in five major groups of twenty to various district link frames and their associated sender link frames. The line link control circuit first makes an availability test on the basis of groups of ten district junctors, to determine how many such groups: (*a*) contain each at least two idle district junctors, (*b*) have their sender link control circuit available at the moment, (*c*) have at least one path available from the calling line through line link, district junctor, and sender link, to a sender group containing an idle sender. District junctor groups not meeting all these requirements are disregarded. The line link circuit signifies a preference for one of the available ten-junctor groups by operating a lock-out relay corresponding to the twenty-junctor group which contains the preferred ten-junctor group. This lock-out relay excludes other line link control circuits and connects the line link control circuit in question to a portion of the common control leads which are associated with the twenty-junctor group and which, on the one hand, are multipled throughout all line link frames served by that twenty-junctor group, and on the other hand, terminate at the sender link frame where the junctor group terminates. Over these leads a signal is passed to the sender link control circuit telling it that a call is waiting on the twenty-junctor group, and this group receives service if it is in preferential relation to other twenty-junctor groups which may at the same moment be attempting to place calls from other line link frames. A signal of acceptance is now returned from the sender link over the common leads above mentioned, to the line link control circuit. The line link control circuit thereupon definitely selects the twenty-junctor group and next the particular ten-junctor group to be used, employing for this purpose certain connector relays to establish connection with additional ones of the common control leads associated with the twenty-junctor group. The choice as to the ten-junctor group is signaled from the line link control circuit to the sender link control circuit, and the latter circuit proceeds to select the individual district junctor, sender link, and sender, as will be described later.

The test for availability of paths begins with the operation of relay **709**, since this relay closes test paths from the sleeves of the ten-line links to the windings of the ten relays represented by relays **1615** and **1616**. One such path may be traced from battery, winding of relay **1615**, conductor **1626**, a make contact of relay **1021**, conductor **1031**, upper lever spring and break contact of jack **801**, conductor **841**, a make contact of relay **709**, conductor **750**, to sleeve conductor **751**. The sleeve conductors are held busy by connection to ground, as will be explained, so that the presence of ground on the sleeve will operate the corresponding relay **1615**, etc., and the latter relay by opening the operating paths of its associated relay **1609**, etc., will indicate that the line link is engaged. Available line links will be indicated by normal relays **1615**, etc. The next step in the test is taken during registration of the tens-group containing the calling line, when relays **1613** and **1614** operate. These relays close the operating paths for the ten test relays represented by relays **1609**, **1610**, etc. Each of these latter relays corresponds to a group of ten district junctors, and the five pairs of relays such as **1609** and **1610**, **1611** and **1612**, etc., correspond to the five groups of twenty district junctors which respectively extend, under ordinary wiring arrangements, to five different district link frames and their associated sender link frames. The operating path for relay **1609** runs from battery, through the winding of relay **1609**, by way of conductor **1627**, upper inner make contact of relay **1613**, conductor **1628**, upper break contact of relay **1615**, conductor **1629**, upper inner break contact of relay **1617**, conductor **1630**, a make contact of relay **1021**, conductor **1032**, upper inner level spring and break contact of relay **1204**, common conductor **1228**, upper break contact of relay **1803**, conductor **1818**, lower outer break contact of relay **1813**, conductor **1819**, lower outer break contact of jack **1812**, conductor **1820**, upper inner break contact of relay **1714**, conductor **1716**, break contact of sender link hold magnet **1705**, to ground. The operating path for relay **1610**, although not shown in full, runs like that just traced for relay **1609**, until it reaches a conductor **1230** at the upper armature spring, second

from the core, on relay 1204, thence by a break contact to conductor 1231, upper break contact on relay 1807, conductor 1821, to a junction point on conductor 1819, from which a path has already been traced to ground at the mold magnet 1705.

Various elements of the test paths just traced will now be considered. Conductor 1228, with its multiple tap 1229, may be taken as typical of the common control leads, already referred to, which at one end terminate in the sender link frame equipment associated with a twenty-junctor group and at the other end multiple to all line link frames served by that group of twenty district junctors. Relays 1803 and 1807 are part of the sender link equipment which is peculiar to the twenty-junctor group and these relays when normal indicate respectively that the first and second groups of ten junctors, in the major group of twenty, contain at least two idle district junctors apiece. Relay 1813, which like relays 1803 and 1807 is associated with the twenty-junctor group, becomes operated whenever the sender link control circuit is engaged. Lead 1829 has ten branches like the one traced through break contacts of relay 1714, and hold magnet 1705, each branch corresponding to one of the ten sender links which carry traffic from the group of twenty district junctors to ten different sender groups. Each of the ten sender groups has its group busy relay such as 1714, which operates when all senders in the group become busy, and which breaks the test conductors such as 1716, to keep further traffic from entering the busy group. Similarly each of the ten sender links under consideration provides its own busy indication, by opening its test lead 1716 at the break contacts of its hold magnet 1705. Hence lead 1829 may be regarded as a paths available lead for the group of twenty district junctors, indicating by the presence of grounds somewhere on its branches that at least one path is available through a sender link to a sender group containing an idle sender. Five leads such as 1829 are provided for the sender link frame, one for each group of twenty district junctors. Reviewing now the operation of relay 1609 in the line link control circuit, it is clear that the operation of this relay indicates the following: (*a*) that for the corresponding group of ten district junctors the line link providing access to that group is available for use, (*b*) that the group of ten district junctors in question contains at least two junctors available for use, (*c*) that the sender link is available for use, (*d*) that for the group of ten district junctors in question at least one sender link path is available and (*e*) that the group of senders to which this link path connects is non-busy or in other words, has at least one of its senders available. These indications have already been referred to, though in different order.

Having determined through the operation of relays 1609, 1610, etc., which groups of ten district junctors are able to serve the call, the line link control circuit next expresses a preference by operating one of the lock-out relays such as 1216, 1217 and 1218, which correspond to the group of twenty districts containing the preferred tens-group. One such relay is provided for each line link having access to the twenty district junctors. Considering relay 1218 as the one to operate in this instance, its energizing path may be traced from ground, over a chain circuit involving the upper break contacts of relays 1216 and 1217, respectively, winding of relay 1218, conductor 1234, a make contact of relay 1021, conductor 1033, make contact of left middle transfer springs on relay 1609, assumed operated, conductor 1631, break contact of left middle transfer springs on relay 1612, conductor 1632, jumper between cross-connection blocks 1608 and 1504, conductor 1633, lower break contact, third from the bottom, on relay 1603, conductor 1634, right inner make contact on relay 1505, resistance 1506 to battery. It will be observed that the operating chain circuit for relays 1218, 1217, etc., just traced is wired in reverse order with respect to the functional chain circuit wired through the lower transfer springs of these relays, so that if two or more become operated, the one farthest from the source of operating ground receives preference. Therefore, when some relay such as 1218 operates, it gives its corresponding line link frame access to the group of twenty districts and excludes other line link frames. It will be noted furthermore that relays 1218, etc., not only act as lock-out relays, but they serve also as connector relays to connect their respective line link frames to some of the common control leads pertaining to the twenty-district group. Thus at relay 1218 conductor 1235 from the line link frame connects through a make contact of relay 1218 to multiple tap 1233 and the common control lead 1232. Multiple tap 1236 on lead 1235 illustrates the multiplying by which the line link reaches its four other relays like 1218, so as to gain access to the common control leads of other twenty-district groups.

With the operation of relay 1218, the line link frame is able to signal over the common control leads to the sender link frame and demand service on the twenty-district junctor group. Relay 1613 connects ground from its lower outer armature and front contact, over conductor 1635, make contact on relay 1213, conductor 1235, contact of relay 1218, multiple strap 1233, conductor 1232, make contact of key 1909, normally operated, winding of start relay 1912, series chain through continuity contacts of relays 1913 and 1914, series chain through lower inner break springs of relays 1907, 1906, 1905 and 1904, to battery at the bottom break springs of relay 1908. The start relays represented by 1912, 1913 and 1914 are five in number, one each for the five groups of twenty district junctors served by the sender link frame. In order to cope with simultaneous operation, these relays have their operating chain wired in reverse order with respect to their functional chain. Hence the operated relay nearest the beginning of the functional chain receives preference, while an operated relay nearest the source of the operating chain opens the latter chain to guard against interference. Assuming relay 1912 to be the preferred relay in this case, it locks to battery on its right inner make springs and closes ground from its left outer armature and make contact, over conductor 1924, a contact of key 1909, normally operated, conductor 1925, winding of relay 1713, to battery. One relay 1713 is furnished for each group of twenty district junctors, and each such relay has its armature contacts wired to various common or frame leads and its make contacts to corresponding individual leads associated with the twenty district junctors. Consequently the relay upon operating appropriates the sender link frame for

use with the corresponding twenty-district group, since the operation of other relays of the kind is prevented by the chain wiring on the left outer contacts of start relays 1912, etc.

Having granted preference to a particular group of twenty district junctors, the sender link circuit signals accordingly to the line link circuit attached to that district junctor group. The ground used for this purpose is the paths available ground already traced from break springs of hold magnet 1705, conductors 1716, break contacts of relays 1714, etc., to conductor 1820, thence by conductor 1717, through a make contact of relay 1713, over conductor 1718, a make contact of key 1909, operated, conductor 1926, break contact of relay 2010, conductor 2035, a make contact of key 1909, conductor 1927, a make contact of relay 1713, conductor 1719, lower armature and make contact of relay 1218, conductor 1237, make contact of relay 1213, conductor 1238, lower outer armature and break spring of relay 1603, conductor 1637, the jumper between the terminal blocks 1604 and 1608, conductor 1638, chain circuit on right inner armature and break contact of relay 1612, assumed normal, conductor 1639, to the lock winding of relay 1609, and battery. From conductor 1238 a branch conductor 1636 carries ground to the winding of relay 1617, and battery. Relay 1609 locks operated, while relay 1617 operates and opens the operating paths of all ten of the relays 1609, 1610, etc., thus restoring all except the locked one. Relay 1617 connects ground from its lower make contact over conductor 1640, winding of relay 1515, to battery, operating the latter relay. Relay 1515 closes a circuit from ground at the left inner make contact of relay 1507, conductor 1539, upper inner make contact of relay 1515, conductor 1540, lower inner armature and break contact of relay 1603, conductor 1641, cross-connection between terminal blocks 1604 and 1608, to the chain circuit at the left outer transfer springs of relay 1612, conductor 1642, left outer armature and make contact of relay 1609, conductor 1643, a make contact of relay 1021, conductor 1034, upper outer make contact of relay 1218, conductor 1239, winding of relay 1211, and battery. Relay 1211, like relay 1218, is representative of the preferred group of twenty district junctors and its operation completes the process of selecting the twenty-group. Relay 1211 also closes additional control leads for the selected junctor group, and completes the operating paths for relays 1209 and 1210, which represent respectively the first and second ten district junctors in the twenty-group. Relay 1209 will be the one to operate, since it is assumed that the first one in the pair of test relays 1609 and 1610 be locked operated. The operating path for relay 1209 extends from battery, through the winding of relay 1209, conductor 1240, upper inner make contact of relay 1211, conductor 1241, left inner make contact of relay 1203, conductor 1242, left inner make contact and armature of relay 1609, conductor 1644, left inner break contact of relay 1612 to conductor 1645, jumper across connecting blocks 1608 and 1604, conductor 1646, lower break contact, second from bottom, on relay 1603, conductor 1647, lower outer make contact on relay 1613, to ground. Relay 1209 is now enabled to operate the primary select magnets of the line link, since the choice of the district tens-group determines the terminating or secondary end of the line link, while the horizontal group relay 709, previously operated, determines the originating or primary end of the link. The operating path of the select magnets may be traced from battery, windings of the primary select magnets such as 705, two to seven in number, multiple strap 755 and conductor 754, a make contact of relay 709, common conductor 756, upper inner make contact of relay 1209, conductor 1243, a make contact of relay 1213, connector 1244, to ground at a break contact on release relay 1509. Relay 1209 also notifies the sender link as to the choice of the district tens-group, with ground from its lower make contact, common control lead 1245, winding of relay 1711 and battery, operating relay 1711. Relay 1711 operates relay 1709 in an obvious circuit and prepares paths for making a busy test of the individual districts composing the tens-group, as will be explained later. Relay 1709 prepares the operating circuits for the ten pairs of primary hold magnets, such as 1700 and 1701, which give access from the ten district junctors to the corresponding ten sender links.

Returning for a moment to the stage at which the start relays 1912, etc., operated, it will be seen that any one of these relays closes a circuit to operate relay 1919, from battery, right outer make springs of relay 1912, etc., conductor 1928, upper outer transfer springs on relay 1916, conductor 1929, winding of relay 1919, to ground. Relay 1919 connects ground from its upper make contact conductor 1930, winding of relay 1903, conductor 1931, to battery at the upper break springs of relay 1920, operating relay 1903. Meanwhile relay 1908 operates in a path from battery, winding of relay 1908, conductor 1932, a make contact of key 1909, conductor 1934, to ground at a make contact of relay 1713. Relay 1908 grounds the off-normal ground lead, supplies ground for operating relays 1904, etc., and operates relay 1902 over a path from ground at the upper outer break contact of relay 2028, conductor 1935, lower inner make contact of relay 1908, conductor 1936, winding of relay 1902, to battery. Relay 1908 also removes battery from its lower break contact in order to open the operating circuit of the five start relays 1912, etc., and prevent useless operations. Relay 1902 upon operating locks to the off-normal ground lead, grounds conductor 1938 to operate relay 2032 and start the timing circuit, and operates all five of the district group busy relays such as 1813, by connecting ground from its left make contacts over paths including leads 1939, make contacts of key 1909, conductor 1720, windings of the relays 1813, to battery. Each relay 1813 opens the paths available lead 1819 to make the corresponding twenty-district junctor group test busy to all its associated line link frames.

District junctor test

With the operation of relay 1711 above mentioned, the ten test leads such as 1721 coming from the ten district junctor circuits are connected respectively through the windings of the ten test relays represented by 1904, 1905, etc., to ground. The test lead of a busy district junctor is opened, while that of an idle district junctor is connected through a resistance to battery, so that idle districts will be indicated by operated test relays 1904, 1905, etc. Taking relay 1904 as an example, its operating path is traced from ground at a make contact of relay 1908, winding of relay 1904, right outer make contact of relay

1903, a make contact on key 1909, conductor 1723, left outer make contact of relay 1711, conductor 1721, to the district junctor circuit, break contact of make busy jack 2212, conductor 2214, lower outer break contact of relay 2207, upper outer break contact of relay 2203, resistance 2201, to battery. Relay 1904 is supplied with operating ground over an individual lead, while the other nine test relays are for convenience supplied with ground in groups of threes. The operated test relays, having locked themselves in local circuit to battery on their upper inner make contacts, connect battery to conductor 1940 and through a make contact of relay 1902 to the winding of relay 1916 and ground, operating the relay. Relay 1916 at its upper outer make contacts, connects battery from conductor 1928, through a make contact of key 1909, conductor 1967, to ground through the winding of relay 2100, operating that relay for a purpose to be explained later.

At this stage the test relays 1904, etc., provide economical means for recording on a traffic meter the number of times the last district junctor in a group of ten is selected to serve a call. Relay 1916 at its upper outer break springs opens the energizing circuit of relay 1919. The latter relay is slow to release, so that it momentarily delays its own release and that of relay 1903 controlled by it. Relay 1903, released by relay 1919, opens the operating paths of all the test relays 1904, etc., but the relay occasioned by slow-release relay 1919 has meanwhile covered any inequalities in the operating times of the test relays and has therefore insured the operation of all such relays having operating paths to idle district junctors. Having made sure that all idle districts are registered, the circuit distinguishes between the case where only one district is idle, and the case where two or more are idle. This is done by means of chain circuits on the upper contacts of test relays 1904, etc. Considering the pair of adjacent relays 1907 and 1906, a series circuit may be traced from battery, make contact 1945 and make contact 1946 on relay 1907, over a conductor to make contact 1947 on relay 1906, to conductor 1943, a right make contact on relay 1902, conductor 1944, operating relay 1920 through its winding to ground. Hence as regards this pair of test relays, both relays operated together will energize relay 1920 to indicate that the two district junctors represented are idle, whereas either test relay operated alone will fail to operate relay 1920 and will indicate that only one of the district junctors is idle. Successive pairs of adjacent test relays are similarly equipped to indicate the availability of their corresponding two districts. Now to extend the scope of this arrangement to any two test relays, whether adjacent or not, as well as to any number of the relays, a tie is made between the series chains of the several pairs of relays. This tie is shown at break contact 1948 on relay 1906 and break contact 1949 on relay 1905, and it will be noted now that pairs of non-adjacent relays such as 1907 and 1905 provide a series path leading to conductor 1943, while the three relays 1907, 1906 and 1905 provide between them two series paths to conductor 1943, and so on. The failure of relay 1920 to operate indicates that out of the group of ten district junctors only one idle district is left to serve the call, and so with relay 1920 normal a count is registered on traffic meter 1707. The meter control relay 1708 is energized in a path from battery, winding of the relay, right inner make contact of relay 1709, conductor 1728, make contact of key 1909, lower break contact of relay 1920, conductor 1950, to ground at a lower make contact on relay 2005, whose operation is explained later. Relay 1708 energizes the meter 1707 and locks to a break contact of the meter until the latter fully operates. If on the other hand relay 1920 operates, it does so because two or more districts in the group are available, and it opens the meter path to prevent registration. Relay 1920 locks to conductor 1943 to make itself independent of the test relays 1904, etc., and opens the operating circuit of relay 1903 to restore the latter without waiting for the release of slow relay 1919.

With all idle district junctors in the group registered upon operated test relays 1904, etc., as above described, the selection of the individual district junctor is actually determined, though it remains uncompleted for the moment. The way in which this selection is governed by chain wiring on the lower outer contacts of test relays 1904, etc., in combination with certain preference leads grounded in the line link circuit, is explained later under the heading "Operation of sender link primary and secondary hold magnets and line link secondary hold magnet."

Sender group test (regular) and sender group selection

While the district tens-group is being selected and the test for idle districts is under way, the sender link control circuit proceeds to test the sender groups for available senders, and next to select a sender group and an individual sender to serve the call.

Ten test relays represented by 2019, etc., in the sender link control circuit, test respectively the ten sender groups serving the sender link frame, to determine how many of the sender link paths accessible to the selected district group will each meet the following requirements: (*a*) that the sender link itself is idle, (*b*) that the associated sender group is not being selected at the moment by some other sender link frame, (*c*) that the sender group is not entirely busy and (*d*) that the sender group contains more than one idle sender. Sender groups containing only one idle sender apiece are disregarded at this time, since they are held in reserve for a reason which will be explained further on. Taking test relay 2019 as an example, its operating path runs from battery, winding of relay 2019, left outer break contact of relay 2011, conductor 2036, a contact of key 1909, conductor 1951, lower break contact of relay 1714, common conductor 1729 to an armature and make contact on relay 1713 corresponding to the selected district group, individual lead 1730 corresponding to the first sender link for that district group, break contact of secondary hold magnet 1704 of the sender link referred to, common conductor 1731 relating to the sender group serving the sender link in question, inner transfer armature and break spring of relay 2100, common conductor 2131, break contact of relay 2101 to conductor 2133, left inner break contact of relay 2105, conductor 2134, to ground at the right inner chain contacts of relays 2112, 2113, etc. Various elements in the foregoing path require further explanation. The ten-sender group busy relays 1714, etc., have already been mentioned in connection with the paths available test of the line link circuit. One of these relays per sender group is furnished on each sender link frame served by that sender

group, and the relay operates and opens the test paths whenever all senders in the group become busy. Lead 1730 is individual to the sender link, and hence for each twenty-district junctor group represented by group connector relay 1713, there are ten leads 1730 fanning out to break contacts of the secondary hold magnets 1704 of the ten-sender links. Common lead 1731, with its multiple strap 1732, appears on the armature springs of the five secondary hold magnets 1704 which give access respectively from the five district groups to the sender group corresponding to lead 1731. One relay 2100 is furnished on each sender link frame to switch the ten test leads 1731 corresponding to the ten-sender groups. Further mention of relay 2100 will be made later in the discussion of the sender group reserve feature. Relays 2101, 2102, 2105, the ten relays 2109, etc., and the ten relays 2112, etc., are sender group equipment, furnished on the basis of one set for the office. The relays represented by 2112, 2113, etc., are ten in number, one each for the individual senders composing the group, and each relay is operated when its corresponding sender becomes busy. The right inner contacts of these relays are arranged in chains to indicate on test lead 2134 whether or not the group contains at least two idle senders, the arrangement being the same in principle as that previously described for the district test relays 1904, etc. Since an indication relative to two elements in the group is desired, a chain circuit embracing two relays is furnished on each pair of adjacent test relays such as 2113, 2114, etc. Each such chain feeds ground to the test lead 2134, thus giving a ground indication when both the corresponding senders are idle and a non-ground indication when either or both of the senders are busy. In order to extend this method of indicating consecutively numbered busy senders so as to apply to any pair or any number of pairs in the group, the various chains are tied together as indicated at the right inner contacts of relay 2113. Consequently test lead 2134 will be grounded if two or more senders in the group are idle, and it will not be grounded if only one sender remains idle or if all are in use.

Returning now to the ten test relays 2019, etc., the operation of any one of these indicates that for the district junctor group carrying the call there is a path available over a particular sender link to a sender group containing at least two idle senders, and furthermore that the sender group at the moment is free to accept the call. After testing in this manner, the control circuit selects one of the sender groups by operating the lock-out relay such as 1815 corresponding to that sender group. A preference chain of lock-out relays 1815, 1816, etc., is furnished for every sender group, the first relay 1815 being controlled by the first or preferred sender link frame served by the sender group, the second relay such as 1816 by the next sender link frame served by the sender group, and so on. Consequently each sender link frame controls ten lock-out relays, one for each sender group, but the wiring may be "slipped" or rotated in such way as to give a certain sender link frame a position of first preference over other frames with reference to a given sender group, second preference on another sender group, and so on. The operating path for relay 1815 may be traced from ground, through the winding of relay 1815, conductor 1822, contact of key 1909, conductor 2037, right make contact of relay 2019, through connecting blocks 2022 and 2023, conductor 2038, left inner make contact of relay 1912, to battery through resistance 1911. Resistance 1911 prevents the battery fuse from being blown by accidental crosses between the left-hand adjacent sets of contacts on relays 1912, etc., during relay adjustment. It will be noted in connection with the path just traced for operating relay 1815 that the preference as among the various sender groups is governed partly by the sequence wiring on relays 2019, etc., representing the ten-sender groups, and partly by the wiring on relays 1912, etc., representing the five twenty-district junctor groups, the two chain circuits being suitably interconnected by jumper wiring at terminal blocks 2022 and 2023. The result of this combination is the random choice of a sender group and hence the random distribution of traffic over the various sender links, for the purpose of equalizing wear upon the links. Because of the chain wiring on relays 2019, etc., the sender link can operate only one of its lock-out relays such as 1815, at a time. If some other sender frame at the same instant operates its lock-out relay such as 1816, the latter relay will lock itself and will take precedence because the functional chain on the upper outer chain contacts of the relays runs from left to right or in reverse direction with respect to the operating chain on the lower contacts. Assuming, however, that relay 1815 is the only lock-out relay operated in the present instance, this relay at its bottom chain circuit opens the operating path of other relays in the group to exclude other link frames, and at its upper outer make contact closes a locking circuit for the corresponding test relay such as 2019. The lock circuit may be traced from ground at the upper outer contacts of relay 1817, chain circuit through relay 1816, upper outer make contact of relay 1815, conductor 1823, contact of key 1909, conductor 2039, right inner or lock contact and lock winding of relay 2019, to battery. Relay 1815 also connects the same ground through its upper inner make contacts to lead 1824, through a contact of key 1909, conductor 2040, to the winding of relay 2011, to battery, operating relay 2011. Relay 2011 is a gate relay whose operation opens the energizing paths of all the test relays 2019, etc., to release all except the locked one. Relay 2011 also at its right make contact supplements the ground on the paths available lead 1926, so that if the last path available is being used to serve the call the subsequent opening of the paths available lead 1926 will be unable to remove ground from lead 2035 and thus dismiss the line link. Relay 2011 furthermore closes one section of the energizing path for relay 2018, traced from battery, winding of relay 2018, left outer make contact of relay 2011, left middle break contacts of the normal relays 2021, 2020, etc., left outer make contact of relay 2019, lower outer break contact of relay 2008, to conductor 1933 and a path already traced to ground at a make contact of relay 1713.

Relay 2018 may be considered as a check relay which in conjunction with the indicating chain arrangement at the left middle and outer contacts of relays 2031, etc., certifies the release of all unused ones of the latter relays and prevents them from causing interference. The elements of the chain arrangement are as follows: (a) a series chain A through the left outer break contacts of relays 2019, 2020, etc., which derives its ground at the first chain relay and connects through a make contact of the last chain relay to

the winding of check relay **2018**. Chain A thus serves as a source of ground from preceding normal relays to enable the last chain relay to operate the check relay; (*b*) a series chain B through the left middle break contacts of relays **2021**, **2020**, etc., which carries the winding of the check relay through the last and intermediate relays to a make contact of the first chain relay and ground. Chain B thus brings the check relay under control of each chain relay succeeding the first, and enables the first chain relay to operate the check relay; (*c*) a make contact connection such as **2041** on each intermediate relay to serve as a tie between chains A and B when the relay is operated. Thus chain A, with preceding relays normal, becomes a source of ground whereby an intermediate relay such as **2020** can operate the check relay, whose winding is brought over chain B from the succeeding normal relays. The operation of some other relay preceding relay **2020** will open the ground supply, while the operation of some other relay succeeding relay **2020** will open the winding path of the check relay, so that in either case the check relay is prevented from operating. Thus the condition for operating the check relay **2018** is that all the chain relays **2019**, etc., except one shall have restored, and so the control circuit is guarded against the possibility of connection with more than one sender group, even momentarily.

With the operation of relay **2018**, connection is made to the selected sender group circuit by way of connector relay **1814**. One such connector relay is furnished on the link frame for each sender group, so that there are ten such relays per frame, with the frame wires multipled at the armature contacts of all ten. From the viewpoint of the senders, there is one connector relay per sender group on each sender link frame served by the sender group. The wiring from the sender group equipment of Fig. 21 multiples across from frame to frame, appearing on the make contacts of the various connector relays **1814** representing the sender group. The operating path for relay **1814** may be traced from battery, winding of relay **1814**, conductor **1825**, key **1903**, conductor **1952**, upper inner make contact of relay **2018**, left inner make contact of relay **2019**, to ground.

Sender link selection

The same ground supplied by relay **2018** to conductor **1825** for operating relay **1814** is passed back over branch conductor **1733**, through a make contact of relay **1713**, to operate a pair of select magnets **1703** and **1702** at the primary end of the sender link to be used. By referring to the trunking diagram of Fig. 5, it can be seen that this sender link is the proper one to select; for both ends of it have now been identified, the primary end by the operated relay **1713** representing the selected district group, and the secondary end by the locked up relay **2019** representing the sender group to receive the call.

Sender selection

With connection established by way of connector relay **1814** to the chosen sender group, selection is made at random from among the idle senders in the group. Relays **2112**, **2113**, etc., represent ten relays which serve as busy relays respectively for the ten senders in the group, each relay being operated when its corresponding sender is busy. Furnished also for each sender is a selection relay **2109**, etc., the ten such relays being connected in the usual chain arrangement already described, so as to select their respective senders according to a certain order of preference. A preference chain is also provided on the contacts of the ten busy relays **2112**, etc., for controlling the operation of the selection relays **2109**, etc., but this preference chain is reentrant or closed from the last relay **2114**, through to the first relay **2112**, and back again, and at five equally spaced points around the chain the five ground supply leads such as **2135** are brought in.

Assuming the first sender to be among those idle at the moment and ground to be present on lead **2135**, then the busy relay **2112** is normal, and relay **2109** receives preference and operates to select the first sender. In detail, the assumed operating path extends from battery at the right inner break contacts of relay **2111**, the chain circuit through the right inner break contacts of intermediate relays **2110**, etc., winding of relay **2109**, left outer break contact of relay **2112**, lead **2135**, right outer break contact of relay **2102**, conductor **2136**, a make contact of relay **1814**, conductor **1826**, a make contact of relay **1713**, common control lead **1734** for the selected twenty-district group, to the line link circuit, a make contact of relay **1211**, make contact of relay **1201**, conductor **1246**, chain circuit on upper middle contacts of relays **1512** and **1511**, make contact of relay **1511**, to ground. Five complete ground paths like that just traced are provided, each taking its source on a pair of the ten line test relays **1511**, **1512**, etc. Only one such lead can be grounded because normally but a single one of the relays **1511**, etc., is allowed to remain operated, as already explained, and an extra safeguard is provided by means of the series chain wiring. Moreover, since the line test relays **1511**, etc., represent calling lines, which originate calls at random, the five leads are grounded at random on successive calls and thus afford convenient means for distributing traffic. The first such use of these leads is in connection with the random selection of an idle sender in a group of ten, as just described above.

The sender selector relay **2109** having operated to the lead **2135** locks itself to battery, and at its right outer chain contacts closes a branching ground circuit to select its corresponding sender. The ground is supplied from a make contact of relay **1814**, over lead **1827**, and after passing through the right outer front contact of relay **2109** to conductor **2137**, it is fed over branch conductor **2138**, make contact of relay **1814**, conductor **1828**, winding of secondary select magnet **1706** to battery, operating the select magnet. The chain circuit at the right outer contacts of relays **2109**, etc., prevents the grounding of more than one select magnet, although ten paths are provided. It is obvious that the secondary selecting magnet energized as shown is the correct one, since the choice of these select magnets has been restricted by connector relay **1814** to the ten magnets giving access to the senders in the selected group, and since, furthermore, the individual select magnet is energized by the same sender selector relay **2109** that selects and starts the individual sender. The starting of the sender by relay **2109** is accomplished with ground supplied from relay **2109** to conductor **2137**, as already described, thence by way of branch conductor **2439** to the sender and the windings of sender relays **2300** and **2301**, operating these relays.

The sender now records the class of service characterizing the subscriber's line, such as indi-

vidual message rate, two-party message rate, coin, etc. Since the position of a calling line on the line frame is necessarily recorded in the line link control circuit, as already described, the position of the line affords a convenient basis for indicating the class of service. To assign a line to a class of service, the line is placed in a particular position in its group of ten lines, so that all lines of a certain class appear, for example, as number 1 in their respective tens-group, while lines of another class appear as number 2, etc. In the line link control circuit, the line recording relays 1511, etc., apply ground to a single one of the ten class leads 1541, etc., depending upon which relay is operated to record the calling line. Ground is thus passed over conductor 1541, a make contact of relay 1021, conductor 1035, class connection blocks 1205 and 1206, make contact of relay 1211, common conductor 1247 associated with the twenty-district group, to the sender link circuit, a make contact of relay 1713, conductor 1735, make contact of relay 1814, conductor 1829, common to the sender group, then to the sender circuit, a make contact of relay 2300 representing the individual sender, to operate a class of service recording relay, not shown. It will be noted that a maximum of eight different class of service indications can be passed through the sender link circuit to the sender circuit, this being a suitable limit imposed by the capacity of the connecting relays. For the same reason, in the line link circuit a limit of five is placed upon the number of class indications that may be passed from a given line link frame to its associated sender link frames. Thus a sender link frame may assemble eight different class of service indications from all the associated line link frames, but only five such indications from a particular line link frame.

The sender also at this time makes a record of the district link frame, so that later the information can be used by the decoder in operating the district frame connector. The operated relay 1814 provides convenient means for indicating the location or number of the district frame, since as already stated, each sender group has one of these connector relays on each of its associated sender link frames, and the sender link frame in turn serves to designate the corresponding district frame. Each connector relay 1814 is wired to give a ground indication over two leads, one to show the tens-group in which a frame is located and the other the individual or unit. Thus lead 2142 is grounded by any one of the first ten connector relays 1814 for the given sender group, and conductor 2143 is grounded by any of the second ten. The ten leads which designate the units are shown under bracket 2313 at relay 2301, each lead appearing on a connector relay in the first ten and multipling to a corresponding connector relay in the second ten. To take an example, the fifteenth frame would be indicated by ground on conductor 2143, representing the second ten, in combination with ground on the fifth lead under bracket 2313. The twelve frame indicating leads just mentioned, common to the group of senders, are carried into the selected sender through contacts of relays 2300 and 2301, and so to the windings of recording relays located in the sender but not shown in Fig. 23.

Operation of sender link primary and secondary hold magnets and line link secondary hold magnet

While the sender is occupied with the registrations explained above, preparations are made for operating the primary hold magnets of the selected sender link. Relay 2109 and its left outer make contact closes ground to operate relay 2101, which opens the test path associated with the sender group and makes the latter test busy at other sender link frames served by it. Ground from a make contact of relay 1814 is supplied over conductor 1830 to the left inner double make contacts of the sender selector relays 2109, etc., and this ground is used to lock up the operated relay 2109 and to energize relay 2102. Relay 2102, having first opened all five of the leads 2136, one of which has been used for operating the sender selector relay, then connects conductor 1831 to conductor 1832 to operate relay 1917 in the control circuit. The operating path for relay 1917 runs from battery, through the winding of relay 1917, left outer break contact of relay 1903, upper middle make contact of relay 1916, conductor 1953, upper inner break contact of relay 2005, lower outer make contact of relay 2018, conductor 2042, a make contact of key 1909, conductor 1954, make contact of the operated select magnet 1706 at the secondary end of the selected sender link, conductor 1736, a make contact of relay 1814, conductor 1832, left outer make contact of relay 2102, conductor 1831, a make contact of relay 1814, conductor 1737, make contact of relay 1713, conductor 1738, make contacts, in series, of select magnets 1702 and 1703 at the primary end of the selected sender link, conductor 1925 and ground at the right outer make contact of relay 1709. Certain elements of the path just traced require explanation. Conductors 1954 and 1736 closed by secondary select magnet 1706 are common to the frame, so that any secondary select magnet on the frame is able to close this part of the path. Conductors 1736 and 1737 are connected together by relays 1814 and 2102, which pertain to the selected sender group. Conductor 1737, common to the frame, is connected through contacts of district group relay 1713 to a branching path which is related to the ten sender links serving the district group and which is arranged to be grounded whenever any one of the ten links has its pair of primary select magnets operated. Thus it will be seen that relay 1917 cannot operate and prepare the energizing path for any hold magnet until after the select magnets at both ends of the sender link have closed their make contacts and therefore have had opportunity to position their select fingers. The line link select magnets have previously been operated, as described, so that now both frames are ready to have their cross-points closed.

Relay 1917 in operating prepares the energizing paths for the primary hold magnets of the sender link, and operates relay 1918. The operating circuit of the latter relay traces from battery through the winding of relay 1918, left inner break contact of relay 1903, lower inner make contact of relay 1917, conductor 2043, upper outer break contact of relay 2008, conductor 1937, winding and lock contact of relay 1902, to off-normal ground. Relay 1918 locks itself to conductor 2043 and energizes, simultaneously, both the secondary hold magnet of the line link and the primary hold magnet of the sender link. The ground used for operating these hold magnets will be the one which has been used already in selecting a sender at random and which is supplied over one of the five preference leads from an operated line test relay in the line link control circuit. Without retracing this lead from its source, the lead will be found entering the sender link circuit as conductor 1734 in Fig. 18, thence

through a make contact of relay 1713, conductor 1826 and the branch 1739, a make contact of key 1909, conductor 1955, upper outer contact of relay 1918, to branching conductor 1958. One branch feeds ground directly to the lower middle chain circuit of relay 1904 and through the make contact, assuming this relay to be operated, thence by conductor 1956, a make contact of key 1909, conductor 1957, make contact of relay 1713, conductor 1740, to the line link circuit and the upper middle make contact of relay 1209, conductor 1243, winding of the line link secondary hold magnet 711, and battery, operating the hold magnet. The other branch of conductor 1958 feeds ground through the upper outer make contact of relay 1917, lower outer chain circuit on relay 1904 and the make contact, conductor 1959, a make contact of key 1909, conductor 1741, left outer make contact of relay 1709, to the windings of hold magnets 1700 and 1701 in parallel, to battery, operating the magnets. The chain circuit wired to the lower middle transfer springs of the ten district test relays 1904, etc., is a closed chain, and entering it at equal intervals are the five preference leads represented by conductor 1958, the first lead entering at the armature spring of the first relay 1904, the next lead on the third relay, etc. The chain circuit on the lower outer springs of the ten relays is wired in the same way, and the points of entry for the five branch conductors from relay 1917 exactly correspond to those on the other chain circuit. Furthermore, examination of the circuit will show the following:

(*a*) That the hold magnet on the secondary side of the line link frame, controlling the outgoing end of a district junctor, has its operating path so wired as to be controlled by the same test relay such as 1904, etc., that represents the district in question.

(*b*) That the pair of primary hold magnets on the sender link frame, controlling the terminating end of the district junctor in question, likewise have their operating path controlled by the same test relay 1904, etc., that represents this district. Thus the test relay representing a given district junctor operates the hold magnets at each end of that district junctor, and the chain wiring prevents the operation of more than one such pair at a time. Now it will be recalled that several of the test relays 1904, etc., may be operated at the same time if their corresponding districts are idle, and furthermore that selection of the district remains uncompleted until relay 1918 closes the preference leads. If now the first preference lead is grounded, preference is given to the first test relay 1904 or to the nearest operated test relay, counting upward. If the fifth preference lead is grounded, preference is given to the ninth relay, and so on. Thus preference is distributed among the test relays and their associated districts in accordance with the grounding of the preference leads; and since the grounding of these leads from call to call take place at random, traffic over the districts is likewise distributed at random.

The sender link primary hold magnets 1700 and 1701 in operating close the cross-points to connect the district junctor leads to the sender link. The ground used for operating the hold magnet is extended forward over conductor 1742 to the windings of the secondary hold magnets 1704 and 1705 in parallel, to battery, operating the latter magnets. These secondary hold magnets close their cross-points to extend the link leads through to the sender. Included among these leads is the sleeve conductor 1743 which later is to serve as a locking lead for the four hold magnets but which at the moment carries their operating ground into the sender, through a make contact of sender relay 2300, back over conductor 2144, make contact of relay 1814, conductor 1833, contact of key 1909, conductor 1960, winding of relay 2005, conductor 2044, lower outer make contact of relay 1908, to battery. Relay 2005 operates and thus serves to check the closing of the cross-points at both ends of the sender link. The upper inner continuity contacts of relay 2005 open the operating ground of relay 1917 and at the same time switch this ground over conductor 2045, winding of relay 2006, to conductor 1960, while another make contact of relay 2005 applies supplementary ground to conductor 2045. Relay 1917 now restores and opens the energizing ground for the four sender link hold magnets and relay 2005 as well, leaving magnets and relay dependent for their holding circuit upon the ground applied to conductor 1960 through the winding of relay 2006. Relay 2006 now makes a double connection test; for if the sleeve of the connection just established is closed with or otherwise in contact with the sleeve of another busy connection, ground from the latter will shunt relay 2006 and prevent it from operating. In such case the time alarm will operate, as will be explained later. Assuming, however, that no such trouble condition is present, relays 2006 will operate in series with the four sender link hold magnets and relay 2005, all in parallel, to battery. Relay 2006 in operating energizes relay 2013 in a path from ground, left outer break contacts of relay 1910, conductor 1961, make contact of relay 2006, winding of relay 2013, lower inner make contact of relay 2005, resistance 2004, conductor 2046, right outer make contacts of relay 1912, etc., and battery. Relay 2013 at its upper make contacts locks itself to ground, and closes ground to conductor 2047 for a purpose to be explained further on. It will be noted that until relay 2006 operates, relay 2013 is kept shunted with ground through the break contact of relay 2006, lower transfer armature and break contact of relay 2013, lower inner make contact of relay 2005, resistance 2004, to battery, the resistance 2004 serving to safeguard the battery fuse. This arrangement insures that the double connection test is actually made, and relay 2006 operated, before the connection is allowed to proceed; for otherwise a trouble cross between the make contact and armature spring of relay 2005 would permit relay 2013 to operate prematurely.

The sender link primary hold magnets 1700 and 1701 not only close the cross-points, but at their local contacts they close certain control leads. Magnet 1700 grounds conductor 1745 to operate relay 2207 in the district, and magnet 1701 provides a locking path for the line link secondary hold magnet, connecting ground for this purpose over conductor 1744, break contact of district relay 2211, through resistance 2200, sleeve conductor 753 of the district junctor to the line link frame, locking or local contact and winding of line link secondary hold magnet 711, to battery.

Operation of line link primary hold magnet and completion of connection into sender

The closure of the cross-points by line link secondary hold magnet 711 connects the operating

ground of the latter magnet through its local contacts and through the sleeve cross-point to sleeve conductor 751 of the line link. This ground is extended over a path already traced, to the line link control circuit and the winding of the test relay such as 1615, corresponding to the line link under consideration. Relay 1615 upon operating provides a check upon the closure of the line link secondary cross-points, since it serves to close the operating path of the line link primary hold magnet. This operating path for primary hold magnet 704 has already been traced into the line link control circuit and to the lower outer chain circuit on the operated relay 1511, etc., which designates the calling line to be served. Resuming at that point, the path runs over conductor 1537, through the upper outer make contact of relay 1515, conductor 1542, right outer chain circuit and make contact of relay 1609, lower make contact of relay 1615, conductor 1648, a make contact of relay 1213, conductor 1249, a make contact of relay 1218, to common control lead 1250 extending to the sender link circuit, key 1909, conductor 1964, and ground at the lower inner break contact of relay 2008. Control lead 1250, just mentioned, is one of three leads which are multipled by way of taps 1845 to other district group equipments associated with the sender link frame. Primary hold magnet 704 upon operating closes the cross-points, including its own lock circuit to sleeve conductor 751 of the link. Hold magnet 704 also serves as the cut-off relay, for at its lower break contacts it detaches ground from the tip conductor, and line relay battery from the ring conductor, of the subscriber's line. Line relay 706 upon restoring removes ground from the conductor 724, thus releasing relay 1508 in the line link control circuit. The release of relay 1508 controls the progress of the connection at this stage as already shown, and it indicates the following:

(*a*) That the line relay has restored and is, therefore, unable to cause a false start upon release of the line link control circuit,

(*b*) That the line cross-points are closed and the line conductors extended into the sender, thereby enabling the sender to assume charge and dismiss the two control circuits.

Relay 1508 closes a circuit traceable from ground, upper inner make contact of relay 1510, upper outer break contact of relay 1508, conductor 1543, a make contact of relay 1021, conductor 1036, make contact of relay 1218, common conductor 1251 extending to the sender link frame, a make contact of relay 1814, conductor 1836, to the sender circuit, a make contact of sender relay 2300, make contact of sender relay 2304, winding of sender relay 2305, to battery. Sender relay 2304, controlling the circuit of relay 2305, has already been operated as a result of the registration of the class of service and district frame indications. Sender relay 2305 in operating closes ground over conductor 2148, to operate sender busy relay 2112, and the latter relay breaks the operating path of relay 2109 and opens its portion of the test path to conductor 2134, in order to mark the sender as busy.

Sender relay 2305 also prepares for the two-party test of the subscriber's line by connecting the tip and ring leads 2150 and 2151, respectively, to the party test relay 2307. After the party test is completed, the tip and ring leads are switched by relay 2306 to the tone coil 2312 and pulsing relay 2309, respectively. The path to the subscriber's line thus established may be traced from tone coil 2312 through the right make contact of relay 2306, a make contact of relay 2305, conductor 2150 to the sender link secondary switch, sender link conductor 1747, conductor 1749, conductor 767 of the district junctor, to the line link secondary switch, line link conductor 769, line link primary switch, line loop including subscriber station 700, line link primary switch, line link conductor 770, line link secondary switch, conductor 768 of the district junctor, conductors 1750 to the sender link primary switch, link conductor 1748, secondary switch of sender link, conductor 2151 to the sender, make contact of relay 2305, left make contact of relay 2306, winding of pulsing relay 2309, to battery. Over the path just traced, relay 2309 operates, and the calling subscriber receives dial tone, from tone coil 2312, to authorize the dialing of the wanted number. Relay 2309 operates relay 2311 in an obvious circuit, and relay 2311 operates relay 2303. Relay 2302 now operates in a path traceable from battery, through the winding of relay 2302, make contact of relay 2303, conductor 2146, right outer make contact of sender busy relay 2112, just operated, conductor 2145, make contact of relay 2300, conductor 1834, a front contact of sender relay 2300, conductor 1834, a front contact of relay 1814, conductor 1962, key 1909, conductor 2048, upper break contact of relay 2014, conductor 2047, upper make contact of relay 2013, to ground. Sender relay 2302 operates over the path just traced, and locks itself and relay 2305 in an obvious circuit to ground at its own contact 2315. Relay 2302 also connects its locking ground through its left inner make contact to conductor 2314, thence through a make contact of relay 2300 to conductor 2144, which last conductor extends back through the sender link cross-points and provides a lock circuit for the sender link hold magnets. The sender thus takes control of the connection, since the sender link hold magnets, locked under control of the sender, in their turn control the locking circuit of the line link hold magnets. Sender relay 2302 also connects ground from its locking circuit, through its right outer and left middle make contacts, conductor 2316, a make contact of relay 2300, over release lead 2147 to the sender link circuit, through a make contact of relay 1814, conductor 1835, key 1909, conductor 1963, lower inner make contact of relay 2013, conductor 2049, winding of relay 2007, and battery. Since ground for locking the sender link hold magnets has up to this moment been supplied through the winding of control circuit relay 2006, the latter relay may be restored when the sleeve is grounded by the operation of sender relay 2302. If relay 2006 does restore, it operates relay 2007 in local circuit. In any event relay 2007 operates, energizes release relay 2008, and locks itself in a circuit through the upper outer make contact of relay 2005, lower outer make contact of relay 2007, conductor 1933, key 1909, conductor 1934, make contact of relay 1713, to ground. Release relay 2008 at its upper outer contacts opens ground from conductor 2043 to the restore relay 1918, and returns ground over conductor 1937 in order to hold relay 1902 operated and to maintain ground on the off-normal ground lead. Relay 1918 at its upper make contacts opens the preference lead ground whereby the line link secondary hold magnet was operated. Release relay 2008 at its lower inner transfer contacts detaches ground from conductor 1964 and switches the latter to conductor 2005, and through the lower middle break springs of relay 1918,

now normal, to branching conductor 1965, over one branch to the locking winding of the release relay 2003, and over the other branch extending through key 1909 to conductor 1966, to the line link frame, a make contact of relay 1218, conductor 1252, a make contact of relay 1213, conductor 1253, right outer make contact of control circuit relay 1507, upper inner break contact of relay 1508, winding of release relay 1509, and battery. Both hold magnets on the line link frame have now been deprived of their operating ground, so that both magnets are dependent upon their locking path already traced through the cross-points and the junctor sleeve conductor, through the district junctor circuit, to ground controlled by the sender link primary hold magnet. This holding ground backs up over the path just traced above, to hold the sender link release relay 2008 and operates the line link release relay 1509. The continuity of the sleeve holding path is thus verified by the immediate release of the control circuits, whereas discontinuity of the holding path will delay release of the control circuit until the alarm circuit operates, as will be shown later.

Return of control circuits to normal

Sender link relay 2008 at its lower outer break contact deenergizes relay 2018, and the latter relay at its upper make contacts deenergizes a sender connector relay 1814 and the sender link primary select magnets 1702 and 1703. Relay 1814 in releasing restores the sender link secondary select magnet 1706, and the sender group relays 2102 and 2109. Relay 2109 restores relay 2101. The left inner make contact of relay 2102, which restores after relay 1814 releases, shares the current load with the right inner make contact of relay 1814 and saves the latter from breaking the combined current for the sender link secondary select magnet 1706 and the sender relays 2300 and 2301. The select magnet 1706 is first deenergized by a separate make contact on relay 2114, and later the two sender relays 2300 and 2301 are deenergized when relay 2102 restores. Relay 2007, whose operating path has been opened by the release of sender connector relay 1815, remains operated over a locking path through the upper outer make contact of relay 2005, lower outer make contact of relay 2007, to ground on conductor 1933. Further disconnections in the sender link circuit must wait upon the line link circuit.

The line link release relay 1509 operates over the path already traced, and restores the primary select magnet 705 and relay 1613. Relay 1613 restores relay 1209 and removes ground from conductor 1635 to restore relay 1912 in the sender link circuit. Relay 1209 in releasing restores sender link relay 1711.

In the sender link circuit, relay 1912 opens the operating circuit of relay 1713, but the latter has its release delayed until after relay 1711 restores relay 1709. Relay 1912 also restores relay 2100, relay 2013, and lock-out relay 1815, while the last-named relay restores relay 2019. Relay 1713 restores relays 1908 and 2007, and opens the selection lead 1719 to restore line link relay 1609. Relay 2007 deenergizes one winding of release relay 2008, leaving the latter operated momentarily over its other winding to the release lead 1966 extending to the line link circuit. Relay 1908 restores the operated relays 1904 etc., and relay 2005. Relays 1904, etc., restore relay 1916. Relay 2005 restores 2011, which has been held operated thus long in order to prevent the false reoperation of relays 2019, etc., in a circuit through make contacts of relay 1713, while relay 1713 is waiting to be restored. With the release of all relays which have contributed ground to the off-normal ground lead 1968, relay 1902 is free to release. Relay 1902 restores relay 1920 and relay 2032. Relay 2032 restores any operated timing relays such as 2028, 2029, and 2030. A new connection cannot be made unless the timing circuit is reset, for relay 2028 must restore and reclose its upper break contact before relay 1908 can again operate relay 1902. Relay 1902 also deenergizes all five of the relays 1813, assuming their locking circuits to have been opened in a manner to be explained later. With the release of relays 1813, the various sets of test leads 1231 and 1228 are regrounded and the sender link is again made available for use.

The line link release relay 1509, besides producing the actions already described, closes ground over conductor 1544 through the upper inner continuity contacts of relay 1603, and the winding of the latter relay, through resistance 1602 to battery. Relays 1603 and 1600 constitute a counting relay combination whose purpose will be explained later. Relay 1600, although supplied with operating ground simultaneously with relay 1603, remains shunted by ground through its lower break springs, through resistance 1602, to battery. Relay 1603 in operating locks to ground on its upper inner contacts, continues the shunt on relay 1600, and opens its own operating circuit. Relay 1603 also, at its upper outer transfer contacts, opens the grounded conductor 1649, which serves to lock release relay 1509 and prevent its restoring so long as relays 1603 and 1600 are both operated or both normal. Meanwhile, release relay 1509 operates relay 1516 with ground from its own operating and locking circuit, through one of its lower make contacts, conductor 1545, lower outer make contact of relay 1500, winding of relay 1516, to battery. Relay 1516 in operating connects ground from its upper outer make contacts to the common lock circuit of release relay 1509, thus enabling the latter relay to verify the release of relay 1516. The function of relay 1516, whose momentary operation at this stage is without significance, will be discussed later.

The line link circuit now awaits the release of sender link relay 1713, already mentioned, whereby ground is removed from the selection lead 1238 to restore line link relays 1917 and 1609. Relay 1609 restores relays 1211 and 1218, and relay 1218 breaks the release lead 1966 to restore the sender link release relay 2008. Line link relay 1617 restores relay 1515, and the latter in releasing closes ground from its lower outer break contact, upper inner make contact of relay 1509, conductor 1546, make contact of relay 1021, conductor 1037, winding of relay 808, conductor 842, to battery at a break contact of relay 1015. Relay 808 in operating opens the operating path of relay 810 and closes a circuit for holding relay 805 independently of relay 720, this path being traced from battery, break contact 1038 on relay 1015, conductor 813, winding of relay 805, conductor 814, right outer break contact of relay 804, conductor 815, right inner make contact of relay 808, conductor 732, break contact of relay 806, conductor 819, right inner break contact of relay 812, conductor 820, left outer break contact of relay 1015, to ground on key 1013. Relay 808 also, at its right hand transfer contacts, opens the operating path of pick-up relay 1002 in the

time alarm circuit. Relay 1002, depending upon the position of interrupter 1003, may or may not have operated, but if it has operated it momentarily holds relay 810 over a path traceable through locking contact 831 on relay 810, conductor 832, left make contact of relay 1002, conductor 1039, left transfer springs on relay 810, conductor 1022, make contact of relay 720, conductor 732, to ground already traced. Relay 810 cannot restore unless pick-up relay 1002 does so, and therefore the release of the latter relay is verified and the timing feature restored in preparation for the next call. Relay 808 also, at one of its right hand break contacts opens the locking circuit of relay 720 and of relay 1504, and at its left outer break contacts opens the operating circuit of horizontal group connector relay 709. All the relays just mentioned restore. Relay 720 restores relay 710. Relay 709 restores relays 707 and 708, the ten secondary select magnets 712, and any operated ones of the link busy test relays 1615, 1616, etc.

Meanwhile, the release of relay 810 has opened the locking paths for the control connector relays 1021, 1201, 1203, 1208 and 1213, the operating grounds for these relays having been previously broken by release relay 1509. Relay 1021 deenergizes control circuit relays 1505 and 1614 and restores relay 808. Relay 808 restores relay 805, and the latter restores gate relay 723. Connector relay 1208 opens the holding ground for relays 1507, 1510 and 1511, allowing these relays to release. Relay 1507 restores relay 1500 and relay 1501, if the last named relay has not already been restored by the release of relay 1505. Relay 1507 also restores relay 1516, and the latter opens the last locking ground path of release relay 1509. Relay 1509, with its branched locking circuit running locally to several points in the control circuit and over lead 1547 to the control connector relays, thus has its release delayed until after it has checked as normal the various relays concerned. Relay 1509 in restoring opens ground from conductor 1544, and thereby removes the shunt around relay 1600 and allows the relay to operate to ground supplied by relay 1603. The function of relays 1600 and 1603 will be explained later.

The line link control circuit, like the sender link control circuit, has now been restored to normal and is ready to handle another call. The calling subscriber's line remains connected through the line link, the district junctor, and the sender link to the sender, and the sender holds the connection.

The sender and the marker control the completion of the connection. The sender, before disconnecting itself and the link, operates district relay 2203 over a path traceable from battery, winding of relay 2203, lower break contact of relay 2206, now normal, conductor 1752, contact of sender link primary switch, conductor 1751, contact of sender link secondary switch, conductor 2155, to the sender, and ground on a relay contact, not shown. District relay 2203 upon operating connects the calling line to a source of battery current through the windings of relay 2210, and completes the talking path, through condensers, to the called line. The talking current supply path may be traced from ground through the right-hand winding of relay 2210, break contact on relay 2205, make contact 2216 on relay 2203, conductor 767 and a path already traced through the line frame to the subscriber's station 700 and back over conductor 768, contact 2217 on relay 2203, contact 2218 on relay 2205, left-hand winding of relay 2210 to battery. The talking path extends from conductor 767, already traced from the calling line, make contact 2216 on relay 2203, break contact 2215 on relay 2205, condenser 2204, make contact 2219 on relay 2203, break contact 2220 on relay 2205, ring conductor 2223, district link frame 2225, office link frame 2226, terminating equipment 2227, called subscriber station 2228, returning through the three equipments mentioned to tip conductor 2224, break contact 2222 on relay 2205, make contact 2221 on relay 2203, condenser 2202, break contact 2218 on relay 2205, make contact 2217 on relay 2203, to conductor 768 and a path already traced, to the calling line. A non-battery bridge comprising retardation coil 2208 and polarized relay 2209, in series is connected also at this time across the tip and ring conductors to furnish called-party supervision in connection with the terminating equipment. This bridge path may be traced from tip conductor 2224, through break contact 2222 on relay 2205, make contact 2221 on relay 2203, lower inner make contact on relay 2207, winding of retardation coil 2208, winding of polarized relay 2209, lower outer break contact of relay 2205, make contact 2219 on relay 2203, break contact 2220 on relay 2205, to ring conductor 2223. Relay 2210, whose windings feed battery current to the calling line while impeding the high frequency talking currents, operates over the calling line loop and holds relay 2207, previously operated by the sender link hold magnets. Relay 2207 connects ground from its upper outer make contact, through make contact 2229 on relay 2203, through break contact 2230 on relay 2205 paralleled by break contact 2231 on relay 2213, to resistance 2200 and sleeve conductor 753, and so to the locking circuit of the line link hold magnets. This same ground from relay 2207 just traced to resistance 2200, also branches through make contact 2232 on relay 2203 to the winding of the latter relay, holding it locked. Relay 2203 feeds ground from its upper inner make contact, through the upper inner break contact of relay 2205, upper outer break contact of relay 2206, sleeve conductor 2233 to the district link frame, thus holding the district and office links in operated position. The sender and the sender link now restore, leaving the calling subscriber in control of the connection. When the calling subscriber restores his receiver at the end of the conversation, the circuit of relay 2210 is opened, and relays 2210, 2207, and 2203 fall back and open the sleeve holding grounds both ways, thus causing disconnection.

Districts available test

Every time the sender link circuit restores to normal it tests the twenty-district group from which it has just selected a district, to determine whether all districts in the group are now busy, or whether one or more than one are still available. If the two subgroups of ten districts are found to contain more than one idle district apiece, the sender link immediately restores the paths available ground to the regular test leads 1228 and 1231 (Fig. 18) representing these subgroups, thus making these channels again available to the associated line link frames. When a subgroup shows only one idle district, the paths available ground is withheld from the regular test lead and is switched to the corresponding reserve-test lead 1837 or 1838. If all districts in

both subgroups prove to be busy, the paths available ground is withheld from all the test leads for the group, so long as the busy condition lasts, and the associated line link frames are obliged to seek outlet through other district groups. Before consideration is given to the district reserve test, the details of the district available test above outlined will be explained.

Involved in this test is that portion of the district group equipment shown in Fig. 18. In the group equipment for the particular twenty-district group chosen to carry the call, the connector relay 1713 controls paths whereby the circuit is primed or put in readiness to make the districts available test in the group under consideration. Thus relay 1803 is operated in a circuit from battery through resistance 1802, winding of relay 1803, conductor 1726, make contact of relay 1713, conductor 1724, key 1909, conductor 1941, to ground at the lower inner make contact of relay 1916, which operates while the ten test relays 1904, etc. are engaged in testing the district busy test leads 1721. Relay 1803 at its upper inner make contact locks itself to ground, and at its upper outer make contact connects the ten busy test leads 1721 through ten resistances 1800, respectively, to a common junction point on conductor 1839, thence through the windings of relays 1808 and 1809 in series, to ground on conductor 1726. At this time relays 1808 and 1809 are short-circuited by ground from conductor 1840 supplied from conductor 1726 through a separate make contact on relay 1713. This ground connection not only shunts relays 1808 and 1809 to postpone their operation until the proper time, but it also short-circuits completely any of the grounded test relays 1904, etc. whose test paths over conductor 1721 may be open at the time because their associated districts happen to be in use. Without this shunt, a test relay such as 1904 corresponding to a busy district would tend to operate falsely from ground, through its winding, through resistance 1800, the common junction point on conductor 1839, back over resistances 1801, etc. in parallel, to locking battery on the upper inner make contacts of operated test relays 1906 etc. representing idle districts. The ten-district group not concerned in the connection has its test relays prepared in similar manner. Relay 1807 is locked in local circuit, and relays 1810 and 1811 are short-circuited. The group busy relay 1813, at its upper outer and upper inner make contacts, provides individual short-circuits for relays 1809 and 1811, respectively.

The test equipment now remains unchanged until the sender link control circuit restores, whereupon relay 1713 in releasing opens the shunt around relays 1808 and 1810 and opens the operating path of relay 1813. Relay 1813 remains locked, however, under control of both halves of the test circuit, in a path from battery, upper winding of relay 1813, lower break contacts of relays 1808 and 1810 in series, then by one branch through its own contact 1841, to conductor 1726 and ground on the locking contact of relay 1803, and by the other branch through contact 1842, to conductor 1843 and ground on the locking contact of relay 1807. Relays 1809 and 1811 remain short-circuited at the contacts of relay 1813. Relay 1808, with ground supplied from relay 1803, is enabled to make a test through resistances 1800 etc. to the busy test leads of the associated district subgroup A, and relay 1810 makes a similar test on its subgroup B. Relay 1808 is comparatively sensitive, so that it is capable of operating through a single resistance such as 1801, over the busy test lead 1722, and so to battery through low resistance 2201 in an idle district junctor. Relay 1810 is identical with 1808, and either relay in operating registers the fact that in its associated subgroup of ten district junctors there is at least one idle. Assuming first that relay 1808 operates but relay 1810 does not, the former will unlock and restore relay 1813. Relay 1813 will reconnect the paths available ground from conductor 1819 to conductor 1818; but relay 1803 being operated, will withhold the ground from the regular test lead 1228, while relay 1808, also operated, will connect the paths available ground through its upper make contact to the reserve test lead 1837. District subgroup A will, therefore, be indicated as available on a reserve basis, whereas subgroup B will be indicated as unavailable, since the operated relay 1807 and the non-operated relay 1810 will withhold ground from both the regular and the reserve test leads. Relay 1809, with its shunt opened by the release of relay 1813, is inserted into the test path in series with relay 1808. Relay 1808 is of low resistance and is designed to be marginal in its operation, so that it will not operate on the relatively small current through the resistances in a single busy test path, whereas it will operate on the current through two or more paths in parallel. Assuming now that relay 1809 operates in the present instance, its contacts connect its own low resistance winding in shunt with the winding of relay 1803, which is designed to release under this condition. Relay 1803 in releasing opens its locking ground and the ten busy test paths, and restores relay 1808. With both relay 1803 and relay 1808 normal, the paths available ground is removed from the reserve test lead 1837 and is replaced on the regular test lead 1228, so that the district subgroup A is now indicated as containing at least two idle districts, and possibly more than two. The test apparatus for the busy subgroup B withholds the paths available ground from the regular and reserve test leads until its districts commence to restore, whereupon it passes through the stages just outlined for subgroup A. Thus each time a group of twenty district junctors serves a call, its two subgroups are automatically tested to see whether all their districts have been used up, or whether only one is left in the subgroup, or more than one; and suitable indications are set up on the test leads to inform the associated line links accordingly.

District reserve test

District subgroups which contain only one idle district junctor apiece are held in reserve, so long as any other subgroup on the frame contains more than one idle junctor. Broadly speaking, the purpose of this reserve arrangement is to preserve for the line link frame, to the greatest extent practicable, the availability of outlets to district junctors. Since a subgroup of ten district junctors, in order to be loaded efficiently, must be multipled to several line link frames, the seizure or use of all ten junctors occupies outlet facilities totaling the number of multiple appearance times ten, of which total, the ten are usefully employed and the remainder are blocked or "covered." This cover effect is attributable to the fact that the districts are multipled, or in general to the concentration of numerous con-

necting paths (i. e., line links) upon a smaller number of outlet paths (i. e., district junctors). Assuming that no provision were made for a district group reserve test, in light traffic the cover effect ordinarily would signify merely a reduction of one-tenth in the outlet facilities of each line link frame concerned. In heavy traffic, however, a certain line link frame might have link outlets available to only one district subgroup while other line link frames had access to this district subgroup and others besides, yet the line link frame in question might have its available outlet covered by reason of the seizure, at some other frame, of the last district in the subgroup. The call on the blocked frame would thus be delayed. To distribute the traffic and reduce the frequency of such blockades, the circuit is arranged to prevent selection of the last district junctor in any subgroup unless all ten of the subgroups are likewise depleted, or unless the only line links available for the call are those leading to reserve subgroups.

In connection with the paths available test in the line link circuit, the ten test relays **1609** etc. initially use such of the regular test leads **1228** and **1231** as happen to be closed to paths available grounds in various ones of the five associated sender link circuits. It will be recalled that the regular test path may be opened by any of the following occurrences, alone or in combination: The corresponding line link may be busy; the corresponding district subgroup may be used up to the reserve point; the corresponding sender link circuit may not be available; none of the accessible sender links may be idle; for any available sender links, the corresponding sender groups may not be available. Considering the ten paths as a whole, the frequency of occurrence of the district reserve condition is much greater than that of the other events, taken in conjunction or even singly. Consequently, the opening of the ten test paths and the failure of the regular test within a short interval of time serves as a fairly reliable indication that the district subgroups have all reached the reserve point. In such case the ten test leads as they emerge from the line link circuit are switched from the regular to the reserve test paths, and a retest is made in connection with the reserve districts.

The district reserve test feature is controlled in part by relays **1516** and **1517**. Relay **1517** is operated early in the connection over a path from battery, winding of relay **1577**, thence by one branch through the left outer break contact of relay **1507** to conductor **1548**, and by another branch through the lower outer break contact of relay **1516** and the lower inner break contact of relay **1515**, to conductor **1548**, then over conductor **1548** to ground at a make contact of relay **1203**. Shortly afterward relay **1516** operates in a path from battery, winding of relay **1516**, lower outer make contact of relay **1500**, conductor **1545**, upper outer make contact of relay **1517**, conductor **1650**, lower break contact of relay **1617**, conductor **1651**, contact of relay **1021**, conductor **1040**, branching conductor **1254**, to the sender link circuit, through a lower break contact of relay **1813**, to ground. From the viewpoint of the sender link frame, each district group busy relay **1313** supplies a separate conductor **1254** to each line link frame on which the district group has an appearance. From the viewpoint of the line link frame, there is one conductor **1040** per frame, with five branch conductors **1254**, one branch for each district group serving the line link frame. Or, since the district groups in general are terminated at different sender link frames, there will be one branch conductor **1254** from the line link frame to each of the five associated sender link frames. The opening of all five of the branch conductors **1254** deprives line link relay **1516** of its operating path and thus indicates that the line link frame has no outlets available; but so long as any of the branches retains its ground, relay **1516** remains operated to show that at least one district group, with its associated sender link circuit, is available. Relay **1517**, which is made sufficiently slow in releasing to more than cover the time required for the regular test, has one branch of its operating path opened when relay **1516** operates, and the other branch opened when relay **1507** operates at the completion of line registration. The latter event therefore marks the starting point of the timing. If the regular test is not accomplished within the allowed time interval, the release of relay **1517** closes ground from conductor **1548**, already traced, through the lower break contact of relay **1515**, lower armature and make contact of relay **1516**, lower break contact of relay **1517**, conductor **1549**, make contact of relay **1021**, conductor **1041**, winding of relay **1204**, to battery. Relay **1204** in operating transfers the ten test paths **1032**, etc., from the regular test paths **1228**, etc., to the reserve test leads **1837**, etc., respectively. These reserve leads **1837**, etc., will have been connected to paths available ground in the various sender link circuits as already explained, provided the corresponding district subgroups each retain one idle district junctor, and provided also that the other conditions affecting the paths available lead have been met. The line link circuit then makes a selection from among the reserve district groups, following the usual procedure.

It will be noted that a reserve test lead such as **1837** is normally connected to paths available ground through the upper break contacts of sender link relay **1808**, when relay **1803** is normal and the district subgroup is not set for the reserve test. This connection comes into use when the associated sender link circuit has been momentarily busy and has occasioned the reserve test, although the group of districts concerned may not have been used up to the reserve point. The non-reserve district subgroup is thus enabled to participate in the retest, in competition with the reserve subgroups.

The short time interval measured by slow-release relay **1517**, being intended to cover only the actual testing time, cannot start while the test is delayed through some condition such as the momentary occupation of all district junctors. Such an event is attended by the operation of all relays **1813** in the sender link circuits concerned, with the result that line link relay **1516** is deprived of all its sources of operating ground. Relay **1516** falls back and recloses the energizing path of slow relay **1517**; and the test conditions must be reestablished and relay **1516** again operated, before slow relay **1517** can be again deenergized to start the timing.

A separate timing arrangement measuring an interval longer than that of the reserve test feature but shorter than the alarm interval of the starting circuit, is provided in connection with the district group test to detect unusual delays. If for any reason the district group test is delayed for an interval exceeding that measured by the

delay timing circuit, the latter circuit records a count on its register and releases the line link control circuit. Hence the call in progress is compelled to give way to other originating traffic. At this stage also the circuit arrangement permits the intrusion of terminating traffic, for in such case the terminating marker is allowed to release the control circuit and take possession of the line start circuit. The minimum time interval measured by this delay timing circuit is approximately 1½ seconds.

The delay timing feature is started by relay 1508, which operates after the position of the calling line has been recorded. Relay 1508 connects ground from its upper make contact, over conductor 1550, a make contact of relay 1208, conductor 1256, to the armature contact of interrupter 1553. When interrupter 1553 closes its right-hand contact, it causes relay 1554 to operate and lock to ground on conductor 1556. Relay 1554 prepares a circuit whereby relay 1555 is operated and locked to ground on conductor 1256 after interrupter 1553 has measured its interval of 1½ seconds, minimum, and has closed its left-hand contact. Relay 1555 energizes traffic register 1556 and locks itself under control of the register to insure the operation of the latter. Relay 1555 also connects ground over conductor 1557, upper break contact of relay 1214, conductor 1257, a make contact of relay 1021, conductor 1042, lower inner make contact of relay 1508, conductor 1551, upper break contact of relay 1515, assumed to be normal on account of delays, conductor 1542, chain circuit wired through right-hand contacts of test relay 1609, etc., assumed normal on account of delays, conductors 1652, winding of release relay 1509, to battery. Release relay 1509 restores the line link control circuit to free it for new calls. If district group test and selection proceeds on either a regular or a reserve basis within the interval measured by the delay timing circuit, the release of the control circuit is canceled, because the operating path for release relay 1509 is opened by one or more of the test relays 1609, and later by relay 1515. Terminating calls upon reaching the line frame always connect ground over conductor 1258 to the disconnect path above traced. Such a call will immediately dismiss the line link control circuit and seize the starting circuit without waiting for the delay timing circuit to function, provided operations have reached the stage, just mentioned, at which the position of the calling line has been recorded but no district group selection has been made.

Sender group reserve test

Since a sender group is multipled to several sender link frames, the sender links giving access to that sender group are subject to the same kind of cover effect that has been explained in connection with the line links. The sender groups, like the district groups, are furnished with a reserve test feature which diverts traffic from groups containing a single idle sender and which thereby holds such groups as reserve outlets for the associated sender links.

It has been shown that initially the ten sender group test relays 2019, etc., can find grounded test paths only when the corresponding sender groups have more than one idle sender each. The regular test thus made starts when the test paths for relay 2019, etc., are closed by relay 1713; it continues with the operation of a lock-out relay such as relay 1815, and the locking in of the preferred test relay such as 2019; and it ends with the operation of gate relay 2011. The time allowed for the regular test is measured by the combined operating times of line link relay 1617, 1515, 1211 and 1209, and sender link relays 1711, 1904, 1916 and 2100. Relay 2100 in operating transfers the ten paths for the test relays 2019, etc., shifting them to corresponding reserve test leads 2149 in the various sender group circuits associated with the sender link frame. If during the time interval thus measured the regular test has shown no results, the test is repeated on a reserve basis, using the various leads 2149 and their grounds supplied through break contacts of relay 2101. Unless the sender group is momentarily engaged by another sender link control circuit, relay 2101 will be normal at this time and will keep the reserve test leads grounded. Furthermore, unless the sender group is entirely busy, its master busy relay 2105 and its individual busy relays such as 1714 on the various sender link frames will be normal and will leave intact the test paths leading to the sender group in question. Consequently, a continuous test path to ground on reserve lead 2149 designates the corresponding sender group as one which is suitable for selection on a reserve basis. The test relays 2019 accordingly repeat their test, this time in connection with reserve groups of senders, and sender group selection is then made in the manner already described.

It will be noted that the normally grounded condition of leads 2149 admits to the reserve test not only those sender groups which are strictly in the reserve class, but also any sender group which at the moment attains non-reserve status through the release of one of its busy senders.

Timing features—Sender link control circuit automatic release due to traffic delays

If the sender link control circuit is unduly delayed in sender group selection it will automatically dismiss the line link control circuit to give the latter a second trial, and will itself restore to normal. No alarm will be given in such case, for the line transfer is recognizable as a traffic delay.

Relay 2032, whose operation at an early stage of the connection has already been described, starts the timing by supplying battery through resistance 2033 and 2034 to relay 2029 and 2030, respectively. Interrupter 2031 is designed for open and closed intervals of approximately ½ second each. Upon the first closure of the interrupter following the operation of relay 2032, ground from the interrupter is supplied through the left inner or continuity contacts of relay 2029 to operate the relay in an obvious circuit through resistance 2033 to battery. Relay 2029 operates and locks itself, opening its ground operating path. Relay 2030 remains normal at this time, being shunted with interrupter ground connected through its right or continuity contacts to the winding terminal which is supplied with battery through resistance 2034. When interrupter 2031 opens its contact, it removes the shunt from relay 2030, allowing the relay to operate from ground supplied by the locking contact of relay 2029. Relay 2030 in operating opens its own shunt path and prepares a shunt path for relay 2029. About ½ second later, the reclosure of interrupter 2031 shunts relay 2029 to normal, but relay 2029 at its left inner or continuity springs maintains a holding path for relay 2030 under control of the interrupter. With

into service, leaving the last relay 1813 for the district group just used to be restored when relays 1803, 1807, etc., perform their usual test. Thus in the timing operations just described the sender link circuit, after dismissing the line link circuit early in the fourth time interval, remains guarded throughout the rest of that interval, and the entire half-second of the fifth interval, so that meanwhile the line link circuit may be expected to have found an outlet through another sender link frame. The sender link is left in condition to serve other calls, but the minor alarm continues in operation until key 2003 is operated to release relay 2002. Relay 2027 also remains operated under control of relay 2002, keeping lamp 2024 lighted to indicate the frame in trouble.

False starts

If the calling subscriber disconnects at some point after the line link is deprived of holding control over the connection, but before the sender link relay 1918 comes up to operate hold magnets, both circuits will be restored to normal without delay. As has been shown before, the release of the subscriber's line relay restores relays 1511 and 1508, and relay 1503 at its upper outer break contact grounds a control lead which will be found entering the sender link circuit as conductor 1251 in Fig. 18, branching over conductor 1844, through key 1909, conductor 1971, lower break contact of relay 1918, assumed normal, conductor 1972, upper outer break contact of relay 2005, winding of relay 2007, to battery. Relay 2007 at its upper contacts connects ground to conductors 1941 and 1942 to operate district group test relays 1803 and 1807 and prepare them to make their usual test. Relay 2007 also operates release relay 2008 and the latter relay grounds the release lead to the line link circuit, from ground at the lower outer break contacts of relay 2005, conductor 2054, upper inner make contact of relay 1916, whose operation must be awaited, conductor 2055, lower inner contact of relay 2007, lower inner armature and make contact of relay 2008, conductor 2050, lower middle contact of relay 1918, conductor 1965, and so by a path already traced to the line link circuit, where it operates release relay 1509. From this stage, the line link circuit and the sender link circuit are restored to normal after the manner already shown.

If the calling subscriber disconnects after relay 1918 operates, the abandoned call cannot be recognized as such until after the sender has progressed to the point of testing the dialing tip and ring leads for the line closure. With the connection extended to the sender, the sleeve test will be made and relays 2005, 2006, and 2013 operated as usual; but because the sender at this time must wait for a closure across the tip and ring conductors before it can take control of the connection, it refuses to restore the sender link and accordingly withholds the release lead ground whereby relay 2007 normally operates. The sender link timing circuit, after measuring an interval of one second, operates relay 2014 to release the connection. The first half-second, following the operation of relay 2029 on the pick-up impulse, is occupied by the opening of the interrupter and the operation of relay 2030. During the next half-second the interrupter closes and relay 2029 restores, relay 2030 remains operated, and relay 2029 operates. The next opening of the interrupter restores relay 2030 and causes relay 2014 to operate in a path traceable from ground, upper make contact of relay 2028, upper make contact of relay 2032, left break contact of relay 2030, upper outer break contact of relay 2025, lower middle contact of relay 2013, winding of relay 2014, conductor 2056, the chain circuit through the right inner contacts of relays 1914, etc., to battery at the locking circuit of the operated one. Relay 2014 operates relay 2016 if key 2017 is thrown, so that the "false start" meter 2015 registers a count. Relay 2014 also operates relay 2007 in a path traced from battery, winding of relay 2007, upper make contact of relay 2014, conductor 2048, and a path already traced to the sender, and so to ground at a break contact of sender relay 2303, non-operated at this time because the sender has failed to find the line closed. Relay 2007 operates relay 2008, and the latter operates the line link release relay in a path traceable from ground, lower inner make contact of relay 2014, conductor 2054, upper inner make contact of relay 1916, conductor 2055, lower inner make contact of relay 2007, lower inner make contact of relay 2008, conductor 2050, lower middle break contact of relay 1918, restored by relay 2008, conductor 1965, and then by a path already traced to the winding of release relay 1509 in the line link circuit. Both line link and sender link now restore after the manner previously described, and the calling line originates a new call.

Although meter 2015 has been referred to as a false start meter its main use is to aid in the recognition of open-circuit troubles in the tip and ring paths through the sender link circuit. Probably but a small proportion of the true false starts which affect the sender link will be recorded on the false start meter, because it is expected that few such calls will terminate within the short time intervening between the operation of the hold magnets and the point at which the sender tests the line conductors for closure. False start of this class will of course defeat the tip and ring continuity test in the sender, just as a tip and ring open circuit between line frame and sender will do, and in either case a count is made on the meter when the timing circuit comes into action to clear out the connection.

It will be noted that the false start feature is not introduced unless the connection has reached the sender, as is indicated by the operation of relay 2013 to close the circuit of relay 2014. It should be noted also that the failure of the tip and ring continuity test may be due to failure of some kind within the sender itself. Or, the trouble may lie in the line link frame, although this is unlikely because the terminating marker has facilities for detecting and recording continuity troubles of the sort. But on the whole there are few possible trouble conditions aside from an open tip and ring in the sender link frame which are able to cause the false start meter to operate, and therefore the latter trouble, together with false starts, may be assumed as the sources of registration on the meter. The two sources are undistinguishable from each other until the records of several sender link frames are compared; and then upon the assumption that false starts are equally numerous on all the frames, a predominance of counts on the meter of one sender link frame will point to the presence of actual trouble somewhere in the tip and ring conductors extending through that frame.

relay 2029 normal and relay 2030 operated, relay 2028 is operated in an obvious path, and is locked through the upper make contact of relay 2032 to ground on its own upper make contact. Assuming that the district test has been made but not sender group selection, either on a regular or a reserve basis, the operation of relay 2028 closes a circuit for operating relay 2010, from battery, through the winding of relay 2010, lower inner make contact of relay 2028, conductor 2051, break contact of relay 1919, lower outer make contact of relay 1916, conductor 1969, left outer chain circuit on relays 2021, 2020, 2019, etc., lower outer break contact on relay 2008, conductor 1933, over a path already traced to ground on a make contact of relay 1713. Relay 2010 in operating opens ground from lead 2035, which is the selection lead used in holding relays 1609 and 1617 in the line link control circuit. Relay 1617 restores relay 1515, and relay 1609 causes the release of line link relays 1218, 1211 and 1209. The link line control circuit is now free to select another district junctor group. In the sender link circuit, relays 1912, 1711, 1709 and 1713 now restore. Relay 1713 restores relay 1908, and the latter relay restores the operated relays 1904, etc., and relays 1934, etc., in turn restore relays 1920 and 1916. Relay 1713 also restores relay 2019 which at its left make contact has been holding ground on conductor 1937 to keep relay 1902 operated. Relay 1902 now falls back and causes the release of timing relays 2032, 2029, 2030 and 2028, and opens the operating paths of the five relays 1813 which have been guarding the sender link frame against seizure. The relay 1813 associated with the district group just occupied by the connection is the last of the five to restore, and it does so when the district group test relays, 1803, 1808, 1809, 1807, 1810 and 1811, have performed their usual test. The sender link circuit and the district group in question are again available and may be reseized by the line link circuit just dismissed, although the latter event is unlikely if the line link circuit has at the moment available outlets to other sender link frames. Short traffic delays in connection with sender group selection cannot cause the dismissal of the line link circuit; for if sender group selection proceeds within the allotted half-second interval, as it usually will do, the test relays 2019, etc., will open the operating path of relay 2010.

Automatic release under trouble conditions

If the connection proceeds as expected during the first half-second interval, but fails to clear through the sender link circuit within a full second more, the unusual delay may be attributed to circuit trouble of some sort. Under such condition an alarm is given and relay 2010 is operated to dismiss the line link circuit as described before, but in this case the sender link is held busy for an extra half-second interval to allow the line link to select a different sender link frame, if one is available.

From the explanation already given it can be seen that after the initial or pick-up closure of interrupter 2031, the first half-second interval to be measured is marked by the interrupter opening, the operation of relay 2030, and the continued operation of relay 2029; that the second such interval is marked by the interrupter closure, the release of relay 2029, the operation and locking of relay 2028, and the continued operation of relay 2030; and that the third such interval is marked by the interrupter opening, the release of relay 2030, the continued non-operation of relay 2029, and the continued operation of relay 2028.

Three intervals totaling one and one-half seconds have now been measured. On the next interrupter closure relay 2029 again operates and closes ground through its left outer make contact, lower outer make contact of relay 2028, right break contact of relay 2027, key 2003, winding of relay 2002 to battery, operating the relay. Relay 2002 operates the minor alarm pilot relay in a circuit from ground jack 2000, upper outer make contact of relay 2002, conductor 2053, to battery through the winding of alarm relay 2127. Relay 2127 signals a minor alarm by lighting lamp 2128 and operating ringer 2129. Relay 2002 also locks itself under control of key 2003 and closes ground through its lower inner make contact to operate relay 2027. Relay 2027 lights lamp 2024 and at its right-hand contacts switches to the winding of relay 2025 the ground used just previously in operating relay 2002. This ground not only operates relay 2025, but it also operates a trouble meter in the sender link circuit over a path traceable from the winding of relay 2025, conductor 2053, key 1909, conductor 1970, make contact of relay 1713, conductor 1746, to the line link circuit, contact of line link relay 1218, conductor 1259, winding of relay 1214, and battery. Relay 1214 energizes trouble register 1215, and locks through its upper winding to ground on the break contact of the register to insure the operation of the latter. Relay 1214 also locks to ground through a make contact of relay 1213, in order to prevent more than one registration per call. The sender link circuit itself records a count of the trouble on its register 2009, which is operated by relay 2025 over an obvious circuit. Relay 2025 also locks itself to off-normal ground and grounds conductors 1941 and 1942 to insure the operation of relays 1803 and 1807. Relay 2025 moreover operates relay 2010 in a circuit from battery, winding of relay 2010, lower outer break contact of relay 2001, upper outer make contact of relay 2025, left outer break contact of relay 2030, upper make contact of relay 2032, to ground at the upper make contact of relay 2028. Relay 2010 in operating opens the ground from selecting lead 2035 to dismiss the line link circuit by the method already explained. Although most of the relays in the sender link control circuit are now released, by a process already covered, the sender link circuit is guarded against reseizure for the rest of the fourth half-second interval now under consideration, and throughout the fifth such interval as well. For the remainder of the fourth interval the following sender link relays remain operated; relays 1902, the make busy relays 1813, the district group relays 1803, 1807, etc., relay 1918 and alarm circuit relays 2032, 2029, 2028, 2025, 2027, 2010, and 2002. At the beginning of the fifth half-second interval, relay 2030 operates and opens the circuit of relay 2010, but the other relays named continue operated, because relay 2029 holds ground on the off-normal lead through contacts of relay 2025. When the interrupter again closes at the end of the fifth interval, relay 2029 restores and removes ground from the off-normal lead to release relays 2025, 1918, and 1902. Relay 1902 restores relay 2032, and the latter relay restores relay 2028. Relay 1902 also releases four of the five relays 1813 to put the sender link circuit back

Sender link trouble indication and use of emergency control circuit

A holding circuit is provided in connection with the sender link control circuit to assist in the location of troubles whose presence has already been announced by a minor alarm. With the holding circuit made ready, a recurrence of the trouble brings in a major alarm and causes the sender link circuit to be held in whatever position it has reached. The setting of the control circuit then shows how far the call has progressed and indicates the circuits involved, such as the district group, the available districts in the group, the sender sub-group, and the selected sender. The line link frame involved is indicated by the fact that this frame is made to time out and throw over to its mate control circuit, by a process to be described later on. The sender link holding feature should be used only under close maintenance supervision, because the holding equipment when operated removes from service the sender link frame with its associated one-hundred districts, together with a sub-group of senders.

The holding equipment, consisting of hold jack 2000 and relays 2001 and 1910, is ordinarily not used until after some sort of trouble blocks the call and permits the alarm circuit to operate relays 2002 and 2007. Relay 2002 remains locked and actuates the minor alarm until key 2003 is operated to unlock the relay and silence the alarm. The holding feature is then introduced by inserting a short-circuited plug into jack 2000. The circuit of the minor alarm is opened at the inner break contacts of the jack, and relay 2001 is operated in a path through the ring contact of the jack and the short-circuited plug, to ground on the jack sleeve. Relay 2001 at its upper make contact prepares the circuit for the major alarm, and at its lower inner make contact prepares an operating circuit for relay 1910. Relay 2001 also, at its lower break contact, opens the circuit of relay 2010 to keep the latter relay from dismissing the line link circuit. The sender link frame continues to serve calls, and at the next appearance of trouble relay 2002 operates and locks in the usual way, operating the major alarm pilot relay in the circuit from ground at the upper make contact of relay 2001, conductor 2057, winding of pilot relay 2124, to battery. Relay 2124 at its upper transfer contacts opens the circuit of the minor alarm and lights lamp 2125, and at its lower make contact operates the gong 2126 to sound the major alarm. Relay 2003 also closes ground from its lower inner make contact, through the lower inner make contact of relay 2001, conductor 2053, to operate relay 1910. Relay 1910 at its right-hand make contacts locks the operated relay 1912, etc., and at its left inner make contact grounds conductor 1933 to keep relay 1908 operated and the off-normal lead grounded, thus insuring the eventual release of relay 1910 itself before the sender link circuit can be put back into service. Relay 1910 at its left outer break contact removes ground from conductor 1961 to cancel the double connection test, which may have failed initially because of a cross between the selected sender link and a busy sender link, but which might attempt to proceed if the busy sender link should become idle. Relay 1910 also, at its left outer make contact, grounds conductor 1973 to light lamp 1915 through the lower outer contact of relay 1917 as an indication that the connection has reached the stage where the hold magnets have started to operate. This same ground on conductor 1973 is also carried through the upper middle make contact of relay 2005 and the bottom break contact of relay 2013, to light lamp 2012, when the double connection test fails.

The sender link is thus held in the position at which the failure occurred. The district group involved will be indicated by the operated relay 1912, although the record of the district sub-group and the selected district may be wiped out by the automatic release of the line link circuit and the consequent release of sender link relays 1711 and 1709. The identity of the district sub-group may be inferred after noting the idle districts and comparing their location against the setting of the district test relays 1904, etc. The individual district concerned can be known from the operated hold magnet of the secondary line link switch, if the call has progressed that far. The sender sub-group is shown by the operated relay 2019, and the individual sender by the operated relays 2109 and 2112.

After all available data of the kind just mentioned have been noted, the emeregency control circuit may be substituted in place of the regular one, and traffic resumed on the frame. The transfer is manually performed, by first restoring the normally operated key 1909 to detach the frame leads from the regular control circuit and then operating emergency key 1901 to switch the frame leads to emergency control circuit 1974. One emergency key 1901 is furnished for each sender link frame, the armature contacts being wired to the frame leads and the front contacts wired to common leads extending to the emergency circuit. Lamp 1900 associated with key 1901 serves as a guard lamp to warn against double operation of the keys, and it gives a ready indication of the frame on which the emergency circuit may have been connected for use, whether for ordinary maintenance purposes or otherwise.

The regular control circuit may be examined for trouble while the sender link frame is being served by the emergency control circuit. If now the alarm condition is repeated with the emergency circuit, which is in good working order, the control circuit is eliminated as the seat of the trouble.

Miscellaneous maintenance features—Sender link control circuit

In the district group circuit of Fig. 18, jack 1812 provides means for removing a group of twenty districts from service. The insertion of a plug into jack 1812 breaks the paths available test lead 1819, and operates the group busy relay 1813 in an obvious circuit. The break contacts associated with the tip and ring of the jack open the paths controlled by the make contacts of relay 1809 and 1811, respectively, making possible the adjustment of these relays without interference from battery through resistances 1802 and 1806.

In the sender group circuit of Fig. 21, jack 2108 provides means for removing from service a sender sub-group together with the sender links giving outlet to that sender sub-group on the various sender link frames. When a short-circuited plug is inserted into the jack, relay 2107 is operated in an obvious circuit. Relay 2107 operates relay 2105, and the latter relay connects battery from its right-hand make contacts over leads such as conductor 2157 to operate all the

group busy relays 1714 for that sender sub-group on the various sender link frames. Each relay 1714 at its upper break contacts opens its portion of the branches which feed ground to the five paths available leads, and at its lower break contact it opens the path whereby the sender link control circuit tests the sender group under consideration. The latter test paths for the various sender link frames converge into a single path, which as already shown passes through transfer contacts of the reserve test relay 2100, whence the regular test path extends through break contacts of relays 2101 and 2105. Relay 2105 in operating thus provides an immediate bar against access to the busy group, while the various relays 1714, with their break contacts, block the reserve test as the group becomes busy and insure their own release as the group becomes again available.

It will be noted that the master busy relay 2105 operates not only from the busy jack but also over conductor 2158 and the series circuit threaded through the left inner make contacts of the individual sender busy relays 2112, etc. When all senders in the group are thus busy with traffic, a count is made on the sender group busy register 2104. Ground from conductor 2158, through the armature and break contact of relay 2107 and a make contact of relay 2105, operates relay 2103, and the latter operates the meter. The meter is made inoperative by relay 2107, when the make busy jack is in use.

Sender load register

A sender load register device may be furnished in connection with the various sender sub-groups to record the number of times a certain percentage of these groups become simultaneously busy. When the master make busy relay 2105 for a sub-group operates, it connects ground from its left outer make contact, through resistance 2130, to the left-hand winding of relay 2115, the latter relay being common to a number of sender sub-groups. Relay 2115 is a polarized relay of the permanent magnet type, and its two windings are differentially connected. The right-hand winding of the relay will be cross-connected through terminal blocks 2116 and 2117 to some one of the associated resistances, of which resistance 2118 has the lowest value and the others, counting upward, have differing values graduated in corresponding order. Hence, with resistance 2118 connected in the circuit, the greatest current will flow from ground through the relay right-hand winding and the resistance, to battery, the direction of the current being such as to non-operate the relay. The design of the relay and of the resistances is such that under this condition the relay will remain non-operated until its left-hand winding receives sufficient operating current to prevail over the right-hand winding and the polarizing effect of the relay structure. In the assumed case this point is reached when six resistances 2130 contribute current for operating relay 2115, or in other words when six sender sub-groups become busy simultaneously. Relay 2115 operates relay 2120, and the latter operates register 2119. Relay 2120 also operates relay 2121 which locks to key 2122, lights lamp 2123, and brings in a minor alarm by operating relay 2127. As soon as one of the senders involved becomes idle, its sub-group is again available, so that the corresponding relay 2105 falls back and removes ground from its resistance 2130. The operating current of relay 2115 is thereby reduced sufficiently to let the right-hand winding, aided by the polarizing magnetism, restore the relay to normal. Relay 2120 and register 2119 then restore, but relay 2121 and the alarm remain in operation until restored by the operation of key 2122.

To show the significance of the load register feature, let it be assumed that ten sender sub-groups are associated with the same register circuit, and that the latter circuit is connected to function when six branches of its operating path become grounded. The load register 2119 will then record the number of times that 60 per cent of the senders become busy at the same instant, while the ten registers 2104 will show how many times the various sub-groups become busy individually.

Line link control circuit—Rotation of district group preference

Each time the line link circuit restores after a call, it alters the preference arrangement which governs the choice of a district group to insure that on the next call a different group is selected. Without such a shift, the calling subscriber might be unduly delayed or blocked altogether by trouble occurring somewhere in the preferred route through district group and sender link frame, because in periods of light traffic the same faulty channel might be encountered at every attempt. With the circuit as arranged, however, the calling subscriber will be assured of a change in route whenever he is obliged to abandon his first call and try again.

Relays 1600 and 1603 in the line link control circuit are used to rotate preference. It has already been shown how these relays, after remaining normal for one call, are operated by release relay 1509 and left operated in preparation for the next call. Relay 1603 in operating transfers the four leads used in connection with the ten test relays 1609, etc., to effect a choice of district group and sub-group. The transfer contacts of relay 1603 are wired to terminal block 1604, to be cross-connected at will to the terminal blocks 1605, etc., subject to the rule that the break contacts of relay 1603 shall connect to the even or odd test relay of a certain district group, while the make contacts of relay 1603 shall connect to the corresponding test relay of a district group adjacent, either preceding or succeeding. For example, in the arrangement shown, the break contacts of relay 1603 are connected to the armature springs of relay 1612, which is the second or odd numbered test relay for the fifth district group; and the front contacts of relay 1603 are connected to the armature springs of relay 1610, which is the second or odd numbered test relay of the first district group. For the sake of uniformity, line link frames will be wired alike and only at long intervals will cross-connections be changed in order to distribute wear over the line links. It may be noted in passing that since the preference arrangement is associated with two adjacent district groups, the originating traffic will tend to crowd or "pack" upon these district groups and hence upon the corresponding line links. If now the terminating marker is arranged to pack the terminating traffic upon the same links, the remainder of the links serve as overflow outlets, which by remaining free tend to facilitate the matching of paths on terminating calls. In other words, the packing arrangement just described tends to reduce the cover effect on the line links, as regards terminating traffic.

With relay 1603 normal, preference will be given to the second sub-group in the fifth district group, while with relay 1603 operated the preference is shifted to the second sub-group in the first district group, so that in the latter case the call is routed to a different sender link frame. After the next call the preference is shifted back again; for when the line link circuit next releases, relay 1603 is shunted to normal when release relay 1509 operates, and relay 1600 is released when relay 1509 restores.

Line link control circuit—Traffic lockout

When calls originate simultaneously in different horizontal groups, the group receiving service is locked out or denied service for the rest of its lines until after the other waiting groups have each placed one call. This arrangement prevents groups with preferred location in the starting chain from monopolizing the line link control circuit and thereby causing undue delays on calls from groups less favorably situated.

During disconnection of the line link control circuit, relay 808 operates, as has been shown, and restores relay 810 and the group start relay 720 which by reason of its preferred position has been responsible for the call just completed. Assuming other group start relays such as 721, 722, etc., to have operated at the outset, simultaneously with relay 720, these other start relays will have remained locked around the break contacts of common gate relay 723, through break contacts of the respective relays 719, to line relay grounds controlled by the various calling subscribers. Consequently, with one or more of the start relays 721, 722, etc., held operated after start relay 720 releases, relay 805 does not release but is held over to the next call, which is allowed to start when relay 808 is restored by the release of control connector relay 1021. Gate relay 723 remains operated under control of relay 805, to exclude horizontal groups not entitled to service at the moment. Relay 803 in releasing lets relay 810 operate in the customary manner through a make contact of relay 805, and the new call proceeds as usual, preference being given to the horizontal group whose start relay is lowest in the series chain. At each release of the line link control circuit, relays 805 and 723 are held over and one start relay is eliminated. The release of the last group start relay permits relay 805 to restore, and relay 805 releases gate relay 723 to admit calls from all waiting groups. It will be noted that the various start relays 716, 717, etc., of the duplicate or B start train are free to operate while the A start chain is in operation, since gate relay 719 remains normal. Nevertheless the B train is ineffective at this time because its master start relay 804 is kept inoperative by the corresponding start relay 805 in the A train.

Terminating calls

The terminating marker in completing a call to a certain line frame first gains access to that frame through the line choice connector circuit, not shown in these drawings, and then tests to determine whether or not the line link control circuit is occupied with an originating call. If the line link group is so occupied, the marker waits, meanwhile making a busy test on the sleeve of the subscriber's line. Upon the release of the line link control circuit, the terminating marker is given its turn, and thereafter, so long as both originating and terminating calls are waiting, the two kinds are served alternately. Once having seized the start circuit of the line link frame, the terminating marker neutralizes the line link control circuit and gains access through the horizontal group connector relay (relay 703) to the ten line links which serve the desired line. The secondary select magnets of these links are operated locally by the horizontal group connector relay, and the primary select magnet for the line link to be used is operated from the marker after the latter has tested the sleeves of the various incoming links, line junctors, and line links, and has selected a channel through a combination of the three. The marker next operates the various hold magnets of the selected channel, the secondary hold magnet of the line link serving to connect the line junctor to the line link, and the primary hold magnet connecting the line link to the subscriber's line. Finally, the marker makes certain tests of the connection and of the line and then releases itself. The connection is held from the incoming selector, through the medium of the sleeve conductor and the various hold magnets.

The marker in testing the line link start circuit uses a double wound test relay, whose low resistance windings are connected between ground and leads 844 and 843 of the line link frame. Lead 844 extends to the winding of relay 808 in a path including the left outer break contact of relay 804, paralleled by contact 847 on relay 809, conductor 845, right inner break contact of relay 810, winding of relay 803, conductor 842, to battery at a break contact of relay 1015. Lead 843 goes to the winding of relay 807, by way of the left outer break contact of relay 805, paralleled by break contact 848 on relay 818, conductor 846, right inner break contact of relay 809, winding of relay 807, conductor 849, to battery at a break contact of relay 1014. If an originating call is under way, relay 808 will have its circuit opened by relay 810, and relay 807 will have its circuit opened by relays 810 and 805 together, so that the double wound test relay in the marker will fail to find an operating path.

The marker will therefore be obliged to wait, but in the meantime it tests the sleeve of the wanted line over conductors 748 and 747, winding of hold magnet 704 to battery. If ground is already present on the winding of hold magnet 704, the marker recognizes the line as busy and releases at once. Assuming the line to be idle, however, the marker waits until the line link control circuit, upon disconnecting, operates relay 808 in a local circuit already traced. Relay 803 operated holds relay 805 and restores relay 810, and the latter closes leads 844 and 843 to the windings of relays 808 and 807 respectively. Relay 807 immediately provides a battery path for one of the windings of the marker test relay, and the two relays operate in series. The local operating ground for relay 803 overlaps momentarily with ground from the second winding of the marker test relay to insure the continued operation of relay 803 and thus to lock out originating traffic until the delayed terminating call has been served. The marker test relay is able to operate over its one winding alone in series with relay 807 through its other winding shortly supplies additional energy when the operating ground is removed from relay 1103. Relay 803 locks itself around the break contacts of relay 810, and relay 807 locks around the break contacts of relay 809, for a purpose to be explained later. Both the A and the B start trains are

now blocked, because relay 808 prevents relay 810 from operating, and relay 805 does the same for relay 804.

The marker, upon receiving from its double wound test relay the signal to proceed, connects ground over conductor 738 to operate relay 709 for the horizontal group containing the called line. Relay 709 gives notice of its operation by closing together the check leads 759 and 760, and operates the ten select magnets 712 at the secondary end of the line links giving access to the horizontal group. Relay 709 also connects into the marker the ten link sleeves over a path including conductors such as 750, make contacts of relay 709, conductor 841, upper break contact of jack 801, conductor 840, and so through the line choice connector circuit, to ten test relays in the marker. Each sleeve tap 750 is also connected by a branch path and through a separate make contact on relay 709, through retardation coil 715, to battery, this path serving, in the case of idle links, to operate the corresponding marker test relay. The operating path for the primary select magnets 705, which are located on the various cross-bar switches serving the horizontal group, may be traced from battery through the windings of select magnets 705, conductor 754 or the branch conductor 755, front contact of relay 709, conductor 761, to ground in the terminating marker. To complete the connection, secondary hold magnets 713 is operated from the marker over lead 763, and line hold magnet 704 is operated over leads 747 and 748. Both of these hold magnets lock themselves to the sleeve conductor and close their respective sets of cross-points. Line hold magnet 704 at its bottom break contacts detaches the line relay circuit from the line conductors. The marker now tests for continuity of the sleeve circuit and of the line conductors, and then restores the line choice connector circuit. Relay 709 and the select magnets 712 and 705 are restored, but the hold magnets remain locked over the sleeve conductor to ground supplied by the incoming junctor circuit. Upon the release of the marker, relays 807 and 808 are restored, the latter restoring relay 805 if no originating calls are waiting. A waiting originating call, however, with its operated group start relay 720, etc., serves to keep relay 805 operated, and the latter relay upon the release of relay 808 operates relay 810, to operate the control connector relays. Although relays 810 and 808 control the operating paths of each other, relay 810 will operate before the line choice connector can again seize the line link frame to reoperate relay 808, so that at this time a waiting originating call is assured of preference over a waiting terminating call. After the originating call has been served, relay 808 again operates, to give preference to a terminating call, as has previously been shown. Thus, in periods of heavy traffic the originating and terminating calls are handled alternately. In this connection, it will be remembered that when an originating call seizes the control circuit and encounters certain slight traffic delays, a terminating call is then permitted to displace the originating call and take over the start circuit for its own use. Another occasion in which the terminating call is favored over an originating call arises when the two attempts to seize the common start circuit simultaneously. As has been shown, relays 808 and 810 of the A start train control each other's operating paths, and relay 808 locks independently of relay 810. This arrangement is intended to halt any vibrating or "buzzing" action which may be set up when the two relays are energized at the same instant, and to insure the locking of relay 808, with resultant advantage to the terminating call. Relays 807 and 809 of the B start train are similarly arranged.

Both relays 807 and 808 start their respective timing circuits. Relay 807 grounds its interrupter 1001 with ground through conductor 850 on relay 809, right-hand operated transfer contacts of relay 807, conductor 851, to interrupter 1001. Relay 808 similarly grounds its interrupter 1003 with ground through break contact 852 on relay 810, right-hand operated transfer contacts of relay 808, conductor 835, to interrupter 1003. The operation of the timing circuit will be described later.

Emergency operation of line link frame

Pairs of line link frames are provided with interconnections which enable either frame of a pair to make emergency use of the control circuit of its mate, although each normally uses its own control circuit. This transfer arrangement, with its duplicate equipment and its automatic operation, is designed to insure the least possible interruption to originating traffic if trouble occurs at a time of day when the maintenance oversight is reduced. A time alarm is provided on each frame to effect the transfer if necessary and to announce any trouble, whether in the control circuit or elsewhere, which delays the call beyond a set limit.

As has been shown already, duplicate start equipments, each consisting of horizontal group relays, master start relays, a timing circuit, and control connector relays, are furnished on every line link frame. The A start equipment, shown at the right on Figs. 7, 8, 10 and 12, causes the various frame leads to be connected into the local control circuit, which for convenience may be referred to hereinafter as the H control circuit of the home or H frame. The B start equipment, shown at the left on Figs. 7, 8, 10 and 12 connects the frame leads from the H frame across to the mate or M frame and so to the M control circuit. Figs. 9, 11 and 13 show the principal portions of the A and B start equipments of the M frame, the right to left order being reversed to emphasize the symmetrical relationships and to facilitate an understanding of the interlocking features of the pair of frames. Fig. 14 throws into relief the leads directly concerned with the starting operations. It should be understood that any description given below in connection with the home or H frame applies equally to the mate or M frame, for the two are identical.

The A start train is quicker acting than the B train and disables the latter under normal conditions so as to route the connection to the local control circuit. If the A train of the H frame is blocked or delayed through some fault of its own, the B train takes charge and routes the connection across to the mate control circuit, the B start train of the H frame being interlocked with the A start train of the M frame to prevent seizure of the M control circuit from both points at once. The M frame, without waiting for its own control circuit to become idle, may use its B start train to cross back to the H control circuit, which presumably is in working order. Thus in the assumed case the two frames may use each other's control circuit momentarily, but the transfer is not permanent and

each frame always tries to use its own control circuit before seeking the opposite one.

If the A start train on the H frame is actuated properly but the connection is halted by trouble in the H control circuit, the A start train after an interval of from five to ten seconds is disabled by its timing circuit, and a minor alarm is brought in. The B train is therefore permitted to operate and carry the connection across to the M control circuit. Thereupon the M frame, finding its own control circuit in use, may cross by way of its B start train to the H control circuit, only to be blocked there by the trouble assumed. When after five to ten seconds the M frame has its B start circuit timed out and eliminated, the M frame is restricted to the use of its A start train and its own control circuit. The M control circuit thereafter carries the load from both frames, but the one control circuit serves the two frames alternately by reason of the interlocking arrangement provided for the purpose.

If the trouble which causes the H frame to throw over through its B start train to the M control circuit lies somewhere in the frame leads, the trouble may affect the emergency connection likewise. The B start equipment on the H frame will then be eliminated by its timing circuit, and the A start train will be activated; and next the call will revert to the B start train, and so on. The H frame will nevertheless afford service for most of its lines. As will be shown, the circuit arrangement undertakes to restrict the number of troubles capable of producing the reaction mentioned, so that the disturbance can arise only through some fault associated with a small portion of the lines, such as a horizontal group. Other groups, being free from the localized trouble, will be able to break in at the end of the time-out delay, and so receive service.

Various maintenance features are provided, such as exercise jacks for the A and B start trains, and make busy equipment for the control circuit, and these will receive consideration at the proper time.

Momentary transfer to opposite control circuit

It has been shown that an originating call causes two group start relays to operate, such as relay 720 in the A train and relay 716 in the B train, and that these in turn energize their respective master start relays 805 and 804. Relay 804 is made slow operating in comparison with relay 805 so that the latter ordinarily opens the circuit of the former, to disable the B start train. However, should group start relay 720 fail to operate, or should the circuit of relay 805 be opened, the latter relay would fail to operate and relay 804 would do so instead. Relay 804, in operating, at its right outer break contact opens the circuit of relay 805 to disable the A start train, and at its right inner make contact starts its timing circuit by connecting ground to the break contact of the right-hand transfer springs on relay 807, over conductor 851, to the armature contact of interrupter 1001. Relay 804 operates relay 809 in a circuit from battery at the break contact of relay 1014 conductor winding of relay 809, conductor 917, to relay 910 on the mate frame, through the right inner break contact of relay 910, assumed normal, conductor 912, left inner make contact of relay 804, contact 825 on relay 807, conductor 824, to ground previously traced in operating relay 804. Relay 809 operates the connector relays of the B start train, using grounds supplied from the M control circuit over leads 1319 and 1320. Ground from conductor 1319 is connected by a make contact on relay 809 to conductor 853, through the winding of relay 1020, to battery on a break contact of relay 1014. Ground from conductor 1320 is connected by a make contact of relay 809 to conductor 854, through the windings of relays 1200, 1202, 1207, and 1212 in parallel, to battery on conductor 1260 supplied from a break contact of relay 1014. Relay 1020 locks itself through the contacts of relay 809 by grounding conductor 1043, and relay 1212 does the same for its group of relays by grounding conductor 1044. The five connector relays 1020, 1200, 1202, 1207, and 1212 of the B start train connect the frame leads from the H frame into the mate control circuit in the same manner that the corresponding connector relays of the A start train customarily establish connection with the home control circuit. The transfer operation may be illustrated with a single lead, namely, one of the conductors which are tapped off the sleeve leads of the line links. This conductor, numbered 1031 where it enters Fig. 10, appears on armature springs of both connector relays 1021 and 1020, and with the latter relay operated the path extends by way of conductor 1045 across to the mate frame and so into the M control circuit. Examination of Fig. 14 will make clear the relationship of the two frames to their control circuits.

The home frame is now in possession of the M control circuit which, being a duplicate of the H control circuit, is able to perform the same functions. After completing the connection, the M control circuit reaches back to operate relay 807 in the B start train, over a path traceable from battery at the break contact of relay 1014, conductor 849, winding of relay 807, conductor 855, make contact of relay 1020, conductor 1046, to the M control circuit. Relay 807 in operating opens its break contact 825 to restore relay 809, which in turn restores connector relays 1020, 1200, 1202, 1207 and 1212 to dissociate the H frame from the M control circuit. Relay 807 at its right inner make contact closes an obvious path for holding relay 804, subject of course to the control of group start relays 716, etc. With the release of the connector relays, relay 807 has its circuit broken unless a terminating call is waiting, in which event the terminating connection is served next.

The mate frame is denied access to the M control circuit as soon as relay 809 of the H frame operates, for the latter relay controls the path by which the master start relay 905 and its associated relay 910 normally operate. The path for relay 905 may be traced from battery, break contact of relay 1115, conductor 1123, winding of relay 905, left outer break contact of relay 904, left outer break contact of relay 907, conductor 920, conductor 921, left outer break contact of relay 809, conductor 857, break contact of jack 1105, conductor 1124, to ground at the make contacts of the operated group start relay, not shown. The circuit of relay 910 may be traced from battery on conductor 1123, winding of relay 910, conductor 919, left inner break contact of relay 809, conductor 856, right middle make contact of relay 905, break contact of right transfer springs on relay 908, to conductor 920 and the ground just traced for operating relay 905. Thus the A start train of the M frame is disabled when the H frame actuates its B start train to seize the M control circuit. The M frame is not obliged to wait, however, because with its A start train

held out of action, its B start train is made operative to seize the H control circuit. Master start relay 904 of the B train operates in a path traceable from battery at a break contact of relay 1114, conductor 1125, winding of relay 904, left outer break contacts of relays 905 and 908 in series, conductor 922 to the H frame, left outer break contact of relay 810, conductor 858, break contact of jack 1106, conductor 1126 to the B group start relays, not shown, and ground at an operated contact of one of these relays. Relay 904 operates relay 909 over a path extending from battery on conductor 1125, already traced, winding of relay 909, conductor 923, left inner break contact of relay 810, conductor 859, right inner make contact of relay 904, right transfer break contact of relay 907, to conductor 922 and a ground path already traced for operating relay 904. Relay 909 operates the five connector relays 1120, 1300, 1302, 1307, and 1312 whereby the M frame leads are switched across to the H control circuit. The operating path for connector relay 1120 runs from battery at a break contact of relay 1114, through conductor 1127, winding of relay 1120, conductor 1128, a left make contact of relay 909, conductor 924, conductor 836, and by a path previously traced to ground in the H control circuit. The operating circuit of connector relays 1300, 1302, 1307, and 1312 runs from battery at a break contact of relay 1114, over conductor 1129, through windings of the four relays in parallel, conductor 1321, left outer make contact of relay 909, conductor 925, conductor 837 and a path previously traced, to ground in the H control circuit. The connector relays connect the frame leads from the M frame into the H control circuit, one such lead for example being that from the sleeve of a line link. This lead, entering Fig. 9 as conductor 926, passes through a break contact of jack 901, to conductor 1122, through a make contact of connector relay 1120, to conductor 1130, across to the H frame, to conductor 1626 and by a path previously traced, to the H control circuit. Having served the M frame, the H control circuit frees itself in the usual way by operating relay 907 over a circuit traceable from battery, break contact of relay 1114, conductor 1431, winding of relay 907, conductor 927, make contact on relay 920, conductor 932 to the H frame and over conductor 1546 to the H control circuit. Relay 907 restores relay 909, and the latter releases the five connector relays 1120, etc., to detach the H control circuit from the M frame. On the next call the M frame can pick its own control circuit provided the latter is not engaged by the opposite frame; for master start relay 905 of the A train can now operate through the normally closed contacts of relay 809 to switch the call through the accustomed channel. When the M frame is in possession of its own control circuit the B start train on the H frame is disabled, for relays 804 and 809 of the B train both have their operating paths opened by relay 910.

Continuous transfer to opposite control circuit

The transfer may be effected by the start circuit time alarm if the connection is delayed for an interval of five to ten seconds. Master start relay 805 of the A start train connects ground to conductor 834, through a break contact of relay 808, to conductor 835, and so to the armature of interrupter 1003. This interrupter is designed to remain closed on its break contact for a small fraction of a second, to pass slowly from its break to its make contact, producing an open interval of approximately five seconds, to close its make contact for a small fraction of a second, and to complete the cycle by a rapid return to its break contact. Assuming the interrupter 1003 to have its break contact closed at the outset, ground from conductor 835 will pass through the interrupter break contact, over conductor 1047, to the right transfer and break contact of relay 812, to conductor 860, winding of relay 1002, to battery. Relay 1002 in operating locks to ground on conductor 835 and prepares an operating circuit for relay 812 traceable from the make contact of interrupter 1003, right outer make contact of relay 1002, upper break contact of jack 1004, conductor 1048, winding of relay 812 and battery. Relay 1002 thus serves as a pick-up relay, whose operation is made to coincide with the beginning of the five-second interval as a guarantee that no shorter interval than this can be measured off. The maximum interval may, of course, be as much as ten seconds if the interrupter has just opened its break contact before having its armature contact grounded. If with pick-up relay 1002 operated the connection for any reason is delayed until the interrupter closes its front contact, relay 812 will then operate over the path already traced, and will lock through its right inner or continuity contacts, over conductor 820, left outer or continuity contacts of relay 1015, break contact of key 1013, and ground. The same ground which locks relay 812 is extended through the left outer make contact of relay 812, conductors 879 and 835 to the lock circuit of relay 1002 and the armature of interrupter 1003. Relay 812 upon opening contact 861 of its continuity springs breaks the source of ground whereby the group start relay 720 has been keeping relays 805 and 819 operated. Relays 805 and 810 restore, the latter releasing the five connector relays 1021, etc., to disconnect the H control circuit. The group start circuit of the A train meanwhile is held in place by relay 812, which at its left inner make contact grounds conductor 735, to hold gate relay 723, and at its right outer make contacts continues ground on conductors 838 and 1225 to hold relays 720 and 710 respectively. The horizontal group involved in the time delay is thus locked out for the moment, but another waiting group, which may have operated its group start relay such as 717 in the B train, may proceed immediately upon the release of relay 805 to operate relay 804 of the B train and so gain access to the mate control circuit.

Relay 812 also prepares the circuit for operating relay 1015, in a path treaceable from battery, winding of relay 1015, conductor 1050, make contact of right-hand transfer springs on relay 812, conductor 1047, to the break contact of interrupter 1003. The interrupter soon opens its make contact and returns quickly to its break contact, operating relay 1015. Relay 1015 locks in a circuit extending through the right outer break contact of relay 1014, conductor 1051, left middle break contact of relay 811, conductor 862, right outer break contact of relay 906, conductor 928, locking contact 1052 on relay 1015, to ground on a break contact of key 1013. The left outer or continuity contacts of relay 1015 remove from conductor 820 the ground just used for operating this relay and for holding relays 812 and 1002, but first these contacts supply a substitute ground over conductor 1053, to contact 863 on relay 812. From there the ground is carried

through the right transfer contacts of relay 812 to conductor 1047, break contact and armature of interrupter 1003, to conductor 835, thus holding relays 1002 and 812 so long as the interrupter remains on its break contact. Supplementing the holding ground just traced is that supplied from relay 1015 through its locking contact 1052, and the locking path traced, to the winding of relay 1015 and the path including conductor 1050 used in operating the relay. This back-up path from the locking contact of relay 1015 is not yet called upon to hold the relays mentioned, for the same purpose is served by the continuity contacts on relay 1015 which close ground to conductor 1053 before opening ground from conductor 820. Relay 1015 upon operating disables the A start train by removing battery from the windings of relays 805, 808, and 810 and from the five connector relays 1021, 1201, 1203, 1208 and 1213. The frame alarm lamp 1019 is lighted with ground applied by the right inner make contact of relay 1015, and the minor alarm is actuated in obvious manner when the alarm pilot relay 1007 operates in a circuit traceable from battery, winding of relay 1007, conductor 1055, left outer break contact of relay 1011, contact 1054 on relay 1015, to ground. When interrupter 1003 opens its break contact, it severs the locking circuit of relays 1002 and 812. Relay 812 restores the group start relays 720, 723 and 710 to remove the lock-out restriction from the horizontal group just involved in the time delay, enabling this horizontal group to take its turn with the others. Relay 1015 remains locked under control of key 1013 and keeps the minor alarm in operation. With the A start train inoperative, master start relay 804 of the B start train is free to operate and steer calls from the H frame across to the M control circuit.

The M frame, unlike its opposite, retains access at this time to either of the two control circuits, for upon finding its own control circuit in use, the M frame may employ its B start circuit to seize the H control circuit. Assuming now that the trouble which originally blocked the H frame resides in the H control circuit, the M frame will likewise encounter the trouble and will be blocked until its B start train times out. The time alarm features of the A and B start trains on both frames are identical, with the exception of one or two minor wiring differences which will be pointed out, and the details of operation need not be repeated. In the present instance the timed interval ends with relay 1114 operated and locked to key 1113, and with the B start train on the M frame disabled. From this point on, the both frames are forced to use the M control circuit, the M frame by way of its A start frame and the H frame through its B start train. The single control circuit serves the two frames alternately as will now be shown.

Ordinarily, the B start train of one frame and the A start train of the other frame are interlocked in such manner that relays 804 and 809, for example, have their operating paths controlled by relay 910 on the opposite frame, while relays 905 and 910 in turn have their operating paths controlled by relay 809. In the present case, however, with alarm relays 1015 and 1114 locked up, relays 804 and 905 are each made independent of the opposite frame, while their companion relays 809 and 910 remain mutually interlocked as before. In detail, the operating circuit of relay 804 normally extends from battery, through a break contact of relay 1014, conductor 821, winding of relay 804, right outer break contacts of relays 805 and 808 in series, conductor 824, contact 929 on relay 910, conductor 914, break contacts on jack 1006, to conductor 1023 and so to ground already traced. Contact 929 on relay 910 is now eliminated from this path by a short circuit traceable from conductor 824, conductor 826, make contact 1056 on alarm relay 1015, to conductor 1023. Similarly, the operating circuit of relay 905 normally extends from battery, a break contact of relay 1115, conductor 1123, winding of relay 905, left outer break contacts of relays 904 and 907 in series, conductor 920, conductor 921, left outer break contact of relay 809, conductor 857, break contacts of jack 1105, to conductor 1124 and so to ground already traced. The left outer break contact on relay 809 is now eliminated from this path by a short circuit traceable from conductor 920, over conductor 930, right middle make contact of relay 1114, to conductor 1124.

Assuming first that the M frame has possession of its own control circuit, the H frame although obliged to wait, is free to operate relay 804 of its B start train since this relay is now locally controlled. After the M frame has been served, relay 908 in its A train is operated from the control circuit, to hold relay 905 and restore relay 910. Relay 910 restores the five connector relays to free the control circuit, and recloses the circuit whereby the operated relay 804 is able to energize its associated relay 809. Relay 809 operates immediately and breaks the operating path of relay 910, thus locking out the M frame before the five connector relays and relay 908 on the latter frame have had time to fall back and reestablish the operating circuit of relay 910.

With relay 809 operated, the H frame operates its corresponding set of connector relays and so takes possession of the M control circuit. Meanwhile, a waiting call on the M frame may have reoperated relay 905, or may have held the relay operated from the preceding call. The M frame thus waits until the H frame has been served and has had its relay 807 operated, and then, upon the release of relay 809, the M frame is enabled to operate its own relay 910 and again take its turn with the control circuit. This alternate action occurs whenever one frame reaches the waiting position while the opposite frame is engaged with the single control circuit. The alternation is dependent upon the interlocking arrangement which enables either frame to exclude the other upon seizure of the control circuit, but which momentarily obstructs the lock-out feature of the frame just served in order to give advantage to the waiting frame.

Certain interlocking arrangements between the two frames are worth noting. First of all, as has just been shown, master start relay 804 in the B start train of the H frame, and the corresponding relay 905 in the A start train of the M frame, are each rendered independent of the opposite frame under the trouble conditions assumed. Under normal conditions, however, these relays are controlled in part from the opposite frame, and the reason for this can now be explained. The A start train relay 905 of the M frame has its operating path normally controlled by a break contact on the B start train relays of the H frame. The reason for this arrangement has been touched upon already under the heading "Momentary transfer," but it may be briefly restated here. If the H frame, when not permanently transferred, uses its B start train to

reach the M control circuit, the M frame thereby has its quick acting A train disabled, in order that the slow acting relay **804** of its B train may function. Lacking such an arrangement, the H frame would be deprived of the use of its B train and of the M control circuit, under the conditions assumed.

Next, let relay **804** be considered. This relay, constructed to be somewhat slower in operation than the corresponding relay **805** in the A train, is expected to give the A train the advantage so that calls will normally be routed to the H control circuit. However, if relay **804** through weakened adjustment or other fault should operate faster than relay **805**, the connection would be routed down the B start train to the M control circuit. Such unnecessary intrusion upon the M frame is prevented by the break contact on relay **910** which, if open, prevents relay **804** from operating. This contact may therefore be considered to supplement the feature by which the opposite B train is normally subordinated to its associated A train.

Lastly, it will be noted, with reference to relay **810** of the H frame A train and the corresponding relay **909** of the M frame B train, that whereas the two relays control each other's operating paths, the former relay is arranged to lock independently of the latter relay. This arrangement is intended to prevent "buzzing" on the part of these relays when both are energized simultaneously, and it tends to give advantage to the H frame when both frames are competing for the H control circuit.

Let it be assumed that the trouble which causes the H frame to throw over to the M control circuit lies among those leads which relate to a single horizontal group of lines. In particular, assume a broken or open lead **724**, associated with line relay **706** in a certain horizontal group The result will be, first the failure of line registration in the control circuit, and next, operation of time alarm relay **1015** in the A start train, to transfer the H frame. The same trouble will now affect the M control circuit which the H frame seizes through its B start train, so that a time-out will again occur and relay **1014** will operate. Just before relay **1014** operates, however, relay **1111** will have broken the locking circuit of relay **1015** in the A start train, thus restoring the A train to service and establishing a locking circuit for relay **1014**. With relay **1014** operated and the B train made inoperative, the A start train and the H control circuit resume operation. A recurrence of the time-out releases relay **1014** to reactivate the B start train and operates relay **1015** to disable the A train. Hence, the horizontal group affected with the trouble causes the H frame to transfer back and forth from one control circuit to the other, but at each shift the group is momentarily locked out to grant admission to other groups on the frame.

Thus it is seen that the frame circuit undertakes to provide service despite localized trouble of the kind assumed, and since the inconvenience is comparatively limited in extent the trouble indication is given with the minor alarm only. So far as practicable, frame troubles capable of producing a more general effect are precluded by reinforcing the circuit. For example, conductor **1249** extending between relays **1213** and **1218** in Fig. 12 might, if open, block all traffic on the frame. Therefore, this lead is furnished in duplicate, and as an added precaution, since the lead is multipled, the duplicate conductors are separated and then attached at extreme points on the multiple.

Maintenance features—Line link frame chart chain exercise jacks

Since both the A and the B start trains attempt to give service on every call, the blocking of one train allows the other to function, and yet it gives no alarm indication. Troubles producing this effect may be detected by routining the trains separately through the use of an exercise jack with which each train is provided. When the exercise jack of the A train is operated with a plug, it disables the B train and forces calls through the A train to the home control circuit. Similarly, the exercise jack of the B train disables the A train and forces calls across to the mate control circuit. It is intended that only one exercise jack shall be used at a time, for if the two jacks on a frame are operated at once they make each other ineffective.

Jack **1006** is the exercise jack for the A start train. The break contacts on this jack disable the B start train by opening the operating path, already traced, for relay **804**. Originating calls are thus forced through the A train to the home control circuit, so that troubles tending to interfere with the A train will be revealed. The make contact on jack **1006** connects conductor **1022** to conductor **818**, thus short-circuiting that portion of the operating path of relay **805** which includes the break contacts of jack **1005** and the right outer break contact of relay **909**, in series. The effect of the shunt at this time is to make relay **805** wholly independent of the mate frame B start train in case the latter should come into use, but another effect will be pointed out shortly.

In like manner jack **1005** serves as the jack for the B start train. With a plug inserted, this jack breaks the operating ground path for relay **805** of the A train, thus enabling relay **804** of the B train to operate on every call and divert the traffic across to the M control circuit. Jack **1005**, through its make contact, also closes a path traceable from conductor **1023**, over conductor **1024**, make contacts of jack **1005**, conductor **826**, to conductor **824**, to short-circuit that portion of the operating path of relay **804** which includes break contact **929** on relay **910** and the break contacts of jack **1006**, in series. Relay **804** is thus placed on an equal footing with relay **905** in the M frame A start train, and the two frames now use the M control circuit alternately.

If both exercise jacks are put into use at the same time, the make contacts on one jack will undo the effect of the break contacts on the other. Suppose, for example, that jack **1005** is in use to exercise the B start train. The break contacts of this jack open the ground source for operating relay **805** of the A train, while the make contact of the jack renders relay **804** independent of jack **1006**. If now jack **1006** becomes operated its break contacts are unable to disturb relay **805**, while its make contacts reestablish the operating circuit of relay **805**. Both master start relays, **804** and **805**, have now been restored to their normal relation with each other.

Control circuit make busy feature

Each start circuit contains make busy equipment which enables the maintenance man to remove the control circuit from service, together with its associated start circuits consisting of the home frame A train and the mate frame B train.

With its make busy feature in operation, the home frame routes its calls through its B start train to the mate control circuit, and maintenance work may be carried out on the equipment removed from service. A guard lamp is lighted when the control circuit is made busy, to serve as a reminder that the double load upon the opposite control circuit may occasion extra delays in periods of heavy traffic. If a time alarm occurs while one control circuit is plugged busy and the other control circuit is serving both frames, the frame whose timing circuit has functioned will be deprived of service. Under this condition a warning is given with the major alarm, in place of the minor. Similarly, the major alarm is brought in if both frames have their make busy equipment operated at the same time, for under this condition both frames are put out of service.

The make busy equipment for the home frame consists of make busy jack 803 and relay 806, and associated with it is the guard lamp 802, common to all frames. When a short-circuit plug is inserted into jack 803, ground from the jack sleeve is fed through the plug to the jack contacts, operating relay 806 and lighting guard lamp 802. Relay 806 at its right-hand break contact 864 opens the ground path already traced for operating relays 805 and 810 of the A start train. With the A start train rendered inoperative, the B train comes into action and transfers the frame to the mate control circuit. Relay 804 at this time operates independently of the mate frame A start train, to insure alternate service between the frames, as already explained. Relay 804 also operates independently of exercise jack 1006, and of relays 805 and 810 of the home frame A start train, in order that the latter train may be subjected to maintenance repairs without causing interference. The shunt path which frees the operating circuit of relay 804 from the various control points just mentioned, may be traced from conductor 822 at the winding of relay 804, through the upper make contact of make busy jack 803, conductors 878, 824 and 827, right inner make contact of relay 806, to conductor 828 and so to the ground source already traced. In similar manner, the make busy equipment supplies a shunt path to modify the operating circuit of relay 905 on the mate frame, this path extending from conductor 931 at the winding of relay 905, through the lower make contact of jack 803, make contact 866 on relay 806, conductor 865, to conductor 1124 and the ground source already traced. This shunt path makes the mate frame A start train independent of its associated B start train, to allow for maintenance on the latter.

If the H frame, whose make busy jack is assumed operated, times out in connection with the mate control circuit, it causes a major alarm. Its B start train is not permanently locked out of service, however, because the trouble causing the stoppage may be localized in the equipment of one horizontal group of lines, and it is desirable to give service on the remaining horizontal group. Relay 1011, which controls the major alarm, operates in a circuit extending from battery, winding of relay 1011, conductor 1057, make contact 867 on alarm relay 811 of the B train, conductor 868, contact 869 on make busy relay 806, to ground. Relay 1011 locks to ground on key 1013, lights lamp 1012 to indicate the frame in trouble, opens the path including conductor 1055 to cancel the minor alarm, and at its right inner contact connects ground to conductor 1058 to operate the alarm pilot relay 1016. Relay 1016 in operating opens the circuit of the audible minor alarm, lights lamp 1017, and actuates the device 1018 to give a major alarm. Relay 1014, which operates in the usual manner at the end of the timed interval, cannot lock operated in the present case, because its locking circuit has been opened by make busy relay 806. This locking path may be traced from the winding of relay 1014, over conductor 1059, break contact 870 on relay 812, conductor 871, right outer break contact on relay 1015, conductor 1060, right outer break contact of the operated relay 806, conductor 872, locking contact on relay 1014, to ground on key 1013. Since this locking circuit for relay 1014 is broken as stated, the relay restores in due time and does not disable the B start train, so that repeated calls can be put through or at least attempted. Relay 1011 keeps the major alarm in operation until attention is given to the trouble and key 1013 operated to restore the relay.

If, with the H frame make busy feature in operation, the M frame is the one which encounters a time-out delay, the major alarm is operated from the M frame. The frame is permitted to continue in operation, because the alarm relays of its A start train are denied a locking path. The path by which relay 1115 normally locks is traceable from the winding of the relay, through the left outer break contact of relay 1114, conductor 1133, right middle break contact of relay 911, conductor 932, left outer break contact of relay 806, conductor 873, lock contact 1134 on relay 1115, to ground at key 1113. Hence, with make busy relay 806 operated, alarm relay 1115 cannot lock up, and the release of the latter relay puts the A train of the M frame back into service. The operating circuit for relay 1111 extends from the winding of the relay, over conductor 1135, through the left inner make contact of relay 806, conductor 874, contact 933 on relay 912, to ground. Relay 1111 in operating locks to key 1113 and substitutes the major for the minor alarm in the manner already described for relay 1011.

The operation of the make busy equipment on both frames at the same time would put both frames out of action, but would give immediate warning by means of the major alarm. Make busy relay 806 on the home frame cuts out the H control circuit by breaking the operating grounds of the associated start trains; namely, the A train of the H frame and the B train of the M frame. Likewise, make busy relay 906 on the mate frame cuts out the M control circuit by breaking the operating ground of the associated start trains; namely, the A train of the M frame and the B train of the H frame. A detailed description concerning relay 906 can be omitted, since the functioning of this relay may be inferred from the description of its counterpart, relay 806 of the H frame. With both make busy relays operated, alarm relay 1011 is energized over a path from battery, winding of relay 1011, conductor 1057, conductor 875, right inner make contact of relay 906, conductor 934, make contact 869 on relay 806, to ground. Relay 1011 locks operated, lights frame lamp 1012, and operates the major alarm. In like manner relay 1111 is energized in a path from battery, winding of relay 1111, conductor 1135, left inner make contact of relay 806, conductor 874, contact 935 on relay 906 to ground. Relay 1111 locks operated, lights frame lamp 1112, and grounds conductor 1058 to keep the major alarm in operation.

Start circuit hold jack

Hold jack **1004** is provided in connection with the start circuit to aid in maintenance by blocking the transfer feature upon the appearance of trouble, and by holding the circuit in the exact stage reached. With a short-circuited three-conductor plug inserted in this jack, the operating paths of alarm relay **812** in the A start train, and of relay **811** of the B start train, are opened. Also, the start jack and the plug in obvious manner connect the winding of major alarm relay **1011** to the paths ordinarily used in operating relays **812** and **811**, so that the occurrence of a time-out condition which would ordinarily operate one or the other of these relays will instead operate relay **1011**. Relay **1011** will light frame lamp **1012** and will actuate the major alarm to call prompt attention to the stoppage of service on the frame. All apparatus involved will be held in position, assuming of course that the connection is not broken down through some agency beyond control of the start circuit, such as disconnection by the subscriber or by the dial tone delay time-out feature. Even in those cases where the record is effaced after a brief interval, some observations as to the setting of the apparatus should be possible because the maintenance man is expected to remain in attendance at the frame when using the hold feature.

Line link frame—Secondary switch make busy jack

A make busy jack, such as jack **801**, is provided for each one of the ten secondary cross-bar switches on the frame. When for maintenance reasons, it is desired to remove one of these switches from service, the corresponding make busy jack is operated with a plug. Jack **801**, for example, intercepts one of the common leads over which the link sleeve busy test is made on originating or terminating calls, and applies busy ground to the lead. Since this common lead is multipled throughout the ten horizontal group relays **809** so as to be connective with the sleeves of the ten links terminating on a particular secondary cross-bar switch, the busy ground on this one common lead serves to make that particular secondary switch test busy.

The busy test lead referred to is the conductor wired to the armature contact of the transfer springs on jack **801**. With the jack operated by a plug, this conductor is detached from conductor **841** and is switched to busy ground. Branch conductor **840** from this lead is accessible to the terminating marker by way of the line choice connector circuit, and branch conductor **1031** is accessible to the line link control circuit by way of the control connector relays. Jack **801**, moreover, at its lower break contact opens ground from conductor **758**, which is multipled throughout the various horizontal group relays **709** to supply operating ground for the select magnets **712**, etc., on the secondary cross-bar switch under consideration. By this means the select magnets of the secondary switch are freed from unnecessary operation while the switch is plugged busy.

Line link frame—Miscellaneous check features

Various check features are included in the circuit to indicate the presence of trouble. Some of these devices have been dealt with in the course of the foregoing description, and others will be mentioned now.

The failure of a horizontal group connector relay such as **709** to restore will be indicated by the time-out alarm associated with relay **805**, which is kept operated over a path including make contact **764** on relay **709**.

A false ground on one of the conductors **843** and **844** used in connection with terminating traffic will manifest itself through the operation of relay **807** or relay **808** and the corresponding time alarm. The relay **807** or **808** not involved in the trouble may still be used to complete terminating calls.

A false ground on certain group start leads which are concerned with the operation or the holding of group start relays **720**, etc., might cause a succession of false starts. A ground of this nature is indicated by continued operation of the group start relay **720**, etc., and its associated master start relay such as relay **805**, the latter relay actuating the time alarm.

Various leads to be found in the A and B start trains are intended to reveal certain troubles occurring in those areas of the circuit. For example, a trouble ground appearing on the winding of relay **810** in the A start frame might produce no noticeable effect until a call came in and received service. At disconnection, relay **808** will operate as usual, and alarm relay **1002** will restore, but relay **810** will fail to release because of the trouble ground. This false ground backs up over conductor **916** to the left middle make contact on relay **805**, thence by conductor **833**, left transfer springs and their make contact on relay **808**, conductor **876**, conductor **877**, left break contact of relay **1002**, now normal, conductors **1049** and **1048**, winding of alarm relay **812** and battery. Relay **812** then brings in the alarm. A similar indication is given if the left transfer contacts on relay **808** are out of adjustment to such extent that all three contacts of the spring combination are bunched or touching each other. In such case ground from conductor **1022**, supplied when group start relay **720** operates, will be extended through the bunched transfer contacts on relay **810**, to conductor **877**, then by conductor **876**, left break contact on relay **1002**, conductors **1049** and **1048**, winding of relay **812**, to battery, operating the relay and so causing an alarm.

The chain circuit through the lower outer contacts of control circuit relays **1511**, **1512**, etc., used to operate the line hold magnet, is provided with a check feature to give notice of trouble grounds affecting this chain. Check lead **1552** serves to connect this chain to the winding of release relay **1509**, in a circuit traceable from the chain in question, conductors **1552** and **1551**, upper outer break contact of relay **1515**, conductor **1542**, right outer chain circuit through relays **1609**, etc., conductor **1652**, winding of relay **1509**, to battery. Thus release relay **1509** will be held operated by trouble ground appearing on the path traced, and by blocking the control connector circuit this relay will cause the timing circuit associated with the A start train to function on the next call.

What is claimed is:

1. In combination, a line switch frame, lines appearing in said frame, a home control mechanism, a mate control mechanism, a home start circuit for said frame for taking the home control mechanism in use to serve calls on said frame, a mate start circuit for said frame for taking the mate control circuit in use to serve the calls on said frame, means for registering

the calling condition of a line on both of said start circuits, and means for determining the one of said start circuits to be effective for taking in use its corresponding control mechanism.

2. In combination, a line switch frame, lines appearing in said frame, a home control mechanism, a mate control mechanism, a home start circuit for said frame for taking the home control mechanism in use to serve calls on said frame, a mate start circuit for said frame for taking the mate control circuit in use to serve the calls on said frame, means for registering the calling condition of a line on both said start circuits, means normally effective for enabling the home start circuit to seize the home control mechanism to the exclusion of the mate start circuit, and means for rendering the mate start circuit effective to seize the mate control mechanism.

3. In a telephone system, a frame of line switches, groups of lines appearing in the switches of said frame, a home control mechanism, a mate control mechanism, a home start circuit for said frame for taking the home control mechanism in use to serve calls on said frame, a mate start circuit for said frame for taking the mate control circuit in use to serve the calls on said frame, said home start circuit normally operating to render said mate start circuit ineffective, means for registering the calling condition of all groups of lines in both of said start circuits, means for determining which of the two start circuits is effective to take in use its corresponding control mechanism, and means operated when the mate start circuit is effective to disable said home start circuit.

4. The combination in a telephone system of a home frame and a mate frame, each having lines therein, two control mechanisms, individual respectively to said frames, a start circuit for said home frame for seizing the corresponding control mechanism to serve the calls on the home frame, a second start circuit for the home frame for seizing the other control mechanism to serve as a mate control mechanism the calls on the home frame, means for registering the calls on the home frame in both of said start circuits, means for rendering the first start circuit normally effective to the exclusion of the second start circuit, and means for disabling the first start circuit and for rendering the second start circuit effective.

5. The combination in a telephone system of a home frame and a mate frame, each having lines therein, two control mechanisms, individual respectively to said frames, a start circuit for said home frame for seizing the corresponding control mechanism to serve the calls on the home frame, a second start circuit for the home frame for seizing the other control mechanism to serve as a mate control mechanism the calls on the home frame, means for registering the calls on the home frame in both of said start circuits, means for rendering the first start circuit normally effective to the exclusion of the second start circuit, means responsive to a trouble condition for disabling the first start circuit and for rendering the second start circuit effective to seize the mate control mechanism for serving the subsequent calls on said home frame, and means responsive to the occurrence of a subsequent trouble condition for disabling said second start circuit and for rendering said first start circuit again effective to seize the home control mechanism to serve the calls on the said home frame.

6. The combination in a telephone system of a home frame and a mate frame, each having lines therein, two control mechanisms, individual respectively to said frames, a start circuit for said home frame for seizing the corresponding control mechanism to serve the calls on the home frame, a second start circuit for the home frame for seizing the other control mechanism to serve as a mate control mechanism the calls on the home frame, means for registering the calls on the home frame in both of said start circuits, a start circuit for said mate frame for seizing said mate control mechanism to serve the calls on said mate frame, means normally giving preference to said first start circuit over said second start circuit, means for disabling said first start circuit and for rendering effective said second start circuit to seize said mate control mechanism to serve said home frame, and means for causing said second start circuit of the home frame and the start circuit of the mate frame to seize said mate control mechanism alternately to serve first a call on one frame and then a call on the other frame.

7. In combination, a frame of switches, groups of lines appearing in said switches, a home control mechanism, a mate control mechanism, a home start circuit for said frame for taking the home control mechanism in use to serve a call in each of the successive groups having one or more calls therein, a mate start circuit for said frame for taking the mate control mechanism in use to serve a call in each of the successive calling groups, means for registering on both start circuits the calling condition of all line groups, means effective if trouble occurs while either start circuit is operating to serve a call to render the other start circuit and its related control mechanism effective, and means for holding in abeyance the calling group that is being served when the trouble occurs until a call in each of the remaining calling groups has been served.

8. In combination, a frame of line switches, lines appearing in said switches, a plurality of senders, switching equipment including said line switches for extending said lines through to idle senders, means for testing said switching equipment for an idle path from the line to a sender, a home control mechanism for said frame, a mate control mechanism, a home start circuit normally effective to seize the home control mechanism to serve calls on said frame, a mate start circuit for seizing said mate control mechanism to serve said frame, a timing device for measuring a relatively long interval, means effective if a call has not been served within said interval for disabling one of said start circuits and for rendering the other start circuit effective, means for measuring a relatively short time interval, and means effective if no idle path has been found upon the expiration of said short time interval for causing the start circuit then in operation to release the control mechanism to enable said start circuit to make a new trial.

9. In combination, a frame of line switches, lines appearing in said switches, a plurality of senders, switching equipment including said line switches for extending said lines to idle senders, means for testing said switching equipment for an idle path from the line to a sender, a home control mechanism for said frame, a mate control mechanism, a home start circuit normally effec-

tive to seize the home control mechanism to serve calls on said frame, a mate start circuit for seizing said mate control mechanism to serve said frame, a timing device for measuring a relatively long interval, means effective if trouble occurs and prevents a call from being served within the long time interval to release the home control mechanism, to disable the home start circuit, and to render the mate start circuit effective, means for measuring a relatively short interval of time, and means effective if no idle path has been found upon the expiration of said short time interval for causing the release of the control mechanism then serving the call and to enable the start circuit to make a new trial.

10. In combination, a frame of line switches, lines appearing therein, register senders, frames of sender link switches, switching paths including said line switches and sender link switches for extending said lines to idle senders, means for making a preliminary test to determine if an idle path exists to serve a call, a line control mechanism for said line switch frame, sender link mechanisms, one for each of said sender link frames, means for seizing said line control mechanism in response to a call, means controlled by the result of said preliminary test for causing the line control mechanism to seize one of said sender link mechanisms, means effective upon the seizure of said sender link mechanism for measuring a relatively long interval and also a relatively short interval, means in the sender link mechanism for making a further test to determine if an idle sender exists, means effective if said further test fails to find an idle sender within said short interval for releasing the seized sender link mechanism from the line control mechanism, means effective if the sender link mechanism fails to complete its functions within said long interval for releasing it from said line control mechanism, and means for enabling the released line control mechanism to seize anew one of said sender link mechanisms in a repeated trial to serve the call.

11. In combination, a frame of line switches, lines appearing in said switches, register senders, frames of sender link switches, switching paths including said line switches and said sender link switches for extending said lines to idle senders, a line control mechanism for said line switch frame, sender link control mechanisms, one for each of said sender link frames, means for seizing said line control mechanism in response to a call, means including said control mechanisms for making a preliminary test to determine if an idle path exists to serve a call, means effective depending upon the outcome of said preliminary test for causing the line control mechanism to seize one of said sender link mechanisms, means effective upon the seizure of said sender link mechanism for measuring a relatively long interval of time and also for measuring a relatively short interval of time, means in the sender link mechanism for making a final test to determine if an idle register sender exists to serve the call, means effective if said final test fails to find an idle sender within said short interval for releasing the seized sender link mechanism from the line control mechanism, means effective if the sender link mechanism fails to complete its functions within said long interval for releasing it from said line control mechanism, means for enabling the released line control mechanism to seize anew one of said sender link mechanisms in a repeated trial to serve the call, and means for holding busy temporarily a sender link mechanism which has been released from a line control mechanism at the expiration of said long time interval.

12. In combination, a frame having line switches thereon, lines appearing in said switches, a home control mechanism for controlling the operation of said switches, a mate control mechanism, a home start circuit for said frame for taking the home control mechanism in use to serve calls on said frame, a mate start circuit for said frame for taking the mate control circuit in use to serve calls on said frame, means including register relays for registering the calling condition of a line in both of said start circuits, and means for determining the one of said start circuits to be effective for taking in use its corresponding control mechanism.

13. In combination, a group of line switches, lines appearing in said switches, a home control device for controlling the operation of said switches, a mate control device for controlling the operation of said switches, a home registering and starting mechanism including a plurality of line identifying relays and a start circuit for taking the home control device in use to serve calls appearing on said lines, a mate registering and starting mechanism including line identifying relays and a start circuit for taking the mate control device in use to serve calls appearing on said lines, means responsive to calls on said lines for operating said relays to register each call in both of said registering and starting mechanisms, and means for determining the one of said mechanisms to be effective for taking in use its corresponding control device.

ALOYSIUS J. BUSCH.
EDSON L. ERWIN.