April 14, 1925. 1,533,182

C. L. GOODRUM

TELEPHONE EXCHANGE SYSTEM

Filed July 26, 1922 9 Sheets-Sheet 1

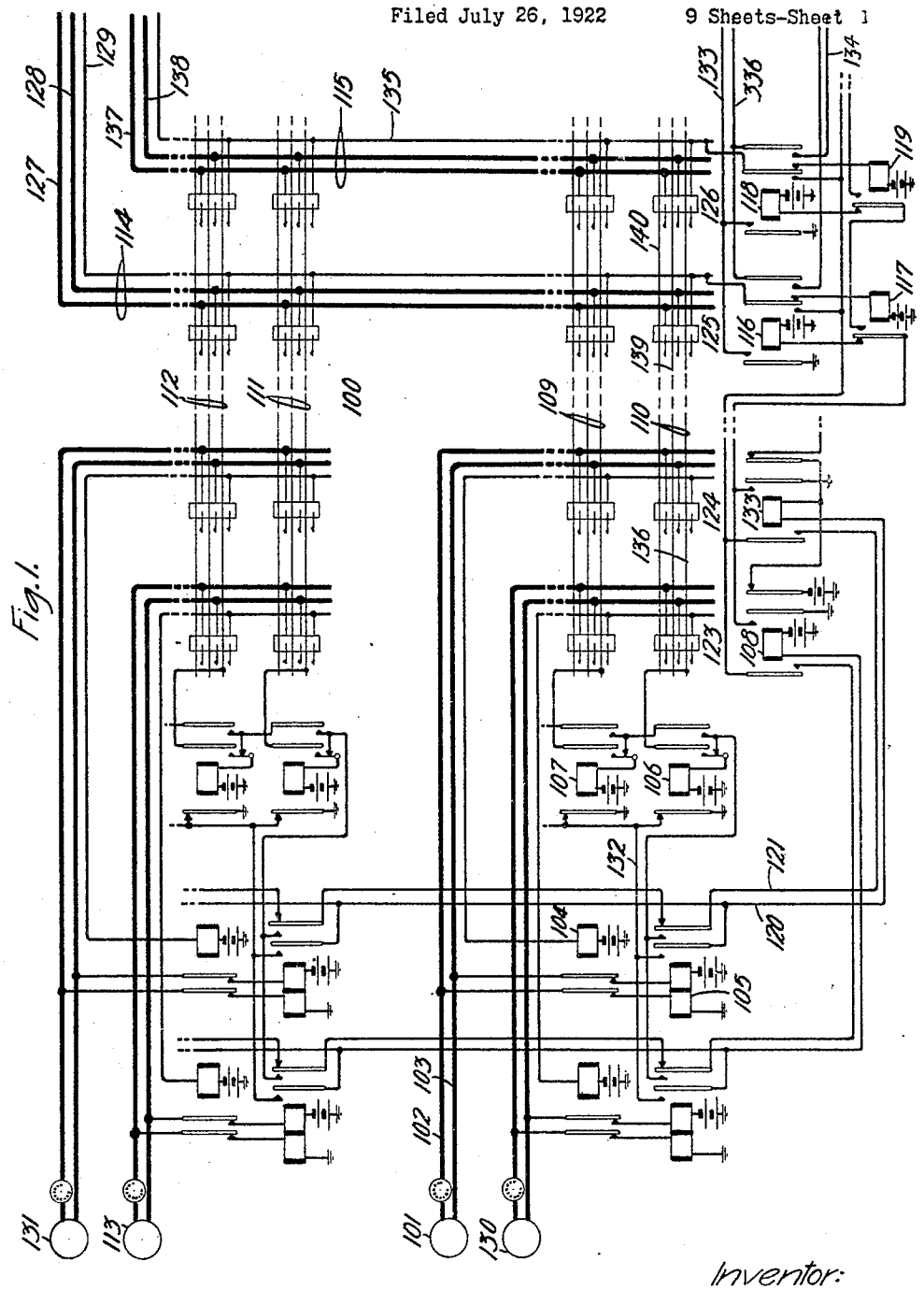


Fig. 1.

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Filed July 26, 1922 9 Sheets-Sheet 2

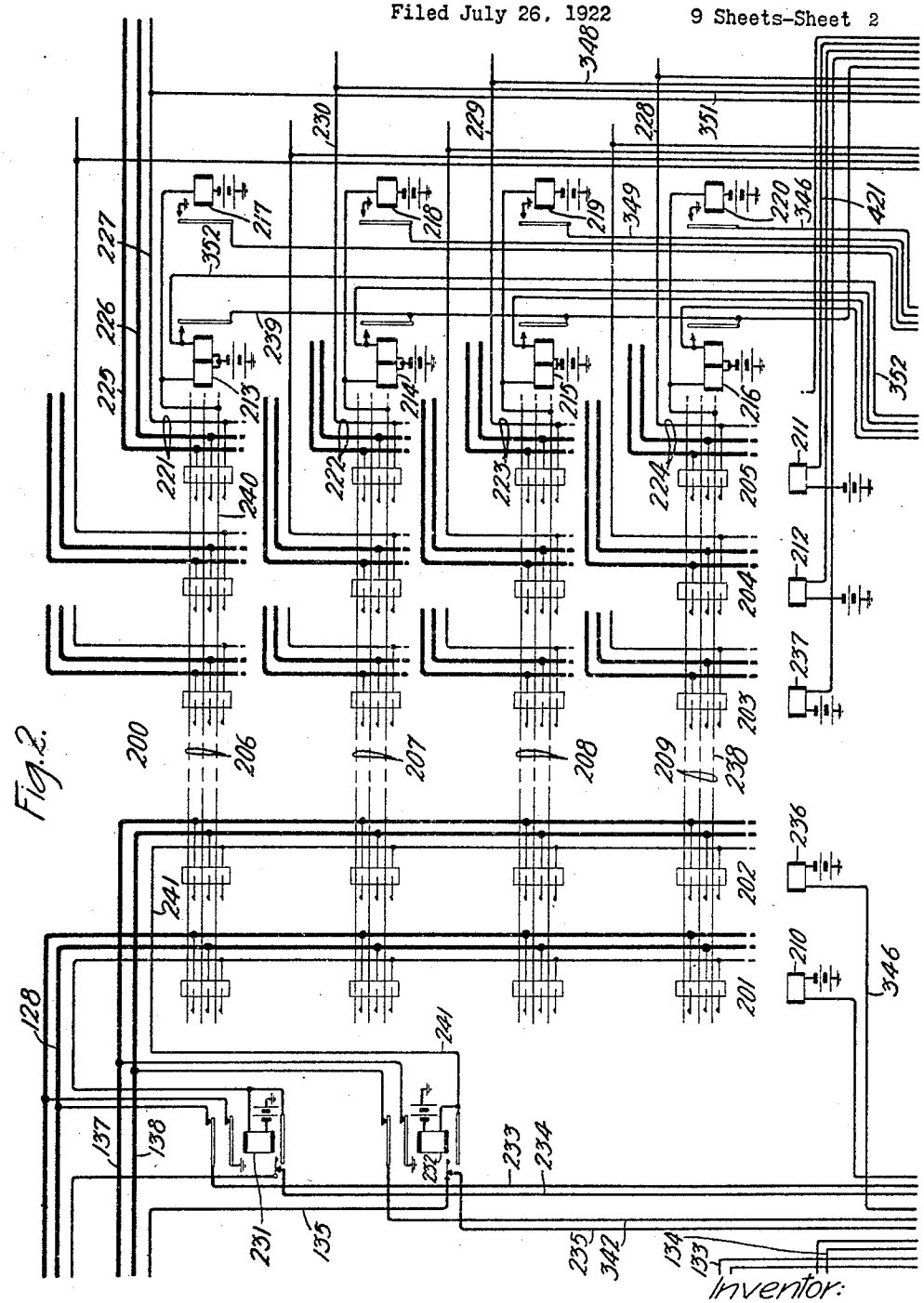


Fig. 2.

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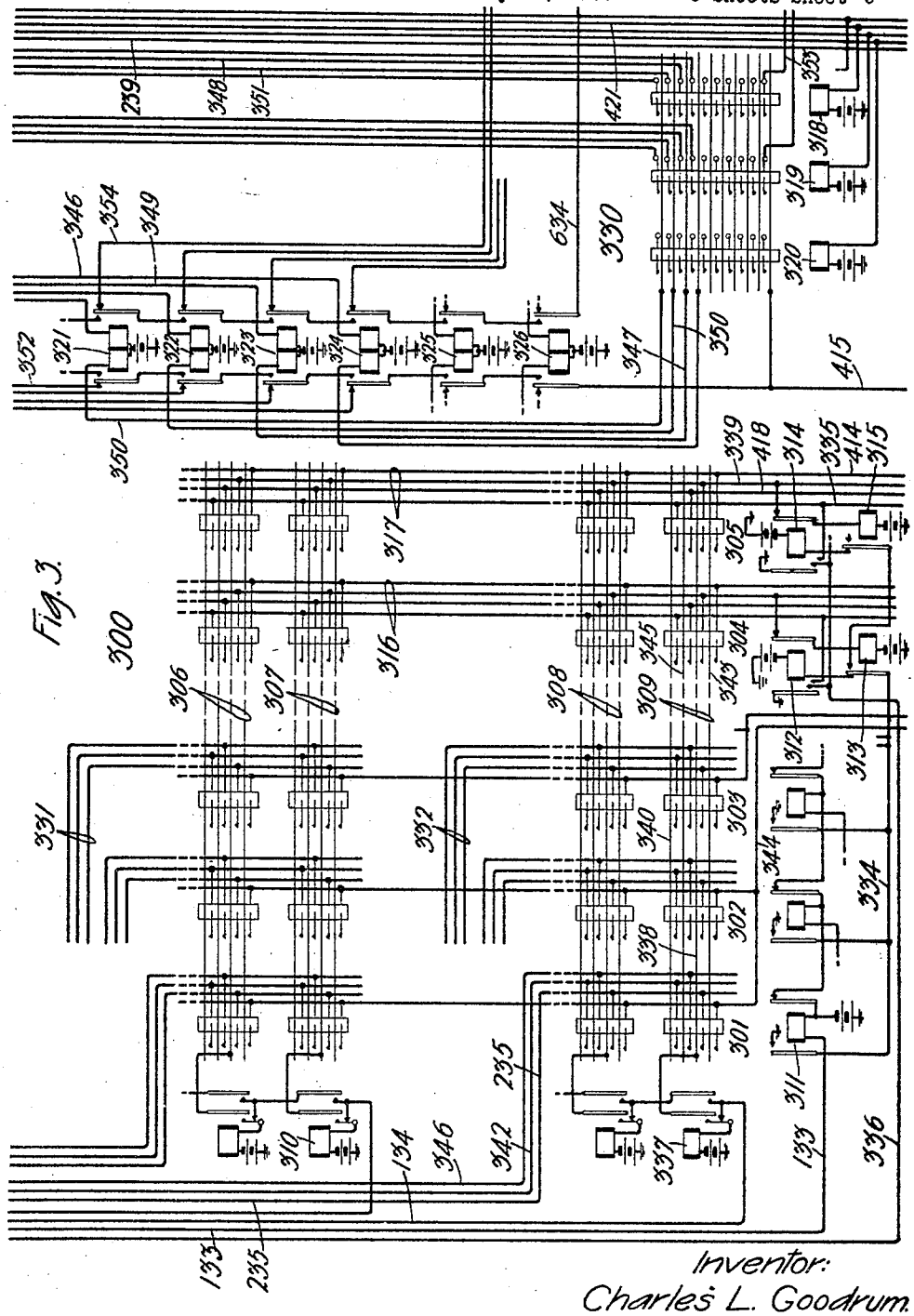


Fig. 3.

300

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TELEPHONE EXCHANGE SYSTEM

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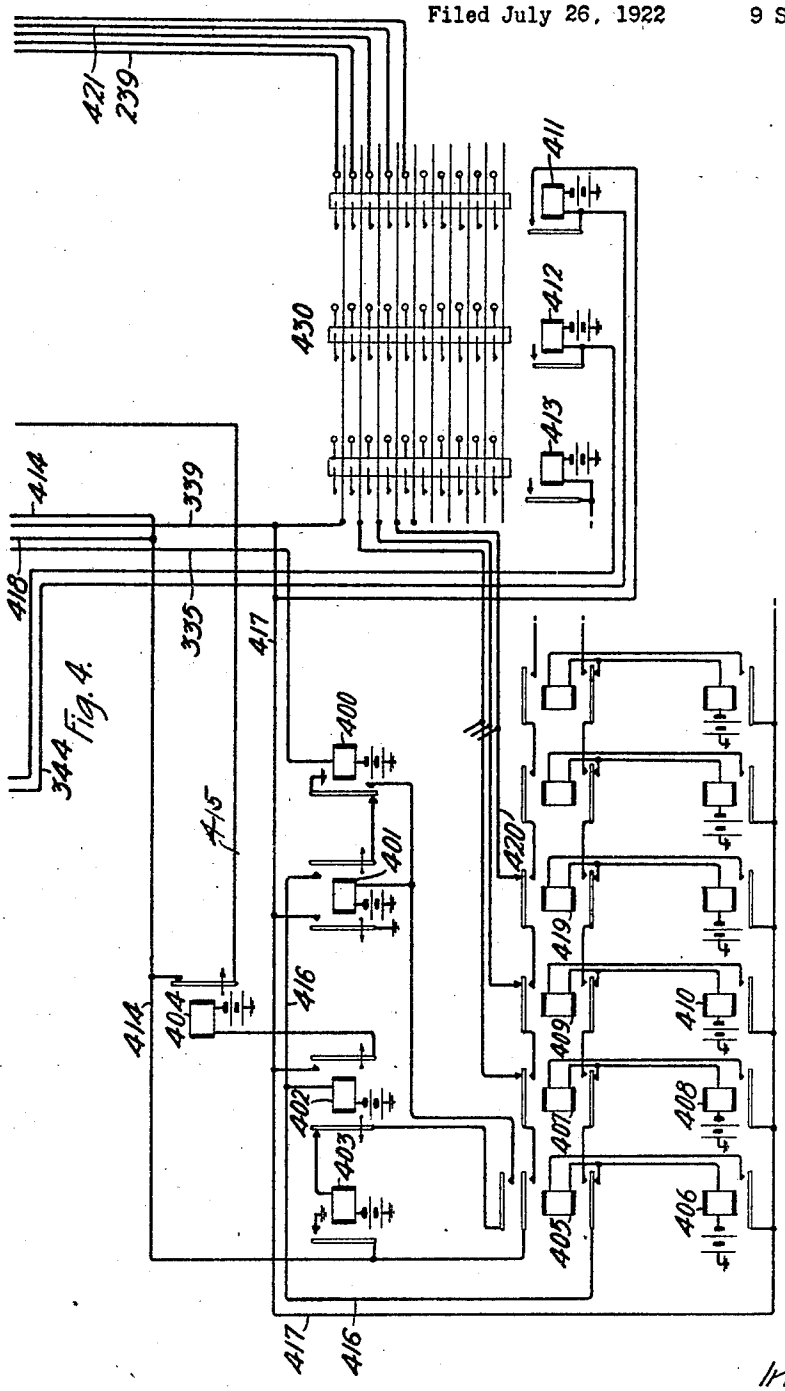


Fig. 4.

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Filed July 26, 1922 9 Sheets-Sheet 5

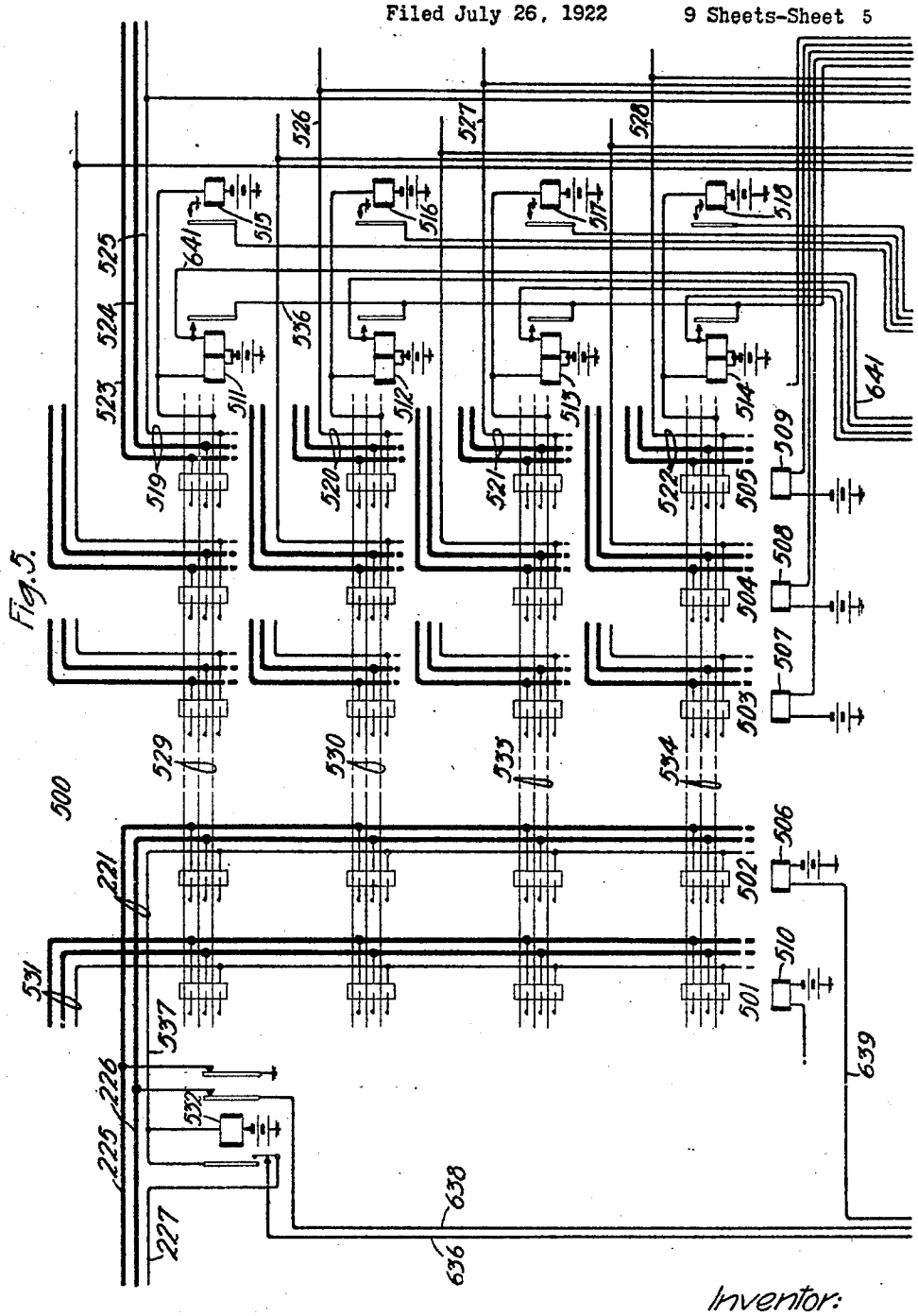


Fig. 5.

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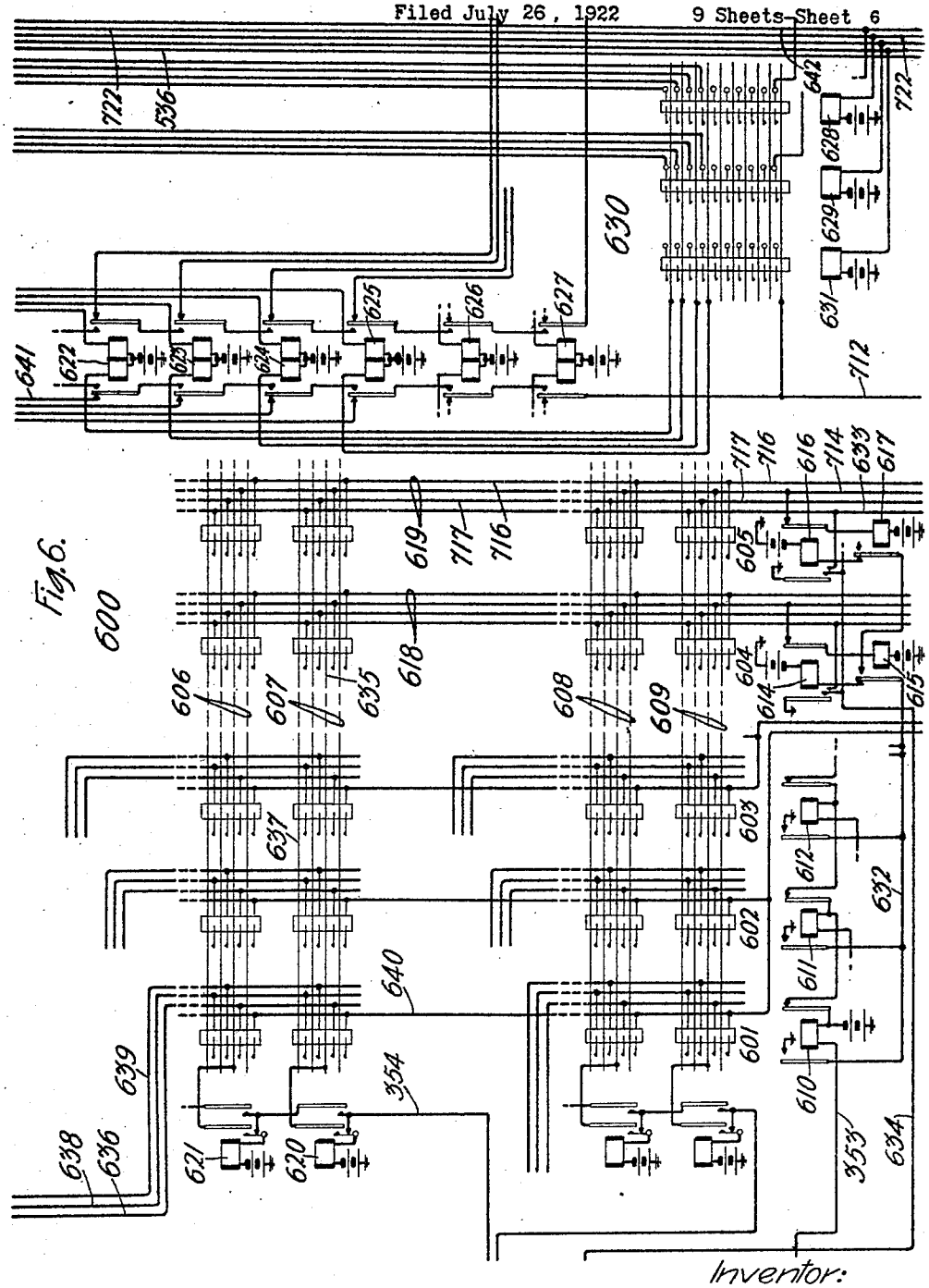


Fig. 6.

600

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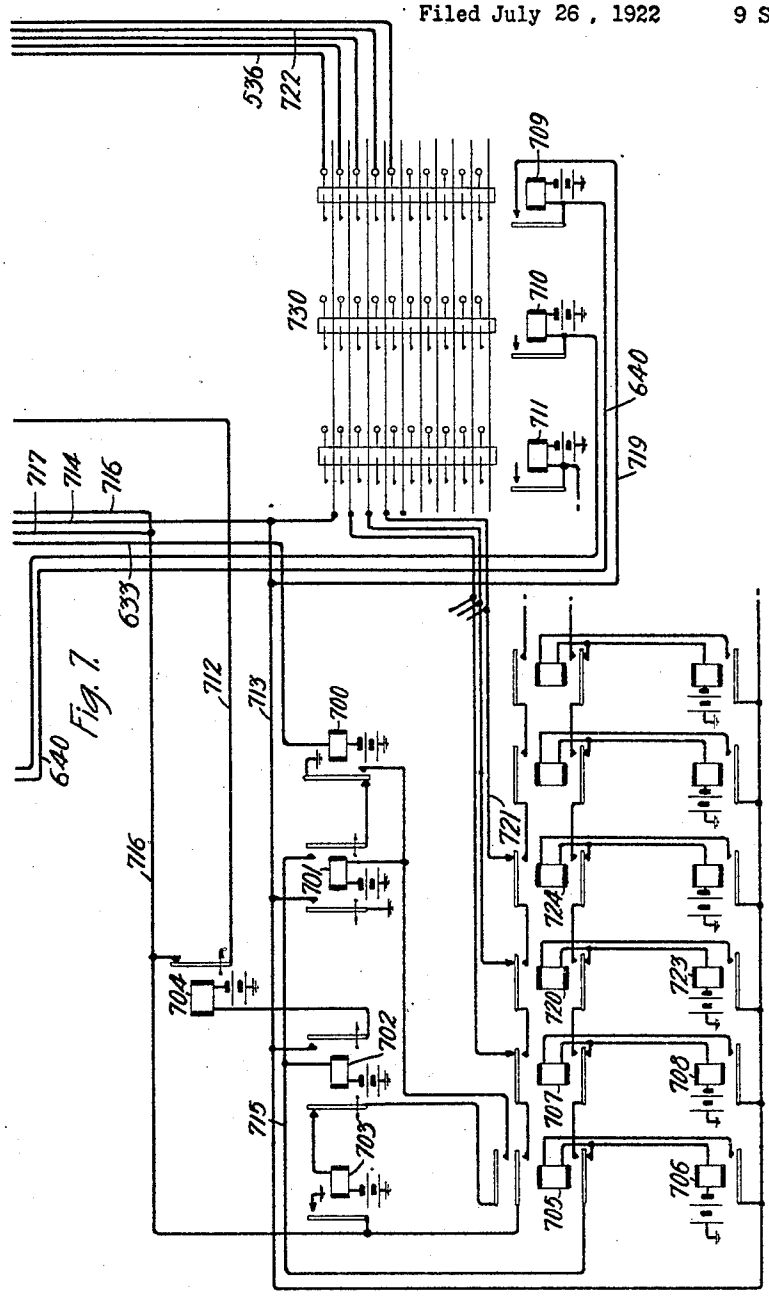


Fig. 7.

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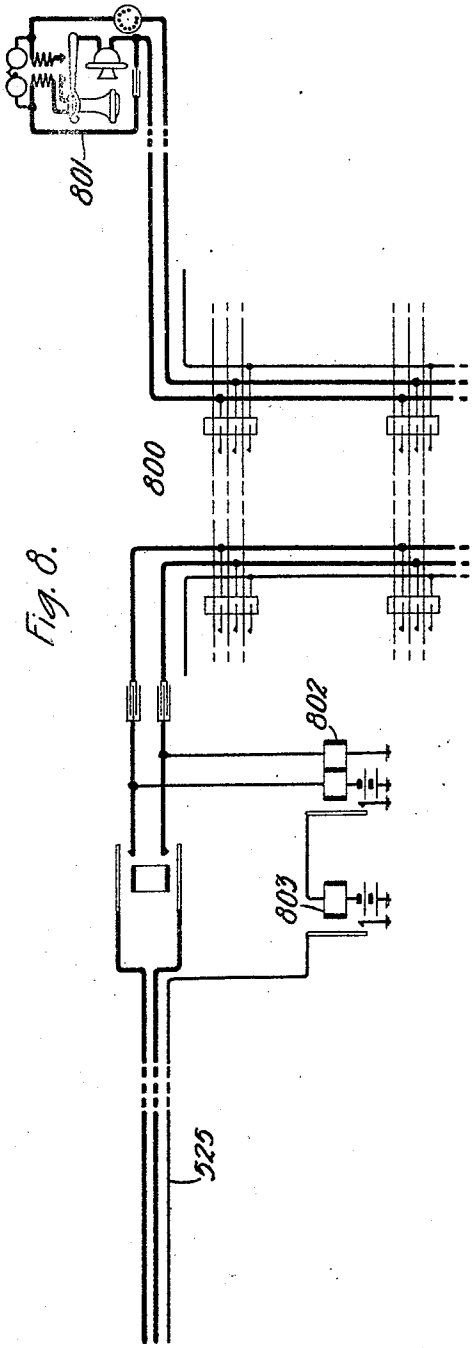


Fig. 8.

Fig. 10.

Fig. 8.			
Fig. 5.	Fig. 6.	Fig. 7.	
Fig. 2.	Fig. 3.	Fig. 4.	
Fig. 1.			

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April 14, 1925. 1,533,182

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TELEPHONE EXCHANGE SYSTEM

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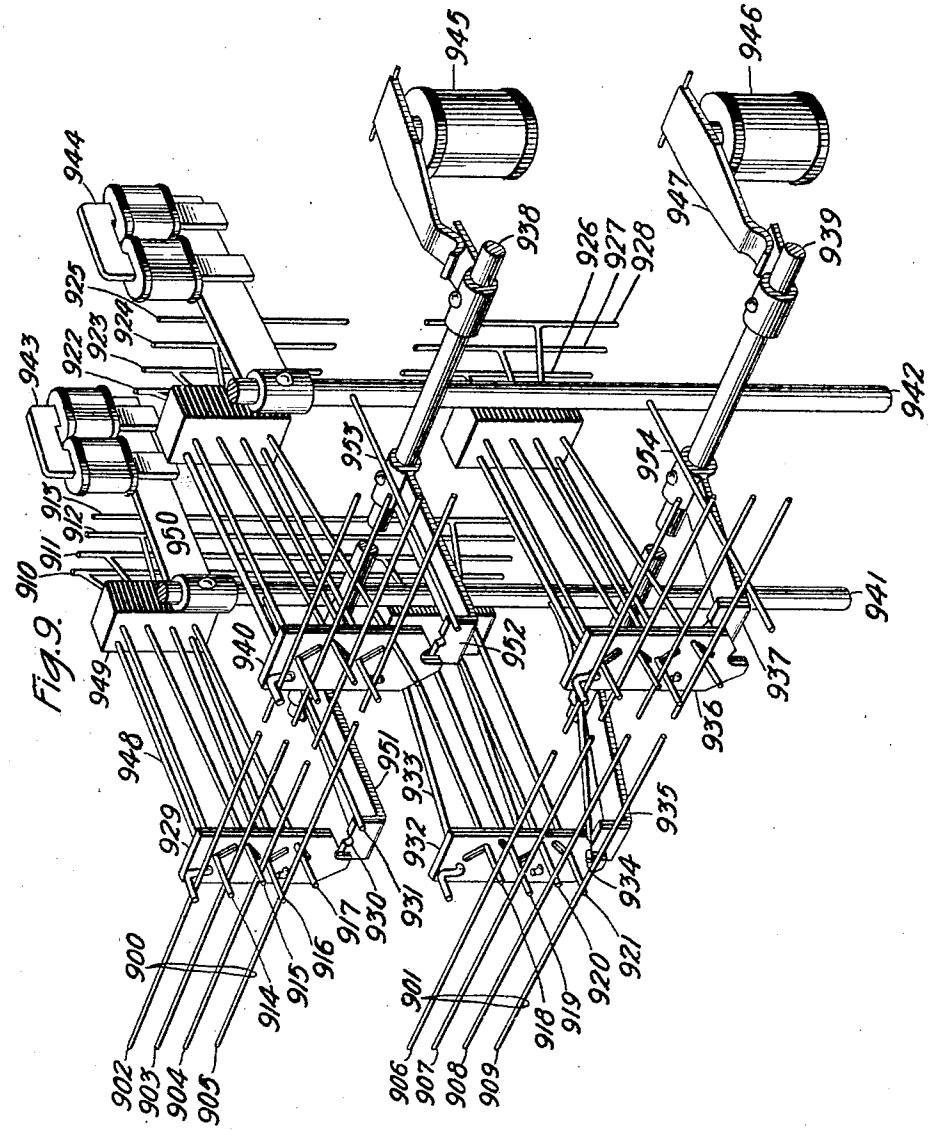


Fig. 9.

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Patented Apr. 14, 1925. 1,533,182

UNITED STATES PATENT OFFICE.

CHARLES L. GOODRUM, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TELEPHONE-EXCHANGE SYSTEM.

Application filed July 26, 1922. Serial No. 577,504.

To all whom it may concern:

Be it known that I, CHARLES LANE GOODRUM, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Telephone-Exchange Systems, of which the following is a full, clear, concise, and exact description.

This invention relates in general to telephone exchange systems. More particularly, it has to do with telephone systems of the class in which machine switching, apparatus is employed entirely or in part for the establishment of conversational connections.

The invention has for its objects to simplify the construction and operation of systems of the foregoing character to increase their flexibility and to render them more economical to produce, more dependable in their functions and of greater serviceability. These objects are attained through the use of a new and improved type of selective switching medium controlled in accordance with designations to cause the selective extension of conversational connections.

A feature of the invention relates to a switching mechanism for connecting incoming circuits to groups of outgoing circuits and having operating members, each serving a group and capable of establishing a plurality of coexisting connections between the incoming circuits and the circuits of the corresponding group, together with designation controlled means for selecting said groups.

Another feature relates to a switching device of this character having links or intermediate circuits for interconnecting the incoming circuits with the groups of outgoing circuits and having cooperating switching members controlled by designation means for selecting the outgoing groups.

A further feature relates to an improved testing arrangement for the switches of this general class whereby a selected group of outgoing circuits may be tested to choose an idle one.

These and such other features and advantages as are contemplated by the present invention will become more clearly understood from the detailed description given hereinafter and also from the appended claims. In the accompanying drawing, Figs. 1 to 8 inclusive, when arranged in the order illustrated in Fig. 10 disclose a portion of a telephone scheme system embodying the principles of this invention.

Fig. 1 shows a plurality of subscribers' lines leading to the central office and terminating in a preliminary or line switch of the particular type employed as a connecting medium in this system.

Fig. 2 shows a first group selector switch in which the trunks leading from the line switch in Fig. 1 terminate. This figure also discloses a plurality of groups of trunks outgoing from the group selector switch.

Fig. 3 illustrates a sender selector switch serving in common a plurality of trunks interconnecting the line switch and group selector switch of Figs. 1 and 2 for connecting any one of these trunks to one of a number of common sender mechanisms. Furthermore, this figure shows a set of common testing relays and a group marker device.

Fig. 4 shows one of the common sender mechanisms together with a marker device for determining the group selector switch involved in the connection.

Fig. 5 illustrates a second group selector switch substantially similar to the switch shown in Fig. 2 and which receives trunks incoming from said first group selector.

Figs. 6 and 7 correspond substantially to Figs. 3 and 4 and illustrate a sender selector switch and one of a number of common senders located at the second selecting stage.

Fig. 8 shows a trunk leading from the second group selector switch which may extend through any number of succeeding group selectors. This figure also shows in diagrammatic form, a final or connector switch together with a called subscriber's line.

Fig. 9 is a perspective view showing the structure and mechanical principles of the switching device employed for establishing connections in this system.

General description of the system and apparatus.

The switching mechanisms shown in Figs. 1, 2, 3, 5, 6 and 8 are of the coordinate type in which incoming circuits appearing in rows of contacts are connectable through link circuits to outgoing circuits also appearing in rows of contacts. The mechanical details of these switches, which are illus-

trated in and will be later described in connection with Fig. 9, are substantially the same as those of the switching device disclosed and described in the British patent to Western Electric Company, Limited, No. 183,438, accepted September 6, 1923.

Considering the circuit arrangement of a switching mechanism when applied to a preliminary or line switching stage as illustrated in Fig. 1, the subscribers' lines 130, 101, 113, 131, etc. appear in rows of contacts, which for convenience may be described as vertical rows. Two such vertical rows 123 and 124 are illustrated and there may be, of course, any number of additional rows. The vertical row 123 comprises a number of subscribers' lines, of which two lines 130 and 113 are shown. The vertical row 124 similarly comprises a number of lines of which the lines 101 and 131 are illustrated. As shown, each line in a vertical row has access to a number of link circuits differing from the link circuits to which each of the other lines of the same row has access. For example, line 130 has access to a group of link circuits 109, 110, etc., there being any desired number of these links. Line 113 in the same vertical row has access to a different group of links 111, 112, etc. In like fashion, corresponding lines of the remaining vertical rows have access individually to the same groups of link circuits.

On the outgoing end of the line switch, which has been generally designated by the character 100, a number of trunk circuits, of which the two trunks 114 and 115 are shown, each has access to all link circuits in all groups. That is to say, the trunk 114 occupies the whole vertical row 125 and is accessible to every link, 109, 110, 111 and 112 in the switching device. The circuit arrangement and operation of the line switch 110 above briefly outlined is substantially the same as that disclosed in the above mentioned British Patent No. 183,438, accepted September 6, 1923.

While the same mechanical construction is retained for the switching mechanism when employed as a selector as shown in Fig. 2, the relative arrangement of the trunks and intermediate link circuits, the control of the various elements due to the necessity of selecting the groups and testing in a group and certain other features of operation, differ from those found in the use of the mechanism as a line switch. In Fig. 2, the first group selector switch 200, like the line switch 100, comprises a plurality of links or intermediate lines 206, 207, 208 and 209, the number of these being taken to suit requirements. The incoming trunks 114, 115, etc. which lead from the line switch 100 each occupies a complete vertical row 201 and 202 of the group selector switch 200. That is to say, the trunk 115 has a set of contacts cooperating with a corresponding set of contacts on each of every intermediate link in the switch 200 and the same is true for all other trunks incoming to the switch. If desirable, the intermediate links could be grouped as illustrated in Fig. 1. However, these links in the group selector switch 200 are not grouped in the present arrangement, but each relates and has access to a single outgoing trunk in each of several groups as will presently be explained.

The outgoing trunk lines are divided into groups, and each group preferably occupies either a portion or all of the same vertical row of contacts. In the disclosure a portion of three outgoing numerical trunk groups are shown appearing, respectively, in the vertical rows 203, 204 and 205. The vertical row 205 contains the group of trunk lines 221, 222, 223, 224, etc. The trunk 221 is accessible to the intermediate link 206 and only to this one, the trunk 222 is accessible to the link 207, the trunk line 223 is accessible to the link 208, etc. Likewise, each of the intermediate links 206, 207, 208 and 209 has access to a single trunk in each of the remaining numerical groups represented by rows 203, 204 and so on.

The outgoing groups of trunks from the first group selector 200 extend and are distributed as incoming trunk lines among a number of second group selectors 500. The particular second group selector switch 500 shown may receive the trunks incoming a numerical group at the switch 200. Other numerical groups of trunks leading from the switch 200 will similarly appear as incoming trunks in other group selector switches 500. The second group selector switch 500 is identical in arrangement and principle to the first group selectors 200. The trunk 221 shown in full which belongs to the numerical group occupying the numerical row 205 at the switch 200 enters and occupies the vertical row 502 of the selector 500. The second trunk shown in the switch 500 may be another trunk belonging to the same numerical group as the trunk 221 or it may lead from a different selector 200.

The switch 500 also has a number of outgoing vertical groups of trunk lines 503, 504 and 505 which represent the second switching stage in the system and which extend to succeeding group selector switches. Although only two switching stages have been shown in detail, it will be understood that any number of succeeding group selecting stages may be provided.

After the last group selecting stage, the final or connecting stage may be provided for completing the connections to the called subscribers' lines. For this purpose a switch of the same general character may be em-

ployed, one of which, switch 800, is schematically shown in Fig. 8, or switches of other types may be used if desired. In accordance with the usual well-known practice, the final connecting stage provides for two directive operations, one to select the group of lines and the other to select the desired line in that group. It is not considered necessary to show in full, further group selecting switches or to illustrate the details of the switch when applied as a final connecting device. The principles of this invention are adequately disclosed in the remainder of the system.

Turning to the preliminary or line switching stage, it may be observed that there are a plurality of line switches similar to the switch 100 each of which has a number of outgoing trunks which may be distributed in any number of first group selector switches 200. Also, the trunks incoming to any selector 200 may lead from one or more line switches 100. A number of these trunks 114 and 115 interconnecting the line switches and first group selector switches are arranged to appear in the sender selector switch 300, the function of which is to connect these trunks to one of a number of common sender controlling mechanisms such as shown in Fig. 4. The sender selecting switch 300 is substantially identical in its arrangement of incoming circuits, links and outgoing circuits to the line switch 100. The total number of trunks which enter the particular switch 200 from the line switches are assigned to the first two vertical rows 301 and 302 in the sender selector switch 300. The trunks 114 and 115, which leave the line switch 100 and enter the group selector 200, appear as illustrated in the vertical row 301 of the sender selector switch. The trunks which appear in the vertical row 303, such as trunks 331 and 332, extend either from the line switch 100 or from another similar line switch and appear as incoming trunks in another first group selector switch 200. In other words, if there are five first group selector switches 200 required to handle the traffic, then the trunks appearing in the sender selector switch 300 will likewise be divided into five corresponding groups, each group occupying, as explained, one or more vertical rows of contacts. The purpose of this arrangement is to enable an identification of the particular switch 200 on which the calling trunk appears as will be understood more clearly hereinafter.

By means of the intermediate link circuits 306, 307, 308, 309, etc., the incoming trunks at the sender selector switch have access to outgoing circuits 316 and 317 leading to common controlling sender mechanisms. The circuit 317 relates to the sender mechanism shown in Fig. 4. The purpose of these sender mechanisms is to receive the registration of a series of impulses representing the group of trunks wanted and to control the selection of such a group at the selector switch 200. In order to prevent interference in the selection of controlling senders, an extended starter wire arrangement is provided whereby the circuit representing the first idle sender will be exclusively selected through an intermediate link.

The device 430 shown in Fig. 4 is a marker for identifying the first group selector switches 200. This marker comprises a plurality of multicontact relays 411, 412, 413, one for each of the several switches 200 at the first switching stage. The relay 411, for example, is individual to the particular switch 200 shown. Whenever a connection is directed to this selector switch over any one of the trunks incoming thereto and the common sender is connected to said trunk by the sender selector 300, the marker relay 411 is operated to associate said sender with the selector 200. Should the call be extended over a trunk appearing in some other selector then another of the multicontact relays 412, 413 operates to associate the common sender with such other selector switch.

The device 330 shown in Fig. 3 is also a marker consisting of a plurality of multicontact relays 318, 319, 320. Each of these relays is individual to a particular group of outgoing trunks at the selector switch 200 and when operated serves to associate the common group of relays also shown in Fig. 3 with said group of trunks. The multicontact relay 318 is individual to the group of trunks occupying the vertical row 205 and through its contacts connects the left-hand windings of the test relays 321, 322, 323, etc., respectively, to the test wires of the trunks of said group. Similarly, the multicontact relay 319 is individual to the group of trunks occupying the vertical row 204 and in like manner connects the left-hand windings of the test relays to the test conductors of the respective trunks in said group. For each of the several group selector switches 200 there is likewise provided a marker device similar to the marker 330.

The set of testing relays 321, 322, 323, 324 comprises a number of relays equal to the number of trunks in a group at the selector switch 200 and, likewise, equal to the number of horizontal or intermediate lines 206, 207, 208, 209. This set of test relays is common to all groups of outgoing trunks and, as explained, through the medium of the marker 330 may be definitely associated with any particular group of trunks desired for testing. The left-hand windings of the several test relays are for the purpose of testing the condition of the respective outgoing trunks in the group. The righthand windings of the relays are for the purpose of testing the condition of the intermediate

lines at the switch 200. For instance, when the testing relay set is associated with the group of trunks 205, the left-hand winding of relay 321 is connected through the contact of relay 318 to the test wire 227 of the trunk 221. The left-hand winding of the next relay 322 is similarly connected to the test wire of the next trunk 222 and so on for each of the remaining relays. The right-hand winding of relay 321 is connected to the contact of relay 217, the winding of which relay is, in turn, directly connected to the test wire of the intermediate line 206. In like manner each of the remaining relays 322, 323 of the test set have their right-hand windings correspondingly connected to the armatures of relays 218, 219, etc. individual to the successive intermediate links 207, 208, etc. By this arrangement a test is made both of the outgoing trunk and also of the intermediate link which has access to said outgoing trunk in order to determine whether either or neither is busy or both.

As will be brought out more clearly hereinafter, any one of the intermediate links 206, 207 may be taken for use in extending a connection to trunks in each of several outgoing groups. Hence, it may occur that while selection is being made in the group 205, the outgoing trunk 221 is idle, while at the same time the intermediate link 206 is busy in connection with a call previously extended to an outgoing trunk in some other group. Thus, it is impossible to obtain connection with the trunk 221, notwithstanding the fact that it is idle per se. For this reason, it is necessary to employ the double test feature above outlined whereby no outgoing trunk will be taken for use regardless of its idle condition provided the corresponding intermediate link, which must extend the connection thereto, is at the time engaged.

At the next group selecting stage represented by the single selector switch 500 there are provided a number of common senders, one of which is shown in Fig. 7, a sender selector switch 600 for associating these senders with trunks 221, 531, etc. incoming to the switches 500 from first group selectors 200 and the marker devices 730 and 630 all of which are substantially the same as above explained in connection with the first group switching stage.

Before proceeding with a detailed description of the operation, a brief explanation will be given of the mechanical construction of the switching device employed as a connecting medium in this system. For this purpose, reference is made to Fig. 9 which gives a perspective view of a portion of the switching mechanism clearly illustrating the manner in which it operates.

Considering the terminal portion of the switch, there are provided a plurality of intermediate or horizontal link circuits 900, 901, consisting each of a number of plain bare wire conductors. The horizontal link 900 includes as shown four conductors 902, 903, 904 and 905 and the horizontal link 901 likewise has four conductors 906, 907, 908 and 909. As many of these horizontal links may be provided as necessary and each may have more or less than the number of conductors actually shown. These horizontal bare wire link circuits constitute the passive or stationary part of the terminal arrangement. Regarding the switch in the capacity of a selector as shown in Figs. 2 and 5, the incoming trunks or circuits each constitute a vertical row of movable terminals occupying the full row and having access to all of the horizontal link circuits. Fig. 9 shows one of these incoming trunks which is made up of the four conductors 910, 911, 912 and 913. This trunk has a set of movable bare wire terminal conductors 914, 915, 916 and 917, connected to the respective conductors, and which extend through oblique apertures in a movable insulating card 929 to points where they cooperate with the respective conductors 902, 903, 904 and 905 of the horizontal link 900. The card 929 is supported on a spring 948 secured in the insulating block 949 which also secures the movable terminals 914, 915, 916 and 917. Normally the spring wire 948 holds the card 929 in such a position that the movable terminals are out of engagement with the corresponding stationary wire terminals of the link circuit 900.

The wires 910, 911, 912 and 913 of the incoming trunk also are provided with a second set of similar movable wire terminals 918, 919, 920 and 921 which extend through the insulating card 932 to a point where they cooperate with the stationary wires 906, 907, 908 and 909 of the next horizontal link 901. In like fashion, the incoming trunk conductors have a set of these movable terminals in the vertical row for every horizontal link circuit. Obviously, there will be one of these vertical rows of contacts for each trunk incoming to the switch.

In addition to the several vertical rows of incoming circuits each representing a single incoming trunk, there are provided a plurality of vertical rows of outgoing trunks as explained in connection with Figs. 2 and 5. In the structure drawing of Fig. 9, one such vertical row of outgoing trunks is illustrated, two separate trunks in this row being shown. On of these trunks comprises conductors 922, 923, 924 and 925 and has a set of movable wire terminals as shown extending into operative relation to the corresponding wire terminals of the horizontal link 900. The second trunk, the conductors 926, 927 and 928 of which are shown, has a

corresponding set of movable wire terminals which extend into operative relation with the respective wires of the second horizontal link 901. In like fashion, each of the remaining trunks in the group or vertical row will have a set of movable terminals extending into cooperative relation with the remaining corresponding horizontal links.

For operating and maintaining the terminals to establish connection between incoming trunks, links and outgoing trunks, there are provided a plurality of operating members or bars, a bar being arranged to serve each of the several vertical and horizontal rows of contacts. The vertical bar 941 is individual to the vertical row represented by the incoming trunk 910, 911, 912 and 913 and controls all of the movable contacts pertaining to this trunk. The next vertical bar shown, bar 942, is individual to the row of contacts belonging to the group of outgoing trunks 922, 923, 924, 925 and 926, 927, 928. The function of these vertical bars is to prepare the contacts for operation and after the contacts have been operated said bars may restore ready to be taken again for use in preparing another set of contacts.

The horizontal operating members or bars, two of which 938 and 939 are shown, are each individual to a corresponding one of the horizontal links 900 and 901. The function of these bars is to operate the set of prepared contacts and to maintain these contacts in operative condition after the preparing or vertical bars have restored to their normal condition.

The switching device has been briefly outlined in its capacity as a group selector. When desired to employ this switch as a line or trunk connecting switch, as shown in Fig. 1, it is obvious that the incoming subscribers' lines appear in the vertical rows containing the lines 922, 923, 924, 925 and 926, 927, 928, while the outgoing trunks appear as trunks 910, 911, 912, 913, each occupying a full vertical row. Dependent upon the number of horizontal links required for serving each incoming subscriber's line, said line may be provided with a variable number of movable wire terminals cooperating with the respective horizontal links.

A short description of the operation of the switch shown in Fig. 9 is given below.

Assume that it is desired to connect the incoming trunk or circuit 910, 911, 912, 913 to the outgoing trunk 922, 923, 924, 925. First a circuit is closed for magnet 943, which, through its armature 950, rotates the vertical bar 941. The flexible wires 931, 934, etc. attached to the bar 941 are carried by the rotation of said bar against the shoulders on the corresponding insulating cards 929, 932. Since the horizontal bar 938 is in its normal position at this time, the flexible wire 931 passes over the top of the lever 951 and is stopped by the shoulder on card 929 immediately above the notch 930 in the said lever 951. Similarly, the flexible wires 934, etc. pertaining to the remaining horizontal links are positioned with respect to their cooperating levers similar to lever 935.

At the same time a circuit is closed for the magnet 944 controlling the bar 942, individual to the vertical row of trunk contacts containing the contacts of the particular trunk 922, 923, 924, 925 to which connection is desired. The magnet 944 rotates the bar 942 and the flexible wires 953, 954, each individual to a set of trunk contacts, are moved against the insulating cards 940, 936, and into cooperative relation with the levers 952, 937, on the horizontal bars.

Thus, when the contacts of the incoming trunk and the contacts of the outgoing trunk are prepared, it is only necessary to operate the horizontal bar 938 pertaining to the outgoing trunk to bring about the connection. This is done by energizing the magnet 945 which rotates the horizontal bar 938. The bar 938 carries the levers 951, 952, etc. upwardly. Since the flexible wires 931 and 953 have been positioned they are encountered by the levers 951, 952, and flexed upwardly against the movable insulating cards 929 and 940 respectively. The continued rotation of the bar 938 carries cards 929 and 940 to their extreme upward positions whereby the movable wire terminals of the incoming trunk and the outgoing trunk engage the corresponding passive wire terminals of the horizontal link circuit 900 and the connection is effected. The condition of the switch when operated is seen by referring to the terminal set 918, 919, 920, 921 in the lower left corner of Fig. 9.

Following this, magnets 943 and 944 may be released permitting the bars 941 and 942 to return to normal position. Since the wires 931 and 953 are held by the notches in the levers 951 and 953, they flex on the return movement of the bars but do not disengage the lower surface of the cards 929 and 940, respectively. In this way, the continued energization of the magnet 945 after the magnets 943 and 944 have been deenergized, maintains the established connection, while the remaining flexible wires 934, 954 return to normal. Should another connection be desired over another trunk 926, 927, 928 in the same group controlled by the bar 942, it could be obtained by a reoperation of said bar and the use of another idle horizontal link circuit 901 without interference with the first established connection. The details of this feature will be brought out more clearly in connection with the circuit description.

When the established connection is no

longer required, release may be accomplished by deenergizing the horizontal magnet 945. The bar 938 on restoring to its normal position rotates the levers 951 and 952 downwardly permitting the insulating cards 929 and 940 to restore, carrying the movable wire contacts out of engagement with the link conductors. Moreover, the downward movement of the levers 951 and 952 permits the spring conductors 931 and 953 to unflex and move away from the cards 929 and 940, such so that on a subsequent rotation of the bar 938 they will not be encountered unless previously positioned by the vertical bars 941, 942.

Detailed description of the operation.

Consider now, that the subscriber of line 101 desires to obtain a conversational connection with the subscriber of line 801. The calling subscriber, on initiating the call closes a circuit from battery through the right-hand winding of line relay 105, inner contact of cut-off relay 104, conductor 103, over the loop of the line, conductor 102, outer contact of relay 104, left-hand winding of relay 105 to ground. Relay 105 operates and a circuit is closed from ground through the contact of one or more of the horizontal link magnets 106, 107, conductor 132, inner contact of relay 105, conductor 120, winding of the vertical row magnet 133, outer right contact of magnet 108 to battery. The magnets 108 and 133 are individual to the vertical rows 123 and 124, respectively, and serve to rotate the vertical bars, such as bars 941 and 942 of the structure shown in Fig. 9. Provided the magnet 108 is deenergized, indicating that no simultaneous call is being handled in the first vertical group, the circuit above traced is closed and magnet 133 operates to position its bar. The magnet 133 on operating closes a circuit from ground through its inner right contact, front contact of relay 117, assuming the first trunk 114 to be busy, back contact of relay 119, assuming the trunk 115 to be idle, winding of the vertical trunk magnet 118 to battery. Magnet 118 operates and in a similar manner prepares the vertical bar individual to the row 126.

Thus, in response to the initiation of a call, the vertical bar pertaining to the group in which the calling line appears is rotated to prepare the contacts of this line for connection to some idle one of the horizontal links 109, 110 and also the vertical bar pertaining to the row 126 containing the contacts of the idle trunk 115 has been rotated to prepare these contacts for connection with the same idle horizontal link. The contacts for effecting the connection are, however, not operated at this instant. Instead, the establishment of a connection through to the trunk 115 awaits the connection of that trunk through the sender selector switch 300 to an idle sender mechanism as shown in Fig. 4.

At the time the vertical magnet 118 operates a circuit is closed from ground through the left contact of said magnet, conductor 133, winding of the vertical row magnet 311, to battery. The selection of the magnet 311 indicates that the selected idle trunk 115 appears in the vertical row 301 of the sender selector 300. Magnet 311 energizes, rotates its associated bar and also closes a circuit from ground through its left contact, conductor 334, front contact of relay 313 (assuming the sender mechanism represented by the circuit 316 is busy), back contact of relay 315, winding of the vertical row magnet 314, to battery. Magnet 314 energizes and prepares its associated operating bar. Magnet 314 also closes a circuit from ground through its left contacts, conductor 335, winding of the impulse relay 400 to battery. By this means, the relay 400 is operated well in advance of the extension of the calling line through to the selected sender mechanism. Relay 400 completes a circuit from ground through its front contact, winding of slow-to-release relay 401 to battery and this latter relay operates.

The magnet 314 furthermore closes a circuit from ground through its left contact, conductor 336, outer right-hand contact of magnet 118, conductor 134, normal contact and winding of the horizontal link magnet 337, to battery. It is assumed that the horizontal link 309 is idle at this time. The magnet 337 operates, rotates the associated horizontal bar to effect a connection between the conductors of the trunk 115 and the conductors of the circuit 317 leading to the sender mechanism through the medium of the link circuit 309. Immediately that the contacts involved in this connection are closed, a circuit is established from battery through the winding and inner front contact of magnet 337, horizontal conductor 338, through the associated contacts to the conductor 339, left contact of relay 401 to ground. The magnet 337 is held in this circuit dependent upon the relay 401 in the sender mechanism.

Immediately that connection is extended through the sender selector switch 300, a circuit for operating the horizontal link magnet at the line switch 100 is established. Assuming the horizontal link 110 to be idle, this circuit may be traced from battery through the winding and normal contact of magnet 106, outer front contact of relay 105, conductor 121, left contact of magnet 133, inner right front contact of magnet 118, conductor 135, lower normal contact of relay 232, conductor 235, horizontal conductor 338, conductor 339 and thence to ground as traced at the contact of relay 401.

The horizontal magnet 106 of the line switch operates in this circuit, rotates the associated operating bar and extends the calling line through to the trunk 115. Immediately that the connection is extended through the line switch, a holding circuit for the magnet 106 is prepared as follows: Battery through the winding and inner right front contact of magnet 106, conductor 136, thence to the conductor 135 and from there to ground over the path previously traced. The magnet 106 in addition to the magnet 337 is held under the control of the relay 401 in the sender.

The horizontal magnet 106 extends the start circuit through to the normal contact of the next horizontal magnet 107 so that subsequent calls may be served by the next link circuit. The cut-off relay 104 is also operated at this time in a circuit from battery through the winding of said relay, through the operated contacts of the switch to the grounded horizontal conductor 136. Relay 104 opens the circuit of relay 105 which becomes deenergized and in so doing opens the circuit of the vertical magnet 133. Magnet 133 releases and permits the associated operating bar to return to its normal position. Magnet 133 opens the circuit of magnet 118 which likewise restores and permits its associated bar to return to normal. When the magnet 118 deenergizes, it opens the above traced circuit for the vertical magnet 311 of the sender selector switch. The magnet 311 on releasing opens the circuit of the vertical magnet 314. Magnets 311 and 314 permit their associated bars to restore. The connection of the subscriber's line through to the selected sender is now held by means of the maintained energization of horizontal magnets 106 and 337. When magnet 118 deenergizes a circuit is closed from battery through the winding of relay 119, inner right back contact of magnet 118 to the grounded conductor 135. Relay 119 operates and extends the start wire on to the next idle vertical magnet. Similarly, magnet 314 of the sender selector 300 on releasing closes a circuit from battery through the winding of relay 315, to the grounded conductor 339. Relay 315 extends the start wire on to the next idle vertical magnet.

Before the vertical magnet 314 releases to open the initial energizing circuit of the pulse relay 400, the circuit for this relay in series with the calling subscriber's line is closed as follows: Battery, through the winding of relay 400, conductor 335, contacts of the sender selector switch, horizontal conductor 340, contacts of the sender selector switch, conductor 342, uppermost contact of relay 232, conductor 138, contacts of the line switch 100, horizontal conductor 139, contacts of line switch 100, line conductor 103, line conductor 102, contacts of the line switch 100, horizontal conductor 140, contacts of said line switch, trunk conductor 137, inner upper contact of relay 232 to ground.

The apparatus is now in condition to receive impulses and, accordingly, the calling subscriber manipulates his dial to transmit a number of impulses representing the first digit of the wanted number. Assume, for example, that the first digit of the desired number is 3. When the calling line opens on the first impulse, the relay 400 releases its armature and a circuit is closed from ground through the back contact of relay 400, right contact of relay 401, conductor 416, lowermost back contact of counting relay 405, winding of counting relay 406 to battery. Moreover, a circuit is closed by way of conductor 416 through the winding of relay 402 to battery. Relay 402 operates and being slow-to-release maintains its energization during the brief interruptions of its circuit at the contacts of relay 400. Similarly, the relay 401 remains operated during the series of impulses. Relay 402 closes a circuit from battery through the winding of the slow-to-release relay 404, front contact of relay 402 to ground at the left contact of relay 401.

The counting relay 406 operates in the circuit traced and a circuit is completed from battery to the winding of relay 406, winding of relay 405, contact of relay 406, conductor 417, to ground at the left contact of relay 401. Relay 405, however, remains shunted as long as the back contact of relay 400 is closed. When the line closes at the end of the first impulse and relay 400 again operates the shunt is removed from the winding of relay 405 and this relay operates and locks in series with relay 406.

In response to the next two impulses of the series, the counting relays 408, 407, 410 and 409 are operated in the manner similar to the operation of relays 406 and 405. After the impulse series has been transmitted and an interval elapses, the slow relay 402 becomes deenergized and opens the circuit of relay 404. Relay 404, however, being slow-to-release, maintains its armature for an interval.

Relay 402, on deenergizing, completes a circuit from battery through the winding of relay 403, back contact of relay 402, uppermost contact of relay 405, front contact of relay 400 to ground. Relay 403 operates and a circuit is closed from ground through the contact of said relay, conductor 414, contacts of selector switch 300, horizontal conductor 343, contacts of said selector switch 300, conductor 344, winding of multicontact relay 411 to battery. Relay 411 operates its contacts and thereby associates the conductors from the counting relays of the sender with the vertical group magnets

211, 212, etc. of the particular selector switch 200 in which appears the trunk 115 involved in this connection. Relay 411 locks in a circuit through its winding and contact, conductor 417, to ground at the left contact of relay 401.

Relay 403 also completes a circuit from ground through its contact, conductor 414, conductor 418, contacts of switch 300, horizontal conductor 345, contacts of said switch, conductor 346, winding of vertical magnet 236 to battery. The magnet 236 operates the bar individual to the vertical row 202 in which the contacts of trunk 115 appear. This particular magnet is selected, as explained, by reason of the fact that the contacts in the vertical row 301 of the sender selector switch 300 are operated. Had the sender been seized through contacts of one of the horizontal links 306, 307 in the vertical row 301, then the magnet 210 at the selector switch 200 would be operated since in this case the trunk 114 would be the one involved.

With the first three pairs of counting relays operated and with the multi-contact relay 411 energized, a selecting circuit is established as follows for selecting a particular vertical magnet 211, 212, 237 at the switch 200 which controls the vertical row representing the desired outgoing group of trunks: ground, through the contact of relay 403, inner contact of relay 405, upper front contacts of relays 407 and 409, upper back contact of relay 419, conductor 420, contacts of relay 411, conductor 421, thence in parallel through the winding of multi-contact relay 318 and through the winding of the vertical magnet 211 to battery. The magnet 211 rotates the associated vertical bar and prepares the contacts of all of the outgoing trunks in the group.

The multi-contact relay 318, which is individual to the group of trunks appearing in the row 205, operates and associates the common test relays with the trunks, respectively, in said group.

The apparatus is now in condition to make a test of the outgoing trunks of the selected group and also of the horizontal link circuits. During this interval the relay 404 is maintaining its armature attracted by reason of its slow-to-release character and does not close its contact until after the tests have been made and the idle trunk to be used is determined. For the sake of illustration, it will be assumed that the trunk 224 is idle, trunks 223 and 222 are busy, trunk 221 is idle, and that the horizontal links 209 and 208 are busy while links 207 and 206 are idle. Since the horizontal link 209 is busy in connection with some other call a circuit is closed from battery through the right-hand winding of relay 324, conductor 346, contact of relay 220 to ground. Relay 220 is energized at this time in a circuit from battery through its winding through the grounded horizontal conductor 238. Therefore, the relay 324 becomes energized. Since the trunk 223 is busy a ground potential exists on the test conductor 229 and a circuit may be traced from battery through the left-hand winding of relay 323, conductor 347, contacts of relay 318, conductor 348 to the grounded conductor 229. Relay 323 operates in this circuit. Moreover, since the horizontal link 208, which has access to the trunk 223, is engaged, a circuit is closed from battery through the right-hand winding of relay 323, conductor 349 to ground at the contact of relay 219. Relay 219 is energized at this time in a circuit from battery through its winding to the grounded horizontal test conductor of the link 208. The test relay 323 in this manner has both of its windings energized, either of which is sufficient to operate the relay. The next outgoing trunk 222 being busy, a circuit is closed from battery through the left-hand winding of relay 322, conductor 350, contact of relay 318, conductor 351 to the grounded test conductor 230. Since neither the horizontal link 206 nor the trunk 221 is busy, the circuits for the windings of relay 321 are held open and this relay remains deenergized.

It will a also be assumed that the two lowermost test relays 325 and 326, which correspond to two horizontal links and the respective trunks (not shown in Fig. 2), are energized by reason of the busy condition of said links and trunks. Thus, all of the test relays shown, except relay 321, are energized through one or the other or both of their windings, according as the represented outgoing trunk, the corresponding link is busy or both are busy.

At the end of the interval necessary to the release of relay 404, the said relay retracts its armature and a circuit is closed from ground through the contact of relay 403, conductor 414, contact of relay 404, conductor 415, left armatures and front contacts of relays 326, 325, 324, 323 and 322 in series, left armature and back contact of relay 321, conductor 352, right-hand winding of the horizontal magnet 213, to battery. Magnet 213 energizes and rotates the associated horizontal bar to operate the prepared contacts in the vertical rows 202 and 205. The operation of these contacts connects the trunk 115 to the corresponding conductors of the link circuit 206 and connects the conductors of said link to the corresponding conductors of the idle outgoing trunk 221 in the selected group. Immediately that the horizontal magnet 213 operates, it closes a holding circuit from battery through its right-hand winding and contact, conductor

239 through contacts of the relay 411, conductor 417 to ground at the left-hand contact of relay 401. This circuit holds the magnet 213 energized under the control of the sender shown in Fig. 4.

Upon the release of relay 404 a circuit is also closed from ground, the contact of relay 403, conductor 414, contact of relay 404, conductor 415, thence through the contact of relay 318, conductor 353, winding of magnet 610 to battery. Since the multi-contact relay 318, which is individual to the selected group of trunks, is operated, the conductor 415 leading from the sender is extended through contacts of this relay to the vertical magnet 610 (which controls the vertical row of contacts 601 in which appear the trunks of the said selected group at the sender selector switch 600. The vertical row 601 having a plurality of trunks appearing therein, it is next necessary to determine the particular location in this row of the trunk 221 selected. This is accomplished in the manner about to be explained.

The magnet 610 operates and prepares the vertical bar and also closes a circuit from ground through its left contact, conductor 632, front contact of relay 615 (assuming the sender represented by the circuit 618 to be busy), back contact of relay 617, winding of the vertical magnet 616 to battery. The magnet 616 operates and prepares the operating bar associated with the vertical row 605 and individual to the sender mechanism illustrated in Fig. 7. The magnet 616 also closes a circuit from ground through its left contacts, conductor 633, winding of the impulse relay 700 to battery. Relay 700 operates and closes a circuit from ground through its front contact, winding of the slow-to-release relay 701 to battery. Thus, the relays 700 and 701 operate in advance of the time when the trunk 221 is extended through the sender selector switch 600 to the sender mechanism shown.

Magnet 616 also completes a circuit from ground through its left contact, conductor 634, right front contacts of relays 326, 325, 324, 323 and 322 in series, right back contact of relay 321, conductor 354, lower contacts of magnet 620, winding of said magnet to battery. In this manner the condition of the test relays in Fig. 3 is used for determining the horizontal appearance of the selected trunk 221 in the sender selector switch 600. That is to say, since relay 321 representing the trunk 221 is idle, the circuit above traced is extended over the right back contact of relay 321 to conductor 354 which leads in to the horizontal magnets 620, 621, etc., of the group of horizontal circuits 606, 607 having access to the trunk 221. The link circuit 607 being idle, the associated magnet 620 is operated in the circuit traced and rotates the horizontal bar to actuate the contacts prepared by magnets 610 and 616.

Immediately that the connection is made at the sender selector switch, a circuit is closed from ground through the left contact of relay 701, conductor 713, conductor 714, contact of selector switch 600, horizontal conductor 635, contact of said selector switch, conductor 636, left normal contacts of relay 532, conductor 227, contacts of selector switch 200, horizontal conductor 240, left-hand winding of magnet 213 to battery. The horizontal magnet 213 is thereby held through its left-hand winding under the control of the sender shown in Fig. 7 and independently of the circuit previously traced through the right-hand winding of said magnet. Moreover, the circuit just traced from ground is further extended by way of the horizontal conductor 240 through contacts of the switch 200 through the test wire 241, winding of relay 232 to battery. Relay 232 operates and extends the grounded conductor 241 through its lower front contact to conductor 135 and through the winding of relay 119 and also through the line switch 100 to the windings of magnet 106 and the cut-off relay 104 to battery.

The lower contact of relay 232 is of the make-before-break character whereby the circuits of magnet 106 and relays 104 and 119 are completed by way of conductor 241 to ground at the contact of relay 701 prior to the opening of the original circuits. Relay 232, at its upper contacts, disconnects the trunk 115 from the sender in Fig. 4 and relay 400 becomes deenergized. Relay 400 releases and after an interval relay 401 retracts its armatures. Relay 401 removes ground from conductor 417, and thereby the horizontal magnet 337 becomes deenergized and the sender selector switch 300 is restored to its normal condition. The removal of ground from conductor 417 also permits the release of relay 315 in order that the vertical magnet 314 may again be selected. The deenergization of relay 401 and the release of the sender selector switch 300 removes ground from the conductor 235, but, as already seen, the line switch 100 is now held under the control of the relay 701 at the succeeding sender mechanism.

When relay 401 releases, and upon the restoration of the sender mechanism, it unlocks the holding circuit of multi-contact relay 411 and this relay becomes deenergized to disconnect the sender from the switch 200. Relay 401 at its left contact also opens the holding circuits of all energized counting relays permitting them to release. When relay 400 releases, following the energization of relay 232, it opens the circuit of relay 403. Relay 403 becomes deenergized and

disconnects ground potential from conductor 414 and also from conductor 420, whereby the previously traced circuits of relay 318 and magnet 211 are opened. Relay 318 disconnects the testing relay set from the group of trunks at the switch 200 and the vertical magnet 211, on deenergizing, restores the associated operating bar to its normal position. All test relays 321, 322, and 323 of the set of test relays, which have been energized through their left-hand windings and circuits leading through the contacts of relay 318 due to the busy condition of the outgoing trunks of the group, are released upon the deenergization of relay 318 provided their right-hand windings are not energized. However, such of these relays as have circuits completed through their right-hand windings through the contacts of the corresponding relays 217, 218, 219 and 220, owing to the busy condition of the several link circuits at the switch 200, will remain operated to indicate this condition when they are next taken into use for testing the same or some other groups of trunks.

It will further be observed that the circuit for the vertical magnet 236 is also opened by the release of relay 403. Magnet 236 becomes deenergized and also restores the associated vertical bar to its normal position.

Relay 403, on retracting its armature, also removes ground from conductor 415, thereby interrupting the circuit of the vertical magnet 610 at the sender selector 600. Magnet 610 restores the associated bar to its normal position and also opens the circuit of magnet 616. This latter magnet deenergizes and the associated bar is returned to normal. However, prior to the release of the vertical magnets 610 and 616 controlling the vertical rows of contacts 601 and 605, respectively, the following circuit has been closed to include the line relay 700 of the sender mechanism: battery, through the winding of said magnet, conductor 633, through the operated contacts of the sender selector 600, horizontal conductor 637, contacts of switch 600, conductor 638, inner right contact of relay 532, conductor 226, through contacts of the selector switch 200, conductor 138, contacts of line switch 100, line conductor 103, line conductor 102, through contacts of the line switch 100, conductor 137, contacts of selector switch 200, conductor 225, outer right contact of relay 532 to ground. Relay 700 is held in series with the line circuit after the original energizing circuit for said relay is opened at the contacts of the vertical magnet 616. In this manner, the control of the holding circuits for the line switch 100 and selector 200 is made dependent upon the calling subscriber's line.

The sender selector switch 600 is maintained in its operated condition by means of a holding circuit which leads from battery through the winding and inner front contact of horizontal magnet 620, through the contacts of the link circuit 607, the horizontal conductor 635, the contacts of the said link circuit, conductor 714 to ground at the left contact of relay 701.

When the vertical operating magnet 616 becomes deenergized following the energization of magnet 610, a circuit is closed from battery through the winding of relay 617, right contact of magnet 616 to the grounded conductor 714. The relay 617 operates and extends the starter wire 632 to the next vertical magnet representing an idle sender mechanism.

Up to this point in the establishment of the connection the calling line has been extended through the line switch 100 to the trunk 115 leading in to the group selector 200, the sender mechanism of Fig. 4 has been associated by the sender selector 200 with the calling line and, in response to the first series of impulses, has selected the group of trunks and an idle trunk 221 therein at the switch 200, thus extending the line through to the second group selector switch 500. In response to the extension of the line to the trunk 221, the sender selector switch 600 has operated to associate the sender mechanism of Fig. 7 with the extended line following which the first sender mechanism and the sender selector switch 300 were released. The line switch 100, the selector switch 200 and the sender selector switch 600 are maintained in their operated condition under the control of the calling subscriber's line through the agency of the impulse relay 700 of the sender mechanism and said mechanism awaits the receipt of the next series of impulses in order to select the desired numerical group of trunks at the selector switch 500.

The calling subscriber next transmits a series of impulses representing the second digit of the wanted number, which is assumed to be the digit 3. In response to the first impulse the relay 700 releases its armature and a circuit is closed from ground through the back contact of said relay, right contact of relay 701, winding of slow-to-release relay 702 to battery. Relay 702 operates and a circuit is closed from battery through the winding of slow-to-release relay 704, right contact of relay 702, left contact of relay 701 to ground. Furthermore, the circuit from ground through the left contact of relay 700 extends by way of conductor 715, lower back contact of counting relay 705, winding of relay 706 to battery. The counting relay 706 operates and upon the termination of the impulse relay 705 is operated in series therewith in a manner understood. During the next impulse, the circuit, through the back contact of relay 700, leads

by way of conductor 715, lower front contact of relay 705, lower back contact of relay 707, winding of relay 708 to battery. At the end of the second impulse, relay 707 operates in series with the relay 708 and the counting relays are held by circuits leading to ground at the left contact of relay 701. In response to the third and final impulse of the second series, counting relays 720 and 723 are operated and locked to ground at the left contact of relay 701.

After the lapse of the usual interval following the second series of impulses, the relay 700 remains energized for a sufficient time to cause the release of the slow relay 702. Relay 702, at its right contact, opens the circuit of relay 704. Relay 704, however, being slow to release maintains its armature attracted for an appreciable interval after the release of relay 702. Relay 702 also completes a circuit from battery through the winding of relay 703, left contact of relay 702, uppermost contact of relay 705, front contact of relay 700 to ground. Relay 703 operates and closes a circuit from ground through its contact, conductor 716, conductor 717, contacts of link circuit 607, conductor 639, winding of vertical magnet 506 to battery. Magnet 506 rotates the associated bar and prepares the contacts of the incoming trunk 221 for connection with any one of the horizontal link circuits in the selector switch 500.

Relay 703 also completes a circuit from ground through its contact, conductor 716, contacts of the horizontal link circuit 607, conductor 640, winding of multi-contact relay 709 to battery. Relay 709 operates and closes a holding circuit from battery through its winding and contact, conductor 719, conductor 713, to ground at the left contact of relay 701. Relay 709, in operating, associates the counting relay set of the sender mechanism with the particular selector switch 500 shown, to which leads the incoming trunk 221.

Relay 703 also closes a circuit from ground through its contact, inner upper contact of counting relay 705, upper front contact of counting relay 707, upper back contact of counting relay 720, conductor 721, contacts of relay 709, conductor 722, thence in parallel through the windings of relay 628 and vertical magnet 509 to battery. The multi-contact relay 628 operates in this circuit and in the manner well understood associates the left-hand winding of the testing relays 622, 623, 624, 625, 626 and 627 with the test conductors of the numerical group of outgoing trunks appearing in the vertical row 505 at the selector switch 500. The vertical magnet 509 controlling this group of trunks is also operated and rotates the associated bar to prepare the contacts of the trunks for connection with the horizontal link circuits. Assume that all trunks 520, 521 and 522 in the group preceding the trunk 519 or the corresponding horizontal link circuits 530, 533 and 534 are busy or both trunks and links are busy. Hence the relays 627, 626, 625, 624 and 623 are all operated due to circuits either through their right-hand windings or left-hand windings or both, and the relay 622 is the first deenergized relay in the set. The deenergized condition of relay 622 represents that the trunk 519 and also the horizontal link 529 having access to this trunk are both simultaneously idle.

The interval following the release of relay 702, during which the test is made, having elapsed, the slow relay 704 retracts its armature and a circuit is established as follows: ground, through the contact of relay 703, contact of relay 704, conductor 712, left front contacts of relays 627, 626, 625, 624 and 623, left back contact of relay 622, conductor 641, right-hand winding of horizontal magnet 511 to battery. Magnet 511 operates and is held temporarily in a locking circuit which may be traced from battery through the right-hand winding and contact of said magnet, conductor 536, contacts of relay 709, conductor 713 to ground at the left contact of relay 701. The magnet 511 rotates the associated bar and closes the contacts of the link circuit 529 which cooperate with the contacts of the incoming trunk 221 and of the outgoing trunk 519.

Relay 704, in addition, closes a circuit from ground through the contact of relay 703, contact of relay 704, conductor 712, through contacts of relay 628, conductor 642, and thence to the vertical magnet at the next sender selector switch similar to switch 600 controlling the vertical row of contacts in which appears the selected trunk 519.

The manner in which the next sender selector switch is operated will be obvious from the description hereinbefore given of the switches illustrated in detail. Immediately that the sender selector switch at the next stage is operated, a ground potential is extended back over the test conductor 525 of the trunk 519 through contacts of the switch 500 to hold the horizontal magnet 511 operated. Moreover, this ground is extended through the contacts of switch 500, conductor 537, winding of relay 532 to battery. Relay 532, at its left front contact, extends the grounded conductor 537 to the conductor 227, whereby the line switch 100 and selector switch 200 are held in an operated condition under the control of the succeeding sender mechanism prior to the release of the sender mechanism in Fig. 7, which is now about to take place. Relay 532, at its right contacts, opens the circuit of relay 700 and this latter relay, in the manner already explained in connection with the release of relay 400, brings about the

restoration of the sender mechanism of Fig. 7, and also causes the release of the sender selector switch 600.

The subscriber may transmit as many series of impulses as necessary and in response to each series, a connection is built forward over a switching stage, as already explained in connection with the two stages shown. In response to the last two series of impulses, the connection is extended over a final connector switch 800 to the called subscriber line 801. Battery current for conversation purposes is supplied through the usual battery feed relay 802, which in addition maintains a circuit for relay 803. Relay 803, being under the control of the calling subscriber's line, is utilized by holding a ground potential on the ground conductor 525, whereby the entire series of switches are held in their operated condition. That is to say, the horizontal magnet 106 of the line switch 100, relay 104, relay 119, relay 232, the horizontal magnet 213 of selector switch 200, relay 217, relay 532, horizontal magnet 511, and relay 515 are maintained energized in circuits extending over the third conductor to ground at the contact of relay 803.

When the conversational circuit is no longer required, the subscribers replace their receivers on the switchhooks. The calling subscriber, on hanging up his receiver, opens the circuit of relay 802, which, in turn, releases the relay 803, removing the holding ground potential from conductor 525. The horizontal magnets 106, 213, 511, and such other similar magnets as may be energized are released to restore the horizontal bars and associated link circuits to normal condition, thereby releasing the established connection through these switches. Moreover, the cut-off relay 104 and remaining relays which are held energized during the connection are released.

If it is desired to select a second trunk in any group during the existence of a call over some other trunk in such group, this may readily be done. For instance, the call above discussed employed the trunk 221 in the group 205 of the selector 200. Immediately that the connection was effected the switching bar controlling the group of trunks 205 was released and the common test relay set was disconnected. Upon the extension of another call to switch 200 requiring a trunk in group 205 the same procedure above described in detail is repeated. The sender selects the group of trunks 205, operates the associated bar and also connects the common test relays 321, 322, 323 with the selected group. In this case, the trunk 221 and link 206, which are already in use on an existing call, will test busy. However, if there is at the time an idle trunk, the link associated with which is also idle, it will be chosen and used for the second connection. Likewise, the switch and testing equipment may be used repeatedly to establish a plurality of coexisting connections.

The switching mechanism, hereinbefore described in detail both with respect to its structural and circuit operations, is employed both as a preliminary switch and also as a selecting switch at a digital stage. Although applicable in either of these capacities, its use as a selector switch is especially emphasized herein. The unusal economy of a switch of this character, when adapted as a selecting medium, is due, among other reasons, to the feature of repeatedly using the switching bars for establishing a plurality of coexisting connections, to the advantageous arrangement of incoming lines, intermediate links, and outgoing lines, and to the flexibility of the mechanism as a whole.

Although the present system is illustrated as one of the full automatic type, it is clear that the invention is not so limited and that the switches employed, together with the other numerous features, may be adapted to systems of the semi-automatic type. For instance, the designation may be received by an operator who records it by means of a keyboard or any other suitable device upon a controlling mechanism, which thereafter determines the selecting operation of the switches.

What is claimed is:

1. The combination in a unitary switching structure of outgoing lines arranged in groups, incoming lines each arranged for connection with any one of said outgoing lines, operating members, one for each of said groups, each member serving to cause the establishment of coexisting connections between said incoming lines and the outgoing lines of the corresponding group, means operated according to numerical designations for selectively actuating the operating member corresponding to a desired group, and means for choosing an available outgoing line in a group.

2. The combination of outgoing lines arranged in groups, incoming lines arranged for connection with the lines of said groups, electromagnets, one for each of said groups of outgoing lines, each electromagnet serving to cause the establishment of coexisting connections between said incoming lines and the outgoing lines of the corresponding group, numerical means for selecting and operating any one of said electromagnets to thereby select the corresponding group of outgoing lines, and means for choosing an available idle outgoing line in the selected group.

3. The combination of outgoing lines arranged in groups, incoming lines arranged for connection with the lines of said groups,

switching bars, one for each of said groups of outgoing lines, other bars, each of said switching bars cooperating with said other bars to establish a number of coexisting connections between said incoming lines and the outgoing lines of the group corresponding to such switching bar, numerical impulse control means for selecting any one of said groups of outgoing lines, and means for selecting an available line in the selected group.

4. The combination in a selective switch of outgoing lines arranged in groups, intermediate lines, incoming lines arranged for connection with the outgoing lines through said intermediate lines, each intermediate line having access to a plurality of said groups of outgoing lines, switching members, one for each group of outgoing lines, each switching member serving to cause the establishment of connections between the intermediate lines and the outgoing lines of the corresponding group, numerical means for selecting one of said groups, and means for selecting an available outgoing line in a group.

5. The combination in a selective switch of outgoing lines arranged in groups, intermediate lines, incoming lines, each having access to all outgoing lines through said intermediate lines, each intermediate line having access to a plurality of said groups of outgoing lines, switching members, one for each group of outgoing lines, each switching member serving to establish connections between the intermediate lines and the outgoing lines of the corresponding group, means responsive to designation impulses for selecting one of said groups of outgoing lines and means for selecting an available line in a group.

6. The combination in a selective switch of outgoing lines arranged in groups, intermediate lines, incoming lines, each having access to all outgoing lines through said intermediate lines, each intermediate line having access to a portion of the outgoing lines in each group, switching members, one for each group of outgoing lines, each switching member serving to establish connections between the intermediate lines and the outgoing lines of the corresponding group, numerical means for selecting said switching members to thereby select one of said groups of outgoing lines, and means for selecting an available outgoing line in a selected group.

7. The combination in a selective switch, of outgoing lines arranged in groups, intermediate lines, incoming lines arranged for connection with the outgoing lines through said intermediate lines, each intermediate line having access to a plurality of said groups of outgoing lines, switching members for said incoming lines, switching members for said intermediate lines, switching members for said outgoing lines, each of said latter switching members allotted to a group of outgoing lines and cooperating with the switching members of said incoming and intermediate lines to establish connections between the incoming lines and the outgoing lines of the corresponding group, numerical means for selecting a group of outgoing lines, and means for choosing an available line in the selected group.

8. The combination in a unitary switching structure of outgoing lines arranged in groups, link circuits, incoming lines arranged for connection with the outgoing lines through said link circuits, each link having access to a number of said groups, switching bars, one for each of said groups, each bar serving to effect connections between said links and the outgoing lines of the corresponding group, numerical means for selecting one of said groups of lines, and means for choosing an available line in a group.

9. The combination of outgoing lines arranged in groups, link circuits, incoming lines arranged for connection with the outgoing lines through said link circuits, each link having access to a number of said groups, switching bars for said links, outgoing line switching bars, one for each of said groups, said link bars cooperating with said line bars to effect connections between said links and outgoing lines, numerical means for selecting one of said groups of lines, and means for choosing an available line in a selected group.

10. The combination of outgoing lines arranged in groups, link circuits, incoming lines arranged for connection with the outgoing lines through said link circuits, each link having access to a number of said groups, switching bars for said links, outgoing line switching bars, one for each group, any link bar arranged to cooperate with any outgoing line bar to effect connection between any link and an outgoing line in any group, numerical impulse control means for selecting one of said groups of outgoing lines, and means for choosing an available line in a selected group.

11. The combination of outgoing lines arranged in groups, link circuits, incoming lines arranged for connection with the outgoing lines through said link circuits, each link having access to a number of said groups, individual bars for said links, outgoing line bars, one for each group of outgoing lines, any link bar cooperating with any line bar to effect connection between the corresponding link and a line in the corresponding group, numerical means for selecting one of said groups of lines, and means for choosing an available line in the selected group.

12. The combination of outgoing lines ar-

ranged in groups, links, incoming lines arranged for connection with the outgoing lines through said links, each link having access to a number of said groups, individual bars for said links, outgoing line bars, one for each group of outgoing lines, each of said line bars arranged to cooperate successively with a plurality of said link bars to establish coexisting connections between the links and the outgoing lines of the corresponding group, means controlled in accordance with designations for selecting one of said groups of lines, and means for choosing an available line in a selected group.

13. The combination of outgoing lines arranged in groups, links, incoming lines arranged for connection with the outgoing lines through said links, each link having access to a number of said groups, individual bars for said links, outgoing line bars, one for each group of outgoing lines, each line bar arranged to cooperate successively with a plurality of said link bars to establish coexisting connections between the links and outgoing lines of the corresponding group, said link bars arranged to maintain the connections established after the release of the line bar, numerical means for selecting one of said groups of lines, and means for choosing an available line in the selected group.

14. The combination of outgoing lines arranged in groups, links, incoming lines arranged for connection with the outgoing lines through said links, each link having access to a number of said groups, incoming line bars, link bars, outgoing line bars, one of said latter bars for each group of outgoing lines, incoming line bars, link bars and outgoing line bars cooperating to effect connection between any incoming line and any link and between each link and an outgoing line in any group, numerical means for selecting one of said groups of lines, and separate means for choosing an available idle line in the selecting group.

15. The combination of outgoing lines arranged in groups, incoming lines arranged for connection with the lines of said groups, operating members, one for each of said groups, each member serving to establish coexisting connections between said incoming lines and the outgoing lines of the corresponding group, means for selecting one of said groups of outgoing lines, and a set of test relays common to said groups of lines for testing the lines of any one of said groups.

16. The combination in a selective switch of outgoing lines arranged in groups, intermediate lines, incoming lines arranged for connection with the outgoing lines through said intermediate lines, each intermediate line having access to a plurality of said groups of outgoing lines, switching members, one for each group of outgoing lines, each switch member serving to establish connections between the intermediate lines and the outgoing lines of the corresponding group, numerical means for selecting one of said groups, and means common to the groups of outgoing lines for testing the lines of any group to determine an idle one thereof.

17. The combination in a selective switch of outgoing lines arranged in groups, intermediate lines, incoming lines arranged for connection with the outgoing lines through said intermediate lines, each intermediate line having access to a plurality of said groups of outgoing lines, switching members, one for each group of outgoing lines, each switching member serving to establish connections between the intermediate lines and the outgoing lines of the corresponding group, numerical means for selecting one of said groups, and means for testing said outgoing lines to determine an available one and for testing said intermediate lines simultaneously to determine an available one.

18. The combination in a selective switch of outgoing lines arranged in groups, intermediate lines, incoming lines arranged for connection with the outgoing lines through said intermediate lines, each intermediate line having access to a plurality of said groups of outgoing lines, switching members, one for each group of outgoing lines, each switching member serving to establish connections between the intermediate lines and the outgoing lines of the corresponding group, numerical means for selecting one of said groups, a set of test relays common to all groups for testing the outgoing line, other relays, one for each group of outgoing lines for associating said common test relays with any one of said groups.

19. The combination of outgoing lines arranged in groups, links, incoming lines arranged for connection with the outgoing lines through said links, each link having access to a number of said groups of outgoing lines, switching bars for effecting connections between said incoming lines and outgoing lines, a common set of test relays associable with any group of outgoing lines for testing and choosing an idle one of said lines, and numerically controlled means for selecting a group of lines and associating the test relays therewith.

20. The combination in a selective switch of outgoing lines arranged in groups, links, incoming lines arranged for connection with the outgoing lines through said links, each link having access to a number of groups, switching bars for establishing connections between the incoming and outgoing lines, a set of test relays, each relay having a first and a second winding, said first windings serving to test the outgoing lines of any group and the second windings serving to

test said links, and means controlled by said relays for rendering said switching bars effective to establish a connection between an incoming line and an outgoing line in any group.

21. The combination of outgoing lines arranged in groups, links, incoming lines, arranged for connection with the outgoing lines through said links, means for selecting a group of outgoing lines, a testing device common to said groups and associable with any one thereof, said device serving to test the lines of the selected group and to test said links, means controlled by said device for choosing an idle outgoing line to which an available link has access, and switching bars for effecting a connection between an incoming line and the chosen outgoing line.

22. The combination of outgoing lines arranged in groups, links, incoming lines arranged for connection with the outgoing lines through said links, numerical means for selecting a group of outgoing lines, a testing device common to said groups, means for associating said device with the selected group, said device serving to test the lines of the selected group and to test said links, means controlled by said device for selecting an idle outgoing line in the selected group to which an idle link has access, and switching bars for effecting a connection between any incoming line and the selected outgoing line.

23. The combination of outgoing lines arranged in groups, links, incoming lines arranged for connection with the outgoing lines through said links, each link having access to an outgoing line in each group, means controlled in accordance with designations for selecting a group of outgoing lines, a testing device common to said groups, means for associating the same with the selected group, said device serving to test the condition of the lines in the selected group and to test the condition of the links, means controlled by said device for choosing an idle outgoing line which is accessible to a link that is simultaneously idle, and switching bars for effecting connection between the incoming line and the selected outgoing line.

24. The combination of outgoing lines arranged in groups, links, incoming lines arranged for connection with the outgoing lines through said links, means for selecting a group of outgoing lines, a set of test relays common to said groups and associable with any selected one thereof, said test relays serving to test the condition of the outgoing lines and to test the condition of said links, means controlled by the test relays for selecting an idle outgoing line to which an idle link has access, and switching bars for effecting connection between an incoming line and the selected outgoing line.

25. The combination of outgoing lines arranged in groups, links, incoming lines arranged for connection with the outgoing lines through said links, numerical means for selecting a group of outgoing lines, a set of test relays common to said groups, relays individual to the several groups for associating said common test relays with any selected group, said test relays serving to test the lines of the selected group and to test said links, means controlled by the test relays for choosing an idle outgoing line to which an idle link has access, and switching bars for effecting a connection between the incoming line and the chosen outgoing line.

26. The combination of outgoing trunks arranged in groups, links, incoming trunks arranged for connection with the outgoing trunks through said links, means for selecting a group of trunks, a series of test relays, each serving in common a particular trunk in each of the outgoing groups, means for associating the relays of the series with the respective trunks of any selected group, said relays arranged to test the respective trunks of the selected group and to test said links, means controlled by said relays for selecting an idle outgoing trunk and an available link, and switching bars for effecting a connection between the incoming trunk and the selected outgoing trunk.

27. The combination of outgoing lines arranged in groups, links, incoming lines arranged for connection with the outgoing lines through said links, each link having access to an outgoing line in each of several groups, means for selecting a group of outgoing lines, a series of test relays, each serving a particular line in each of the several groups, means for associating the relays with the respective lines of the selected group, each of said relays arranged to test the respective lines of the selected group and to test the corresponding link, means controlled by said relays for selecting an idle outgoing line to which an idle link has access, and switching bars for effecting a connection between the incoming and the selected outgoing line.

28. The combination of outgoing trunks arranged in groups, links, incoming trunks arranged for connection with the outgoing trunks through said links, each link having access to an outgoing trunk in each group, means for selecting a group of trunks, a plurality of test relays, each relay having a winding for testing the respective outgoing trunk and a second winding for testing the link having access to said trunk, means for associating said relays with the selected group, means controlled by said relays for selecting an idle outgoing trunk and the corresponding idle link, and switching bars for establishing a connection between an incoming trunk and the selected outgoing trunk.

29. The combination of outgoing lines arranged in groups, links, incoming lines arranged for connection with the outgoing lines through said links, each link having access to an outgoing line in the several groups, means for rendering a link busy when connected to any outgoing line, a plurality of test relays, each relay serving a particular outgoing line in each of the several groups, means for associating the relays with the respective lines of the selected group, each relay arranged to test the respective outgoing line and the corresponding link, means controlled by said relays for selecting an idle outgoing line in the selected group to which an idle link has access, and switching bars for establishing a connection between the incoming line and the selected outgoing line.

30. The combination of outgoing lines arranged in groups, links, incoming lines arranged for connection with the outgoing lines through said links, each link having access to an outgoing line in each group, means for rendering a link busy when connected to any outgoing line, means for selecting a group of outgoing lines, a series of test relays each serving in common a particular line in each of the several groups, means for associating said relays with the selected group, each relay having a winding which energizes when the respective outgoing line is busy, each relay having a second winding which energizes when the corresponding link is busy, means controlled by a relay when neither winding is energized for selecting the corresponding outgoing line and the corresponding link, and switching bars for effecting a connection between the incoming line and the selected outgoing line.

31. The combination of outgoing lines arranged in groups, links, incoming lines arranged for connection with the outgoing lines through said links, each link having access to an outgoing line in each group, means for rendering the links busy when connected to any outgoing line, numerical means for selecting a group of outgoing lines, a plurality of test relays common to all groups of outgoing lines, each relay serving a particular line in each of the several groups, each relay having a winding permanently associated with the corresponding link, each energized whenever said link is busy, each relay having a second winding, means for associating the second windings of said relays with the respective outgoing lines, said latter windings being energized if the outgoing lines are busy, means controlled by a relay when neither winding is energized for selecting the corresponding outgoing line and link, and switching bars for effecting connection between any incoming line and the selected outgoing line.

32. The combination of outgoing lines arranged in groups, links, incoming lines arranged for connection with the outgoing lines through said links, each link having access to a number of said groups, switching bars, one for each of said groups, each bar serving to effect connection between said links and the outgoing lines of the corresponding group, a plurality of numerical controlling mechanisms, means for associating one of said mechanisms with the incoming lines, means for operating said mechism in accordance with a designation, means controlled by said mechanism for selecting a group of outgoing lines, and means for choosing an available line in the selected outgoing group.

33. In combination a plurality of switches at a selecting stage, lines incoming to said switches, a number of groups of lines outgoing from each switch, links for interconnecting said incoming lines and outgoing lines, each link having access to a number of said groups, switching bars, one for each of said groups, each bar serving to effect connections between said links and the outgoing lines of the corresponding group, a numerical controlling mechanism common to said switches, means for associating said mechanism with any switch, means controlled by said mechanism for selecting a group of outgoing lines at the associated switch, and means for choosing an available line in the selected group.

34. The combination in a selective switch of outgoing lines arranged in groups, incoming lines arranged for connection with the lines of said groups, operating members, one for each of said groups, each serving to cause the establishment of coexisting connections between said incoming lines and the outgoing lines of the corresponding group, impulse-storing means responsive to a series of impulses and separate from said switch for selecting one of said groups, and means for selecting an available line in the group.

35. The combination in a selective switch of outgoing lines divided in groups, incoming lines arranged for connection with the lines of said groups, operating members, one for each of said groups, each serving to cause the establishment of coexisting connections between said incoming lines and the outgoing lines of the corresponding groups, a plurality of other similar selective switches, senders responsive to impulses and common to all of said switches for selecting one of said groups of lines outgoing from one of said switches and means for selecting an available line in the group.

In witness whereof, I hereunto subscribe my name this 24th day of July A. D., 1922.

CHARLES L. GOODRUM.