May 26, 1936. T. A. SPENCER 2,041,873

SWITCHING SYSTEM

Filed Aug. 13, 1935 9 Sheets-Sheet 1

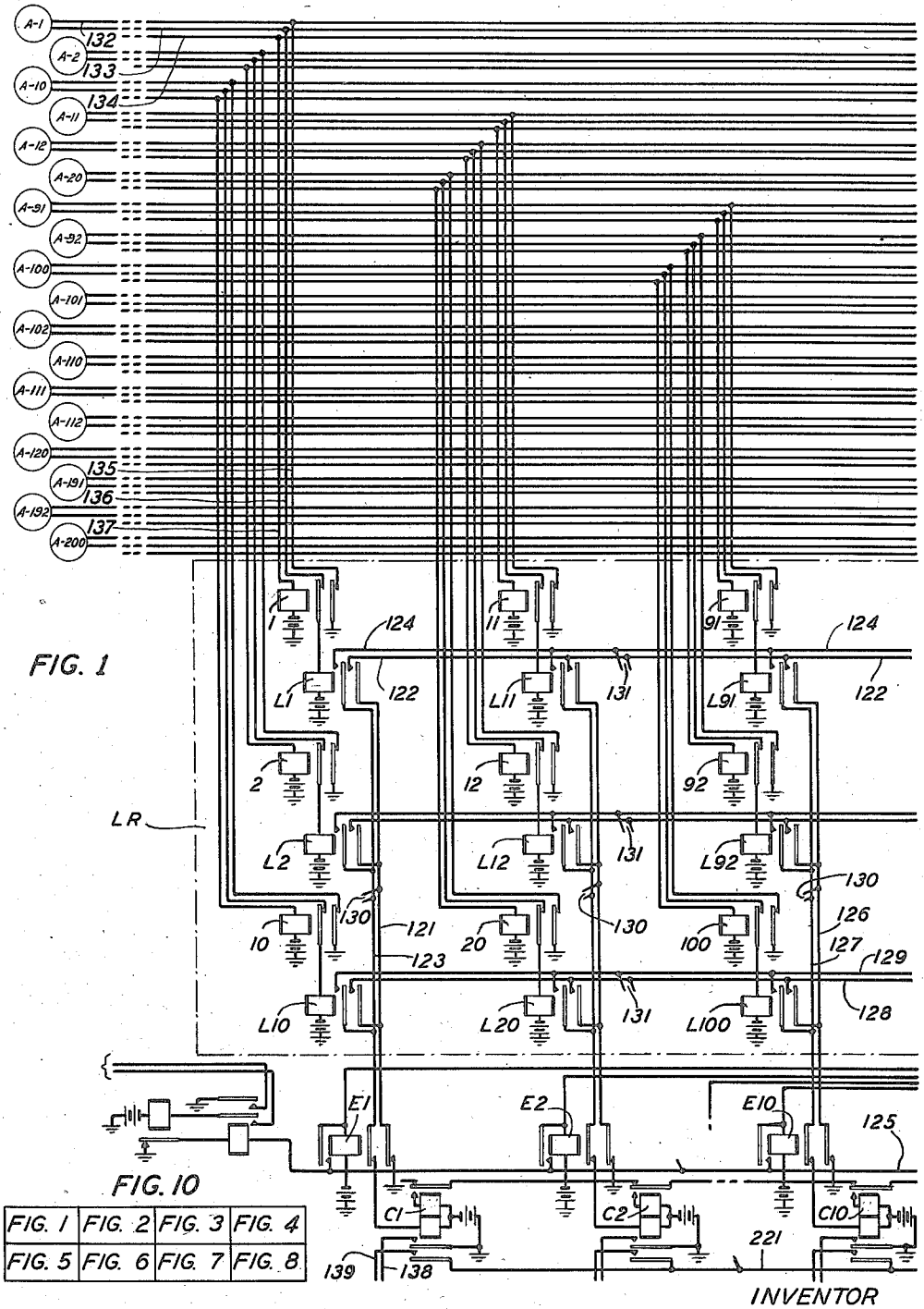

FIG. 1

FIG. 10

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

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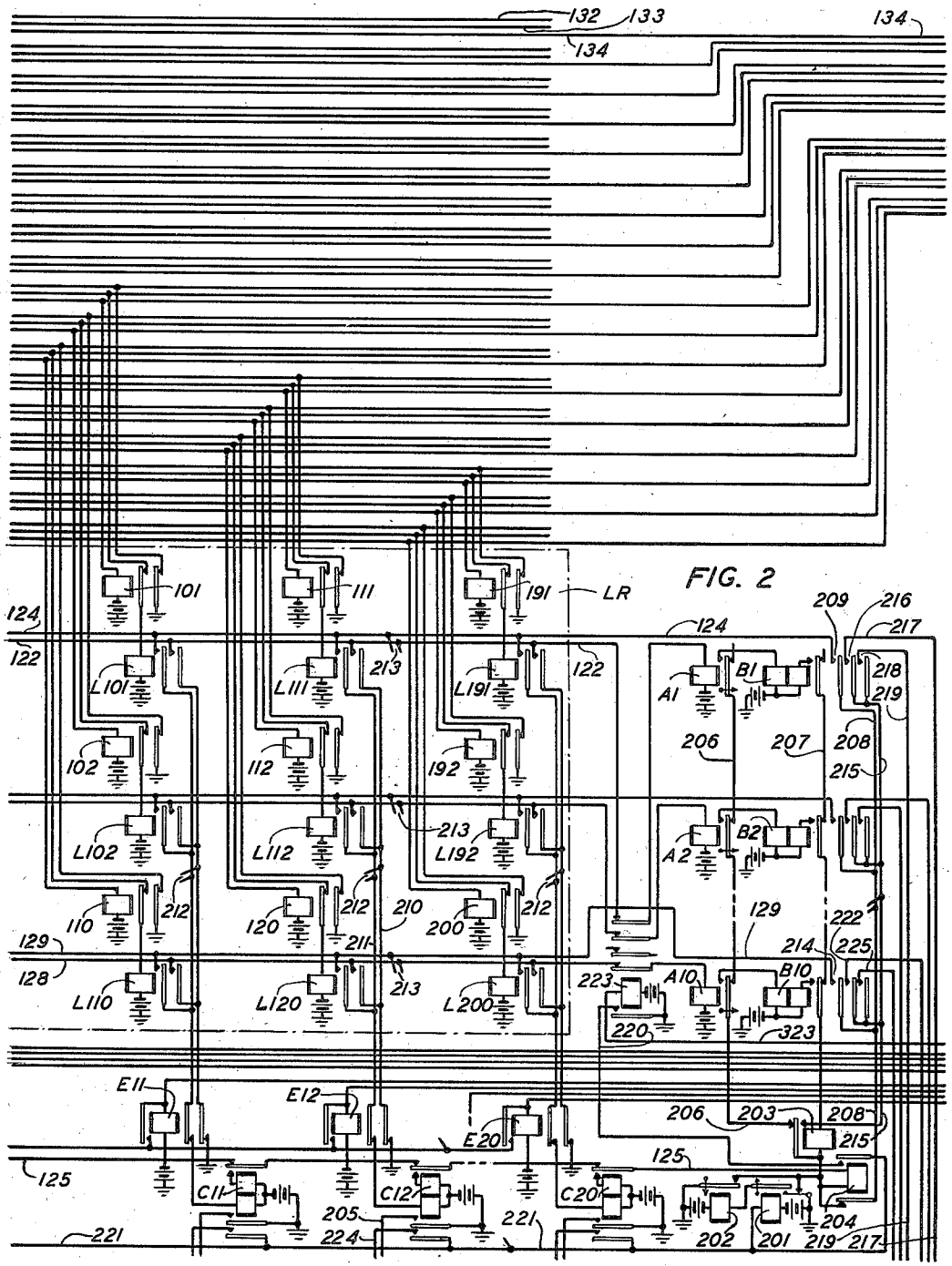

FIG. 2

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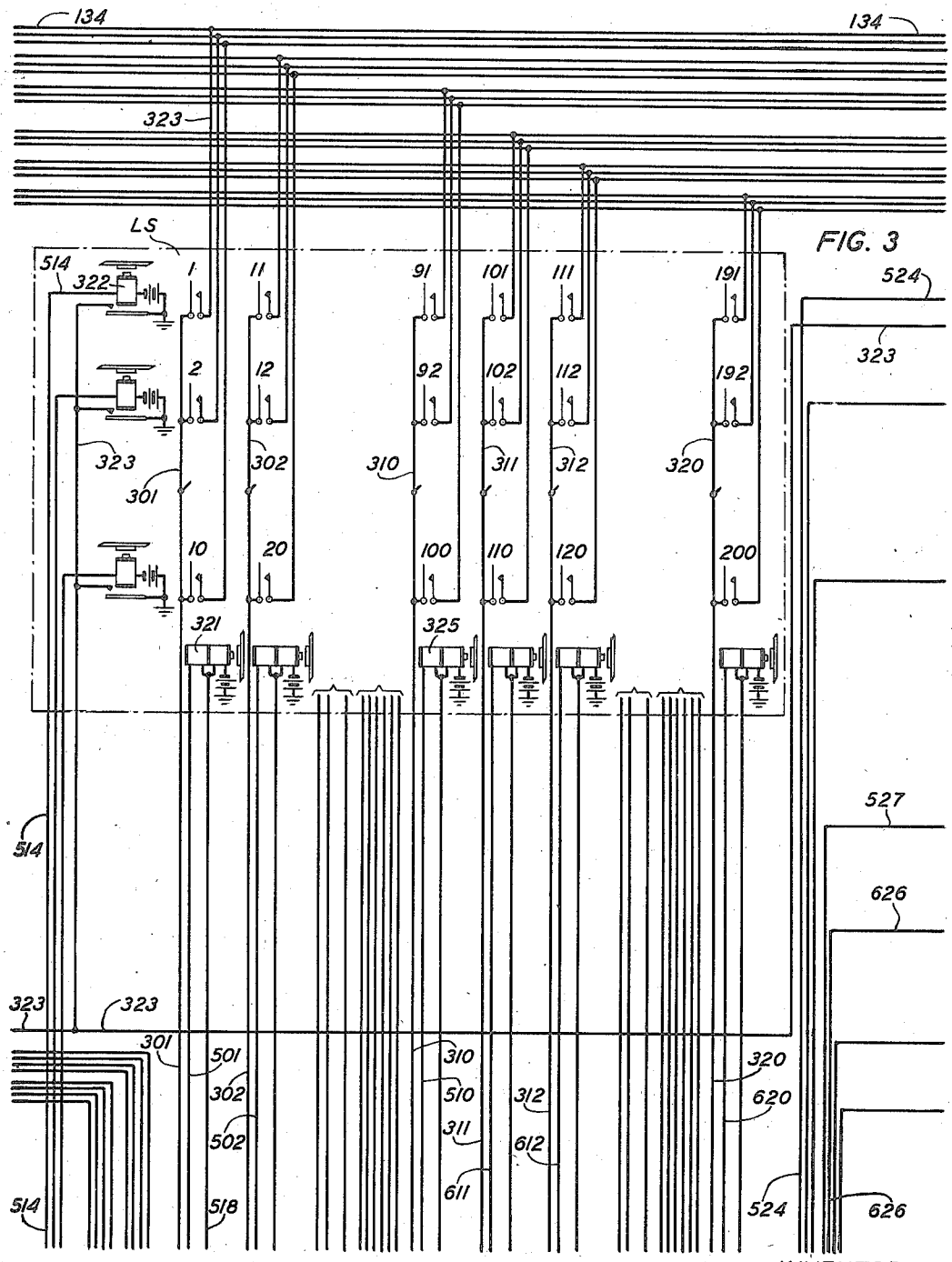

FIG. 3

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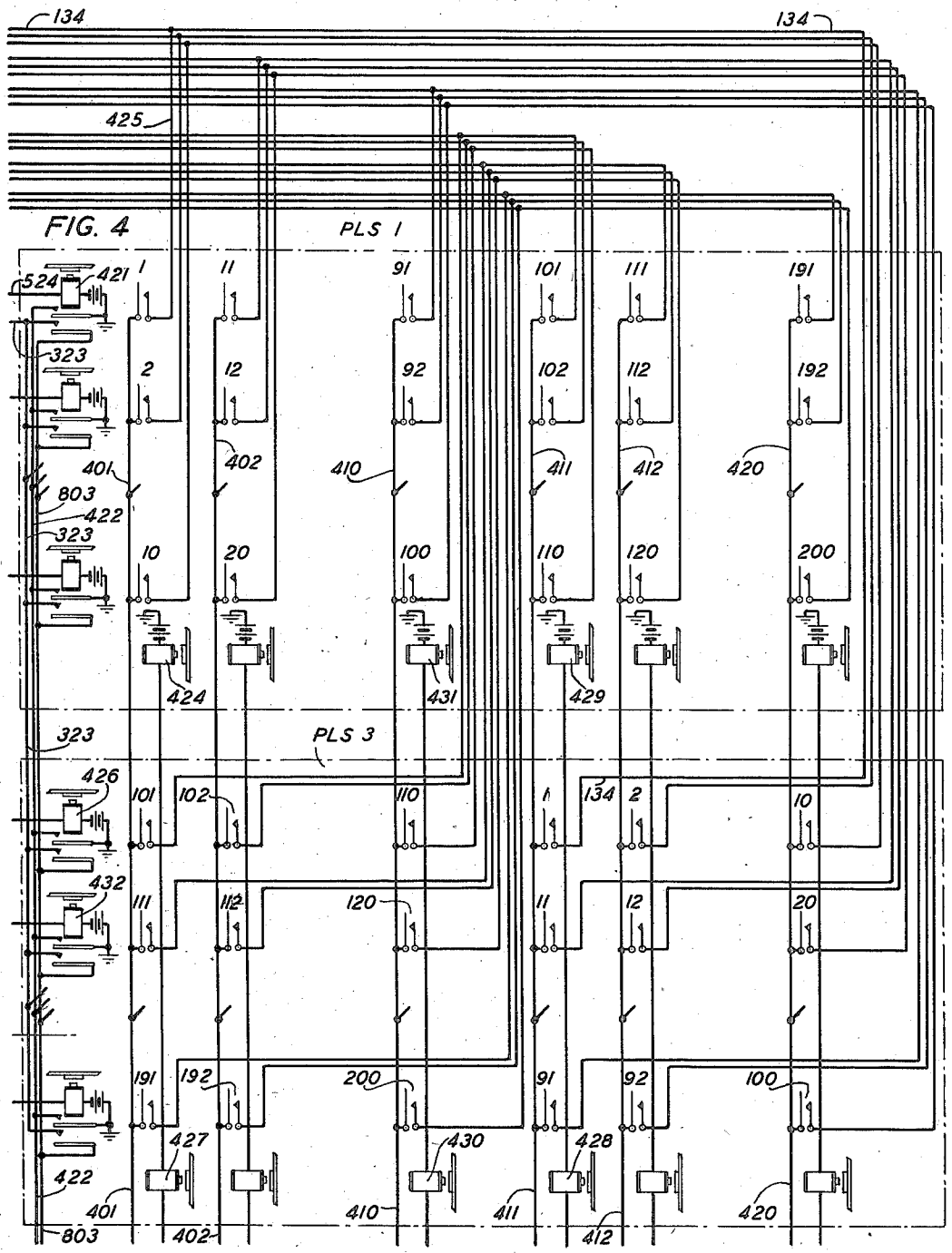

FIG. 4

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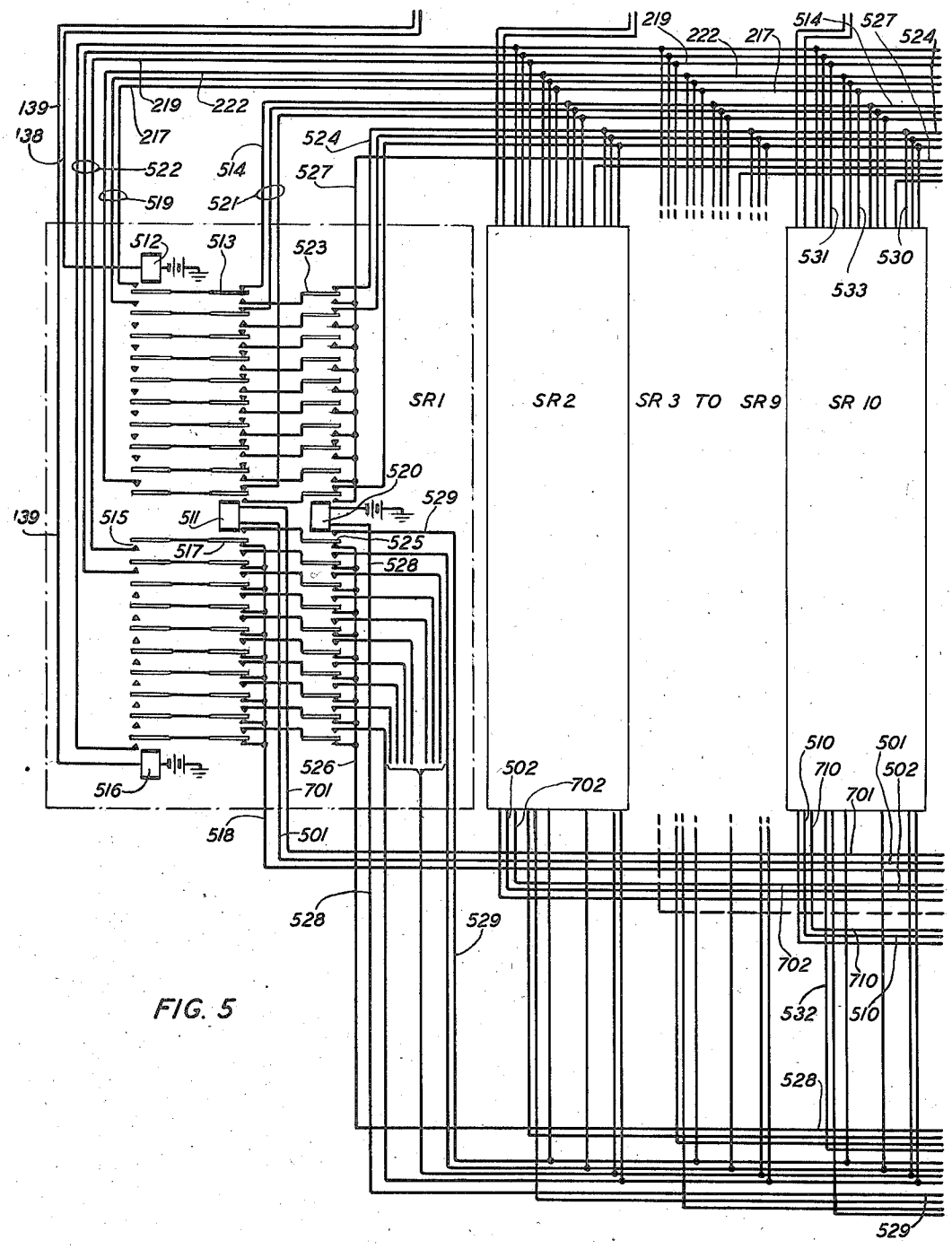

FIG. 5

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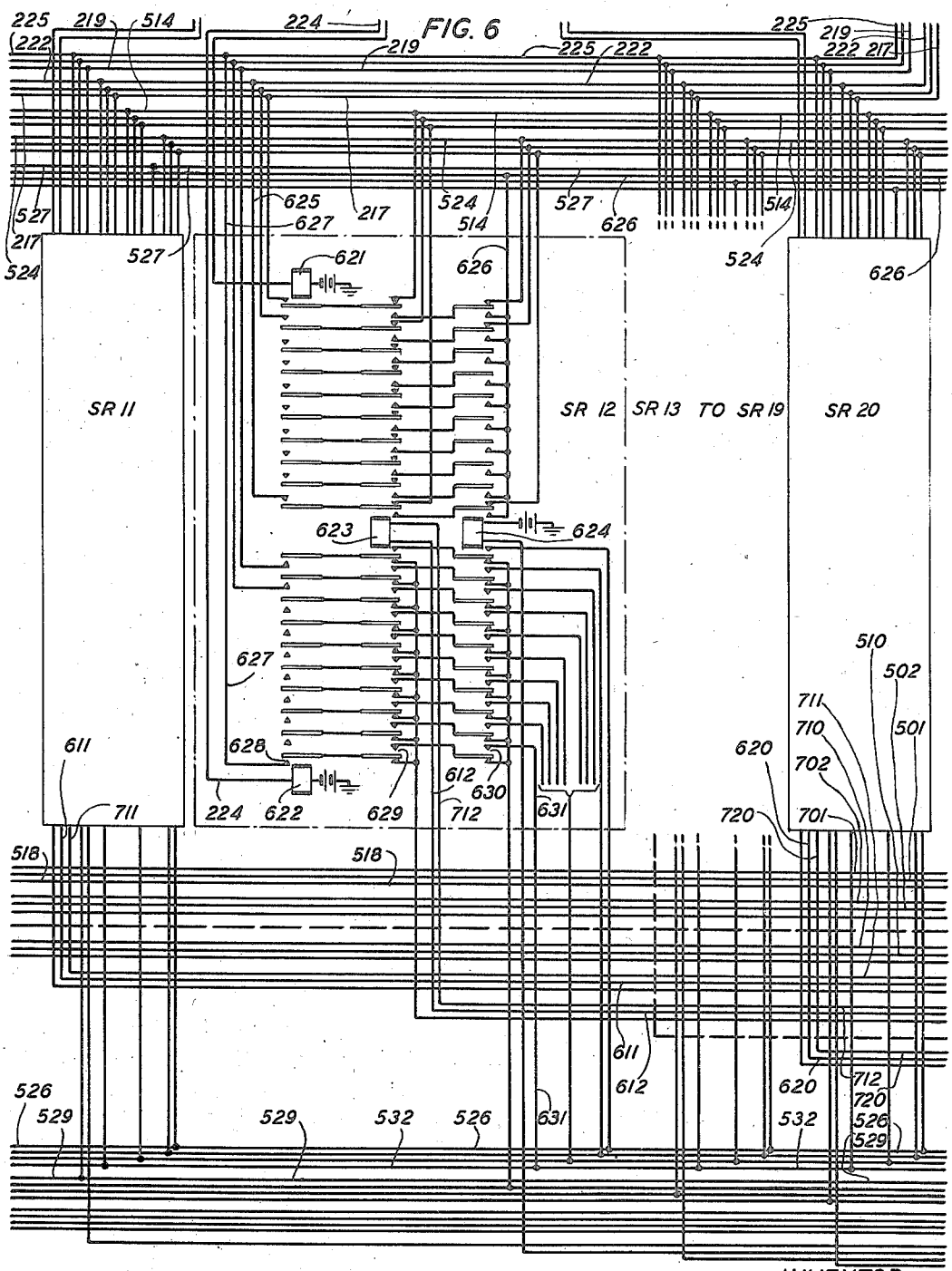
FIG. 6



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SWITCHING SYSTEM

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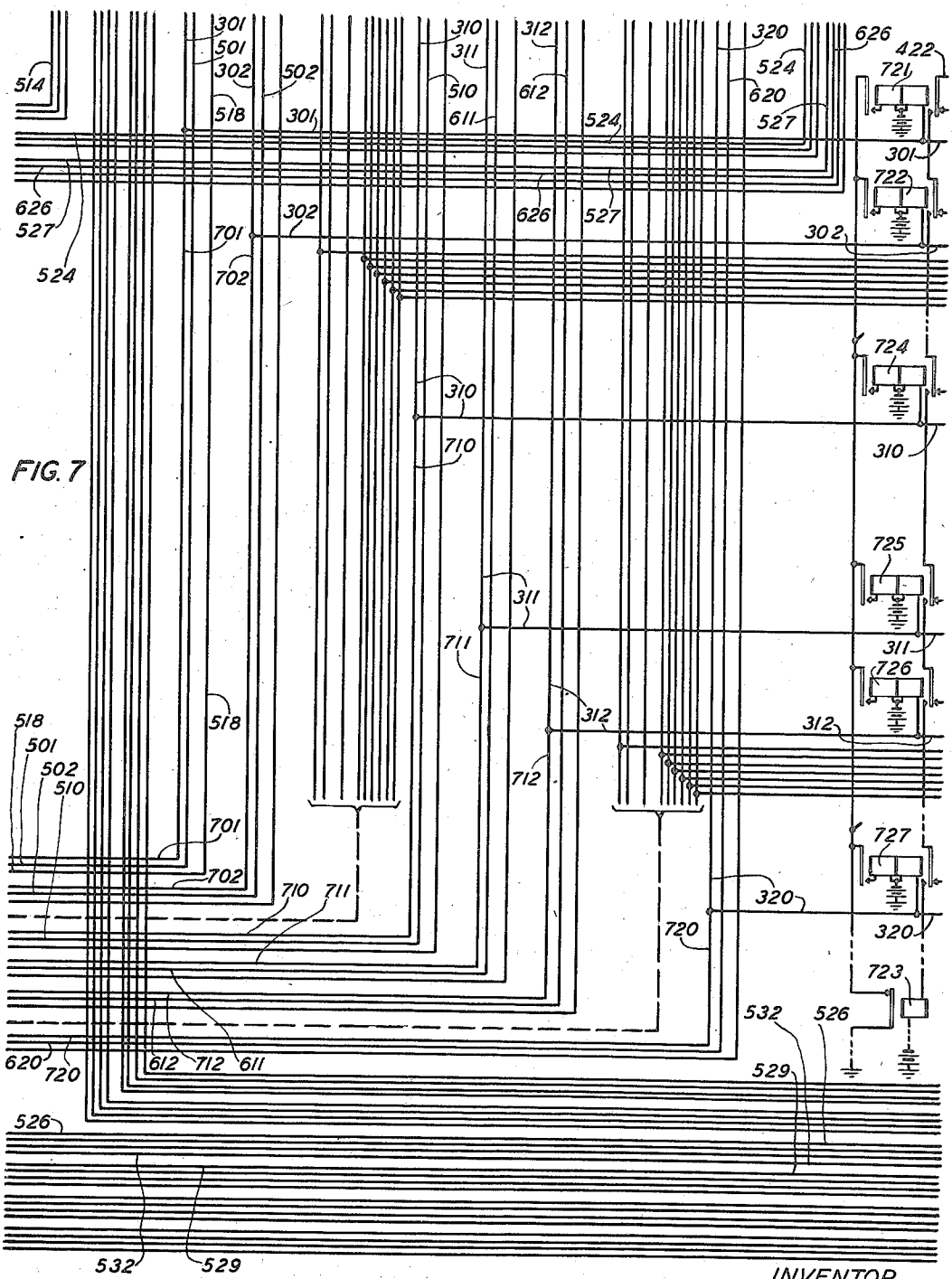

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SWITCHING SYSTEM

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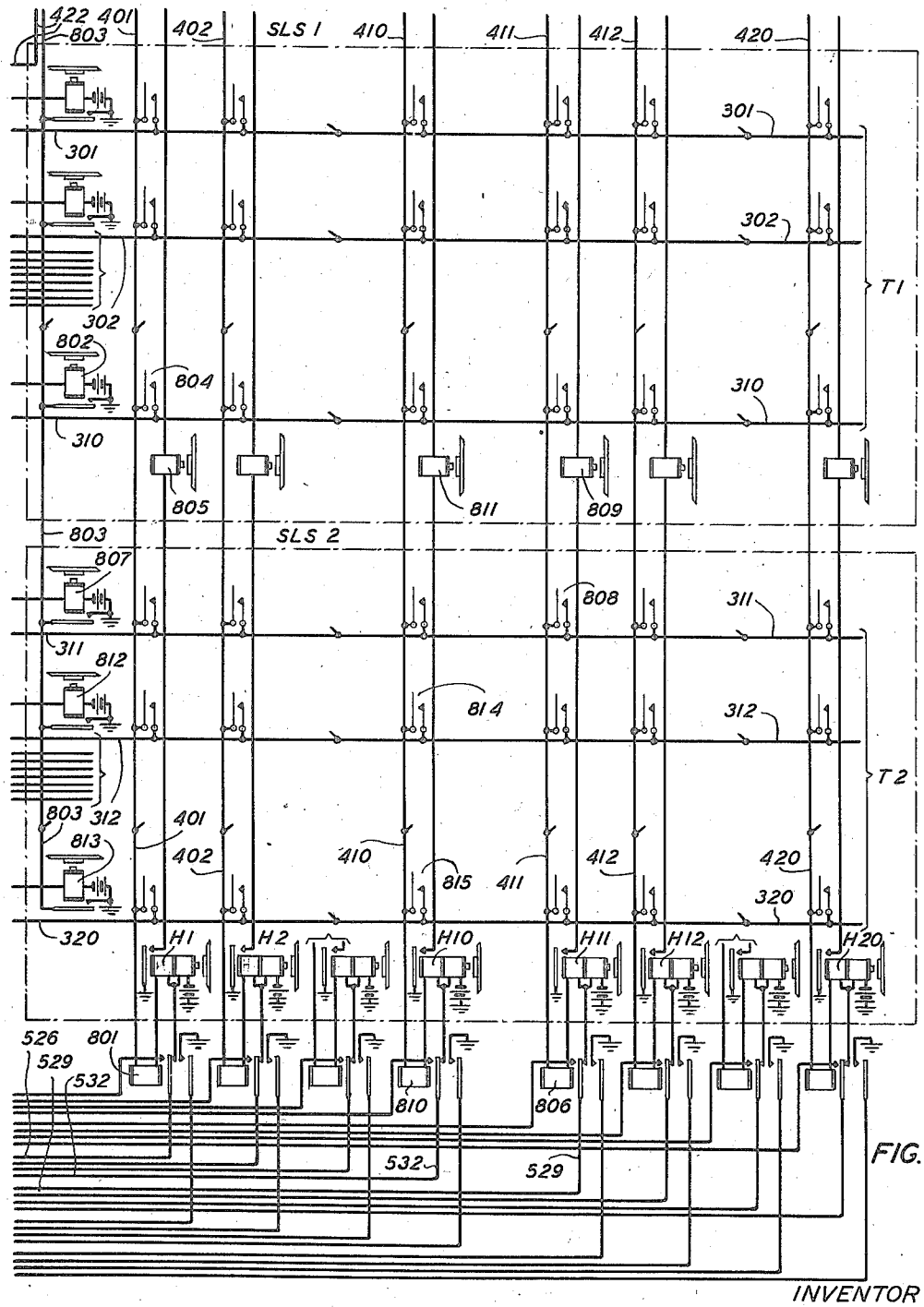

FIG. 8

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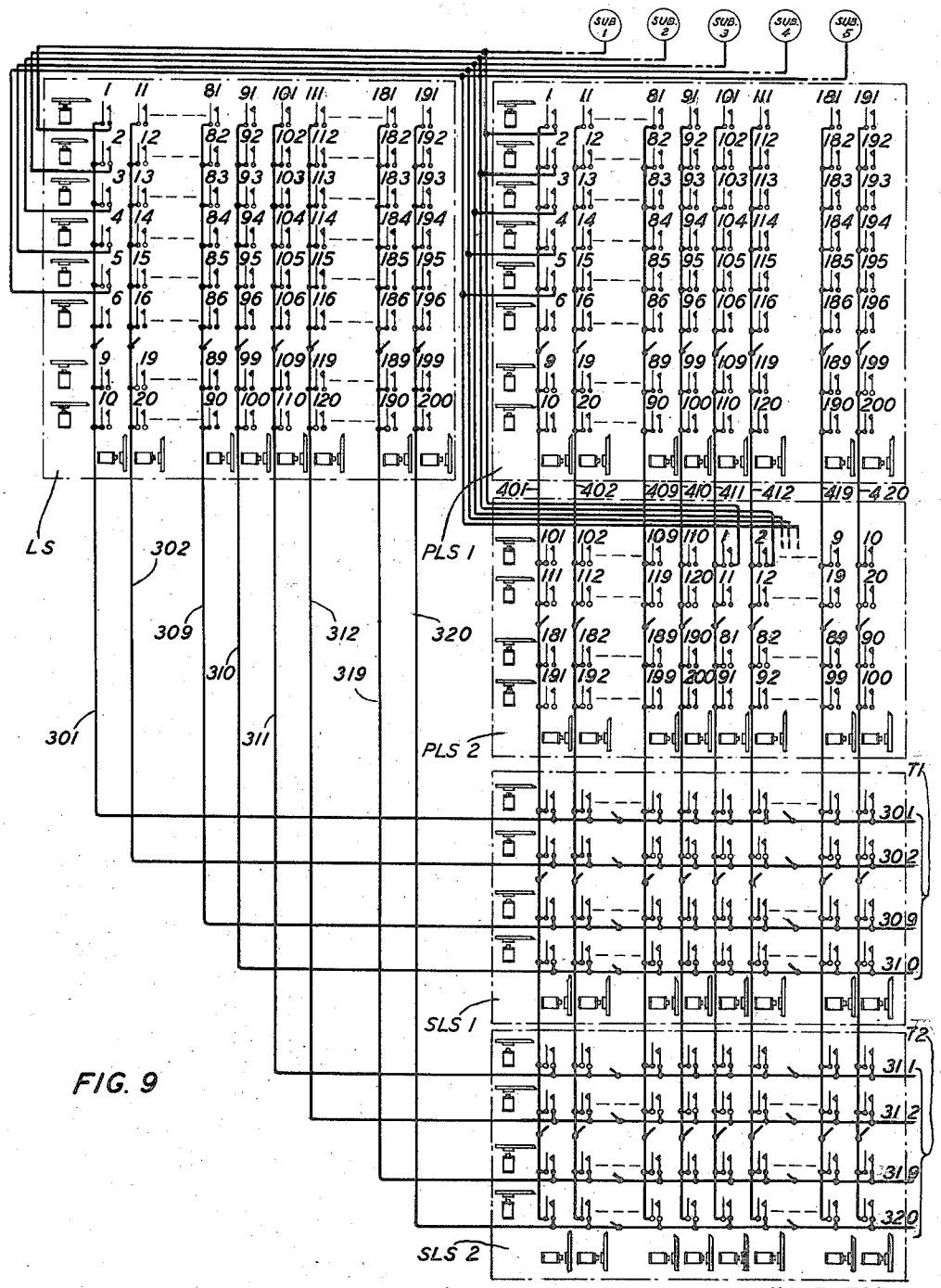

FIG. 9

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UNITED STATES PATENT OFFICE

2,041,873

SWITCHING SYSTEM

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Application August 13, 1935, Serial No. 35,927

5 Claims. (Cl. 179—18)

This invention relates to switching arrangements for telephone systems and particularly to those using switches of the cross-bar type.

The objects of the invention are to increase the accessibility of a group of lines, to economize in the amount of switching equipment necessary to serve the lines, and to improve the arrangement of lines in switching devices of the above mentioned character.

A feature of the invention is a switching system in which a plurality of trunks are accessible to groups of lines which are assigned to the rows of contacts in a plurality of cross-bar switches in such a way that each one of the line groups appears in a vertical row of contacts in one switch, in a vertical row of contacts in a second switch and in a horizontal row of contacts in a third switch, and in which connections may be effected by establishing the connection directly between a particular line group in its vertical-row appearance in the first switch and a particular one of the trunks or by establishing the connection between said line group in the second switch and any one of the trunks by way of a particular one of a number of link circuits, or by establishing the connection between said line group in the third mentioned switch and any one of the trunks by way of said link circuits, the particular link used depending on which line in the group is involved.

Another feature of the invention relates to a system, as above described, in which connections not requiring link circuits are effected directly through the switches in which the lines appear, whereas connections requiring link circuits are effected through other cross-bar switches in conjunction with the said switches in which the lines appear.

The foregoing and other features of the invention will be more fully discussed in the following detailed description, taken in connection with the annexed drawings, and will also be more fully understood from the appended claims.

In the drawings Figs. 1 to 8 when arranged as shown in Fig. 10 illustrate the invention when applied to a line switch stage in a telephone system for connecting any one of a group of 200 lines through cross-bar line switches to an idle one of a group of trunks.

Figs. 1 and 2 show a number of subscribers' lines in each of several line subgroups together with the line and cut-off relays and other control equipment.

Fig. 3 shows a cross-bar line switch in which appears the group of 200 lines illustrated in Figs. 1 and 2 and which serves to extend said lines directly to the outgoing trunks.

Fig. 4 shows two cross-bar line switches in both of which said group of 200 lines appear. These switches serve as primary line switches to extend the lines to link circuits which have access to the outgoing trunks through secondary cross-bar line switches. These secondary switches are shown in Fig. 8.

Figs. 5 and 6 show multi-contact switching relays for controlling the completion of a call from any line group through the switches of Figs. 3, 4 and 8.

Fig. 7 shows control equipment and circuits.

Fig. 9 is a schematic of the line switching stage shown in Figs. 1 to 8.

For the purpose of simplifying the disclosure, only one switch contact is shown at each cross-point in the sleeve or control lead for each line, whereas the switch in actual practice would carry three or more contacts at each cross-point, two contacts being required for the talking leads shown at the top of Figs. 1 and 2. The arrangement of the switches is such that any contact set is capable of operation upon conjoint displacement in definite order, of the two bars, not shown, which intersect in the locality of this set of contacts. The contact sets are maintained actuated by the displacement of the last actuated one of the two bars, and are restored to normal by their own resiliency on the release of the last actuating bar. The first bar to be actuated in operating any given contact set is referred to as the horizontal bar and is actuated by a selecting magnet shown immediately to the left of each row of contact sets in each switch, and the second bar to be actuated is referred to as the vertical bar and is actuated by a holding magnet shown directly below the vertical row of contact sets in each switch unit. The cross-bar switches shown in Figs. 3, 4, 8 and 9 may be of any well-known type, such as the one described in detail in the pending application of J. N. Reynolds, Serial No. 702,453, filed December 15, 1933, granted as Patent 2,021,329, Nov. 19, 1935. Also certain portions of the cross-bar switches have been omitted, as well as much of the control equipment, to simplify the disclosure, only so much being shown as is necessary to a clear understanding of the invention.

The line and cut-off relays of the first 100 lines of the entire 200 lines are shown in part in Fig. 1, in which the first vertical row of relays represent lines 1 to 10, with a line relay L1, L2 or L10 and a cut-off relay, 1, 2 or 10 for each line, inter-

mediate relays being indicated at taps 130. The second vertical row of relays represent lines 11 to 20, and a third row represent lines 91 to 100, with intermediate rows of relays represented at taps 131. In a similar manner the line and cut-off relays for the second group of one hundred lines, lines 101 to 200 are shown in part in Fig. 2 with intermediate relays indicated at taps 212 and intermediate rows of relays at taps 213. Two control relays, such as A1 and B1, are associated with each of the 10 horizontal rows of line relays. These relays in conjunction with another group of control relays, such as C1 and E1, associated with each vertical row of line and cut-off relays, identify the number of a line that is calling so that the trunk to which the line has access may be tested for busy as will later be described. The control relays referred to above are further controlled or directed by relays 201, 202, 203, 204 and 223, located in the lower right corner of Fig. 2, to prevent more than one line at a time from being assigned to an idle outgoing trunk as well as to direct the selection of a trunk.

The system also includes 20 sets of switching relays, such as SR1 and SR12, shown in Figs. 5 and 6 respectively, there being one set of relays for each vertical row of 10 line and cut-off relays. As will later be explained, each subscriber's line is given three successive points of access to the outgoing trunk circuits, so that the purpose of the various sets of switching relays is to direct the completion of a call first through the cross-bar switch LS, shown in Fig. 3, or, if the particular trunk to which the subscriber has direct access in this switch is busy, then the switching relays will direct the call to cross-bar switch PLS1 in the upper part of Fig. 4, and, if the link to which the subscriber has access in this switch is busy, they will direct the call to cross-bar switch PLS2, shown in the lower half of Fig. 4. To effect these accesses, the subscribers' lines have multiplied appearances in cross-bar switches LS, PLS1 and PLS2.

A group of 20 outgoing trunks T1, T2 appearing in Fig. 8 is provided with 20 test relays, one per trunk. Six of these are shown in Fig. 7. These relays act as busy test relays, causing a call being directed over one of the vertical links from crossbar switches PLS1 or PLS2 of Fig. 4 to be directed to the first idle trunk in the two groups of 10 outgoing trunks T1 and T2. The two cross-bar switches designated SLS1 and SLS2 represent the secondary element of a primary-secondary switch arrangement with the links 401 to 420, inclusive, shown vertically in Figs. 4 and 8 and interconnecting the primary switches PLS1 and PLS2 and the secondary switches SLS1 and SLS2. The outgoing trunks 301 to 320 are shown connected horizontally to the cross-bar switch contacts, thus permitting any link to connect with any idle trunk.

The diagram of Fig. 9 shows the cross-bar switch arrangement in schematic form and brings out more clearly the manner in which the subscriber lines are given access to outgoing trunk circuits. Cross-bar switch LS, shown at the upper left of this figure is the same as shown in detail in Fig. 3 and provides for a subscriber line multiple of 200 lines arranged in such a way that each sub-group of 10 successive lines appears in a vertical row and has direct access to one of the outgoing trunks 301 to 320. The same 200 lines have a second appearance in the cross-bar switch PLS1, shown in detail at top of Fig. 4 and schematically at the upper right of Fig. 9, and have the same multiple arangement as in the case of the cross-bar switch LS, namely, each of 10 successive lines appears in a vertical row. This appearance of the lines, however, instead of having direct access to the outgoing trunks 301 to 320 has access to these trunks through link circuits 401 to 420. A third appearance of the same 200 lines is shown in the cross-bar switch PLS2 in detail at bottom of Fig. 4 and schematically just below the switch PLS1 of Fig. 9, these lines having access to the same group of link circuits, but with the links for the first and second hundred lines interchanged. In addition to this, the sub-groups of 10 lines appear in horizontal rows rather than vertical rows. Arranging the line multiple in the above manner provides a high degree of trunk accessibility, considering the limited number of line appearances, because in any subgroup of 10 lines one particular trunk is directly available as a first choice, any one of all the trunks over a particular link circuit is available as a second choice or any one of all the trunks over a different link circuit is available as a third choice. Furthermore, if 10 incoming calls should be centered in one subgroup of 10 lines, for example, all 10 calls would have access to the outgoing trunks over separate links and no call would be blocked as is the case in ordinary subgroup multiple arrangements.

While the invention is illustrated in a system in which the switches act as line switches, it is obvious that it applies to other switching arrangements, such as the intermediate and final switching stages of a telephone system.

A detailed description will now be given of the manner in which an incoming call is connected directly to an idle trunk, or if said trunk is busy the manner in which the call may reach any idle trunk over a particular link circuit, or if said link is busy the manner in which the call may reach any idle trunk over a different link circuit. When the usual receiver is removed at a subscriber station, such as A—1, a bridge is placed across the line conductors 132 and 133. This causes line relay L1 to operate, ground being connected to lead 135 at outside break contact of cut-off relay 1, thence to conductor 132 of line A—1. Battery through winding relay L1 is connected to lead 136 at inside break contact cut-off relay 1, thence to conductor 133 of line A—1. Upon operating, relay L1 at its right inner contact prepares a path for operating relay C1 by connecting lead 123 to lead 124 as later will be described. Relay L1 also closes a circuit for operating relay A1 of Fig. 2 over a path traced from ground at right outside break contact relay E1, lead 121, right outer contact relay L1, lead 122 of top break contact relay 223 of battery through winding relay A1. Relay A1 at its front contact connects lead 206 to left winding relay B1. Lead 206 being a test lead running through the back contacts on other relays A2 to A10 will be open at the left back contact relay 203 if another call in the group of 200 lines is already in the process of selecting a trunk. Assuming, however, that relay 203 is not operated, then ground from the top break contacts of relays 201 and 202 will be connected through break contact relay 203, lead 206, through the break contact of relays A2 to A10, make contact on relay A1 and through left winding relay B1 to battery. Had it been assumed that simultaneous calls had originated on subscriber lines A—1 and A—2 or A—1 and A—10, then relays B2 or B10

respectively would have operated in the path previously traced in preference to relay B1. Since a call from line A—1, is being traced, relay B1 operates to close a circuit from battery through the right winding relay B1 and front contact to another test lead 207, through the armatures and break contacts on other B relays to ground through the winding relay 203. Relay 203 operating, then opens lead 206 as mentioned above and prevents later calls from interfering with the handling of the call on line A—1. Test leads 206 and 207 therefore control the vertical preference in the 200-line group and permit the lowest of the calling lines in any group of 10 to search for a trunk and lock out all other lines until an idle trunk is found or until the call is timed out, when another attempt is to be made to select a trunk.

Before a search is made for an idle outgoing trunk for the call on line A—1, it is necessary to determine in which vertical group of 10 lines the calling line A—1 is located. This is determined by the common relay 204 in lower right corner Fig. 2 and the relays C1 to C20, inclusive, together with lead 125. Therefore immediately after the vertical preference is determined, described in the preceding paragraph, the B1 relay closes a circuit for operating relay C1 over a path traced from ground at the top break contact relays 201 and 202, through lower contact and armature relay 204, thence over multiple lead 208, contact 209 on relay B1, multiple lead 124, through operated inner contact on line relay L1, multiple lead 123, right inner contact relay E1 and through bottom winding relay C1 to battery. Relay C1 in operating locks to ground through its upper winding and front contact to lead 125 traced through all the top break contacts and armatures of relays C2 to C20 thence through winding of relay 204 and ground at top contacts of relays 201 and 202. Relay 204 in operating opens the bottom contact which breaks the operating circuit previously traced for the lower winding of relay C1 thus preventing later calls that might originate in other groups of lines from interfering with the handling of the call on line A—1. The identity or location of the calling line is thus established by virtue of the fact that only one of the B and one of the C relays, namely, B1 and C1 remain operated. Before proceeding, however, to show how this line is actually connected with an idle one of the outgoing trunks, it is thought that the function of the circuits in Figs. 1 and 2 will be more clearly understood if a description is given of several other cases where more than one line originates a call at the same time.

Assuming, for example, that subscribers on lines A—1 and A—91 lift their receivers about the same time, line relay L1 and corresponding B1 and C1 relays will operate as previously described. Line relay L91 will also operate and connect ground that is on lead 126 to lead 122. Since both relays L1 and L91 connect ground to lead 122, which path is further traced through relay A1 of Fig. 2, it is evident that only the B1 relay will operate. The vertical preference is thus determined by the B1 relay being operated, both lines being the topmost one in their respective sub-groups of 10. When, therefore, ground is placed on lead 124 at contact 209 by relay B1, a circuit is established for operating both the C1 and C10 relays traced over lead 124 to right inner contact relay L91, lead 127, right inner contact relay E10 to battery through lower winding relay C10, also traced over lead 124 through inner contact relay L1, lead 123, right inner contact relay E1, to battery through lower winding C1. In this case the locking circuit through the upper winding relay C10 is completed back over the series lead 125 to the winding of relay 204 to ground, while the locking circuit through the upper winding of relay C1 is held open at the top break contact on relay C10. Relay 204 operating, thus opens at its bottom break contact the circuit for energizing the lower windings of relays C1 and C10. Relay C1 therefore releases and relay C10 remains operated. In this manner, line A—91 is identified as the calling line to be handled first and search for an idle outgoing trunk will be directed by the combination of the B1 and C10 relays remaining operated as will later be described.

Another example is assumed where subscriber lines A—1, A—91 and A—120 lift their receivers nearly simultaneously, in which case relay A1 operates over lead 122 through contact on relays L1 and L91 as previously traced. Line relay L120 also operating connects ground that is on lead 210 to lead 128 thence through top inner contact on relay 223 and through winding relay A10 to battery. The operation of relay A10 causes relay B10 to operate from ground on lead 206 and at the same time the right break contact opens the circuit to the armature of relay A1 and prevents relay B1 from operating. The failure of relay B1 to connect ground to lead 124 prevents relays C1 and C10 from operating. On the other hand relay B10 at contact 214 connects ground to lead 129 further traced through inner contacts relay L120 and E12 to battery through lower winding relay C12. In this manner line A—120 is identified as the calling line to be handled first and search for an idle outgoing trunk is determined by the combination of the B10 and C12 relays remaining operated as will later be described.

Going back to the condition ensuing forthwith upon the identity of calling line A—1 being determined by relays B1 and C1 remaining in an operated condition, there will be now by describing the manner in which a search is made for an idle trunk in the two groups of trunks designated T1 and T2 in Fig. 8. Relays 203 and 204 it will be remembered are also in an operated condition at this time. A calling line as previously stated has three possible channels for reaching an idle trunk, so that it will first be assumed that the first choice trunk 301 of Figs. 3, 7, and 8 is idle. Relay 511 of Fig. 5, therefore, is normal, because if the trunk 301 were busy relay 511 would be operated as will presently appear.

Relay 203 when it first operated to open test lead 206 also connected ground from the top break contacts of relays 201 and 202 to multiple lead 215, thence through contact 216 on relay B1 to lead 217, through inner make contact relay 512, which is operated at this time, to top armature 513 of relay 511, thence over lead 514 of Figs. 5, 6, 7 and 3 to battery through winding of selecting magnet 322 of switch LS. In the path just traced relay 512 of Fig. 5 is operated because relay C1, being operated, connects ground at its bottom inner armature to lead 138, thence to battery through winding relay 512. Having operated the selecting magnet 322 in cross-bar switch LS of Fig. 3 corresponding to the horizontal row in which the multiple of line A—1 appears, the circuit will now be described that operates the corresponding holding magnet.

The circuits of this system are organized to avoid interference by preventing the holding magnet circuit from being closed until a particular selecting magnet has operated. Thus the operation of the selecting magnet 322 connects ground at its lower armature and front contact to multiple lead 323 of Figs. 3, and 2, to battery through relay 223. Operation of relay 223 opens the circuit for relay A1 and closes ground to multiple lead 220 which is further traced through top operated contact on relay 204, to multiple lead 221 of Figs. 2 and 1, bottom front contact of operated relay C1, thence over lead 139 to battery through winding relay 516. The latter relay operates and prepares the 10 leads indicated at 522 for operating one of the holding magnets. Ground placed on lead 220 by relay 223 of Fig. 2 also operates slow release relay 201 over lead 221 which in turn operates slow operate relay 202. The latter relay provides a time interval in which to insure operating the holding magnet before ground is removed from the controlling circuits involved in selecting a trunk for line A—1. Relay 201 provides another time interval before restoring ground to the controlling circuits and preparing the system for another call. Although relay 516 closes the circuit for 10 holding magnets only one holding magnet circuit will be grounded as determined by which one of the B1 to B10 relays of Fig. 2 is in an operated position. The circuit for holding magnet 321 as determined by relay B1 may be traced from ground through operated make contact relay 203, multiple lead 215, contact 218 on relay B1 to lead 219 of Figs. 2, 6 and 5, through contact 515 on operated relay 516, thence through armature 517, relay 511 and back contact over lead 518 of Figs. 5, 6, 7 and 3 to battery through holding magnet 321. The latter operates in this circuit causing contacts at the cross-point for line A—1 to close, thus connecting line A—1 directly with trunk 301 over a path represented by lead 134 of Figs. 1, 2 and 3, lead 323 of Fig. 3 and conductor 301 of Figs. 3, 7 and 8.

Upon connecting with an idle trunk, ground is returned over the sleeve or control wire, just traced, for holding the connecting switches until the subscriber restores his receiver to the switchhook, all in a manner well understood in the art. Therefore soon after contacts 1 in the switch LS of Fig. 3 close, ground may be traced from the trunk of Fig. 8 back over lead 301, thence over lead 701, through winding relay 511, lead 501 to left winding of holding magnet 321, to the mid-point of which windings direct operating ground was traced in the previous paragraph. Thus when the timing relays 201 and 202, previously referred to, remove ground from the lead connected to the mid-point of holding magnet 321, the magnet continues to remain operated on the trunk holding ground through both windings in series. Furthermore, since the winding of relay 511 is included in the path just traced, relay 511 also operates and remains operated as long as the connection is held by the subscriber. At this time cut-off relay 1 of Fig. 1 also operates over lead 137 from ground on the sleeve wire 134, thus releasing line relay L1, this action taking place before ground is removed by the timing relays.

Having described a call from subscriber line A—1 on the assumption that the outgoing trunk 301 was idle, this call will now be described on the assumption that trunk 301 is busy and that the next trunk choice is available. In this case it will be observed that the second choice appearance of line A—1 is in switch PLS1 at top of Fig. 4, and to reach an idle trunk of group T1 or T2 it must be assumed that the link 401 is idle, which means all cross-bar switch contacts associated with this link are open and that relay 801 of Fig. 8 and holding magnet H1 are unoperated. It will be remembered that the B1 relay and the C1 relay have operated to mark the location of the calling line and together with relays 203 and 204 remain operated until the line is connected to a trunk. When relay 203 first operated, ground was connected to lead 217 as previously described, which is now further traced through inner make contact relay 512 to top armature 513 and operated contact of relay 511, to armature 523 and back contact on relay 520, thence over lead 524 to battery through selecting magnet 421 of line switch PLS1. Relay 511 is operated at this time because the first choice trunk 301 is assumed to be busy. Relay 512 is operated by relay C1 and relay 520 is unoperated because the link busy relay 801 of Fig. 8 is unoperated. Operating selecting magnet 421 at its lower contact prepares a path for operating relay 223 and at its inner armature and contact closes ground to multiple lead 422, which connects to a series circuit running through the right-hand armatures and front and back contacts of the 20 test relays associated with the 20 outgoing trunks 301 to 320. Lead 422 connects first to the armature of relay 721, but, if the associated trunk 301 is busy, ground on the sleeve lead holds it operated and lead 422 is thereby extended to the right armature of relay 722. If associated trunk 302 is busy, the latter relay will be operated and lead 422 will thereby be extended to the next test relay. Therefore, any selecting magnet in the switch PLS1 or PLS2 which operates and connects ground to the multiple lead 422 will automatically operate the selecting magnet associated with the first trunk in group T1 available to take the call, or if all T1 trunks are busy it automatically in like manner selects the first idle trunk in trunk group T2 or if all T2 trunks are busy, ground on lead 422 will operate relay 723 and unlock all the test relays such as relay 721, that have operated. Since these relays provide for uniformly distributing the traffic over all the trunks, some relays will continue to be held operated, although the trunk itself may be idle. Also those relays associated with trunks that are busy will remain operated even though their locking winding is opened by relay 723. When all the trunks have had a call, relay 723 therefore makes all trunks that are not busy available to receive another call. Assuming now the trunks 301 to 309 are busy and the trunk 310 is the first one that is idle, relay 724 will be the first normal relay in the series starting from the top of Fig. 7, so that lead 422 may then be traced through right back contact relay 724 to battery through winding of selecting magnet 802. Selecting magnet 802 operating connects ground to multiple lead 803, further traced through bottom make contact on operating selecting magnet 421, thence over lead 323, to battery through winding relay 223. The latter relay as previously described supplies ground at its bottom make contact to lead 220 and traced further through top make contact relay 204, lead 221, lower contact on C1 relay over lead 139 to battery through relay 516.

The operation of relay 516 closes the 10 holding magnet leads indicated at 522, one of which will be grounded for operating the holding magnet H1 associated with the idle link 401 of Figs. 4 and

8. This path may be traced from ground on lead 219 previously described, through operated contact 515 of relay 516, armature 517 and front operated contact relay 511, armature 525 and back contact relay 520, thence over lead 526, right inner armature and back contact relay 801 to the mid-point of the two windings of holding magnet H1, to battery through the right-hand winding. Operation of holding magnet H1 on cross-bar switch SLS2 connects ground through the windings in series of the holding magnets that are associated with the same link circuit. In this manner line contacts 1 in cross-bar switch bank PLS1 are held operated by holding magnet 424 and trunk contacts 804 are held operated by holding magnet 805, thereby extending the calling line A—1 traced over lead 134 to lead 425, contacts 1 on cross-bar switch PLS1, link 401, contacts 804 of cross-bar switch SLS1, and finally to trunk 310. Referring to the series circuit through the holding magnets referred to above it will be observed that the holding magnet 427 of cross-bar switch PLS2 will also be operated although no selecting magnet in this switch was energized. The only effect of this is to prevent any contacts at the cross-points in this switch associated with link 401 from being operated as long as this magnet is operated. Similarly the holding magnet H1 of cross-bar switch SLS2 prevents any of the cross-points for link 401 from being operated.

A call originated by subscriber line A—1 will now be described on the assumption that trunk 301 is busy, that link 401 is busy, and that the next choice link is idle. The link in this case is 411, because it is the only other one that can connect the multiple appearance of line A—1 in cross-bar switch PLS2 with one of the idle trunks of groups T1 or T2. Since link 411 is assumed to be idle, relay 806 and holding magnet H11 are unoperated. When relay 203 first operated, ground was connected to lead 217 as previously described, which now may be further traced through inner make contact relay 512, top armature 513 of relay 511, armature 523 and front contact relay 520, thence over lead 527 to battery through selecting magnet 426. Operation of the latter magnet at its bottom outer contact prepares a path for operating relay 223 and at its bottom inner contact connects ground to multiple lead 422, which connects to the series sets of contacts on the test relays shown in Fig. 7 previously described. For this call it will be assumed that the first 10 trunks 301 to 310 are busy or are being held busy so that relay 725 is the first in the series that is unoperated due to the associated trunk being idle. Therefore, ground on lead 422 may be traced through the armatures and front contacts of relays 721, 722 and 724, to right armature and back contact relay 725, to battery through selecting magnet 807 of cross-bar switch SLS2. This magnet operates and closes ground to multiple lead 803 for operating relay 223 through the operated contact on selecting magnet 426, thence over lead 423 and lead 323 to battery through relay 22. Operation of relay 223 closes ground for operating the holding magnet associated with link 411 over a path traced on multiple lead 220, top contact relay 204, lead 221, bottom front contact relay C1, lead 139 to battery through relay 516. The operation of relay 516 prepares the circuits for all ten holding magnets, one of which will be grounded for operating holding magnet H11 associated with the idle link 411 of Figs. 4 and 8. This path may be traced from ground on lead 219 previously described, through contact 515 of relay 516, armature 517 and front operated contact relay 511, armature 525 and front operated contact relay 520, thence over lead 529, right inner armature and back contact relay 806 to the mid-point of the two windings of holding magnet H11, to battery through the right-hand winding. Operation of holding magnet H11 on cross-bar switch SLS2 connects ground through the windings in series of the holding magnets associated with link 411. In this manner contacts 1 in cross-bar switch bank PLS2 are held operated by holding magnet 428, and trunk contacts 808 of switch SLS2 are held operated by holding magnet H11, thereby extending the calling line A—1 to trunk 311. Holding magnet 429 and magnet 809 also being operated at this time merely serve to prevent any other cross-bar switch contacts associated with link 411 from being operated by the selecting magnets as previously explained.

Let it be assumed now that both lines A—1 and A—91 attempt to originate a call at the same time. As previously described only line A—91 will be identified by the control relays of Figs. 1 and 2 wherein relays B1 and C10 remain operated until a connection is established between line 91 and an idle outgoing trunk. This line, as in the case of line 1, has three different channels for reaching an idle trunk so that it will only be necessary to describe one channel which, for the purpose, may be assumed to be the second choice one in which the multiple of line A—91 appears in switch bank PLS1 of Fig. 4. The associated link 410 under this assumption is therefore free at this time which means that test relay 810 and holding magnet H10 are unoperated. Since it is assumed the first choice trunk 310 for this line is busy, it is evident that holding magnet 325 of switch LS will be operated together with its associated switching relay (not shown) in switching relay group SR10 corresponding to relay 511 previously described for relay group SR1. Selecting magnet 421 of switch PLS1 will then be operated from ground through contact 216 on control relay B1 over lead 217 and lead 533 through operated contacts on the switching relays in group SR10 corresponding to relays 512 and 511, and back contact on relay corresponding to relay 520, thence over lead 530 to lead 524 to battery through selecting magnet 421. Switching relays in group SR10 rather than in SR1 function in the above path due to relay C10 being operated instead of relay C1. Selecting magnet 421 then connects ground to lead 422 which connects to the series contacts running through relays 721, 722, etc. It is now assumed that all trunks 301 to 311 are busy by way of example so that relay 726 is the first one that is unoperated. Ground on lead 422 may therefore continue to be traced to battery through selecting magnet 812. Operation of this magnet connects ground to lead 803 for operating common relay 223 as previously described, which in turn connects ground to lead 220 for operating the switching relay in group SR10 corresponding to relay 516 of group SR1. This relay closes the circuits of all associated holding magnets so that ground connected by relay B1 to lead 219 may then be further traced over lead 531 and through operated contacts on the switching relays corresponding to relays 516 and 511 and back contact on relay corresponding to relay 520, thence over lead 532, through inner back contact of relay 810 to mid-point of windings on holding magnet H10. Line 91 appearing in switch bank PLS1 is there-

fore connected over link 410 and trunk contacts 814 to trunk 312 in a similar manner as previously described for line A—1.

If, as previously discussed, lines A—1, A—91 and A—120 attempt to originate calls simultaneously, then the control relays of Figs. 1 and 2 will identify line A—120 as the line next to be served and relays B10 and C12 will remain operated. Since relay C12 controls the switching relays 621 and 622 in group SR12, the selecting and holding magnet circuits will be connected through this group of switching relays in preference to other groups. Assuming now that the first and second choice trunks for line A—120 are busy, relays 623 and 624 will be operated in a manner similar to that previously described for relays 511 and 520. The circuit for selecting magnet 432 may then be traced from ground through operated contact on relay 203 to lead 215, operated contact relay B10 to lead 222, then over lead 625, operated contacts on relays 621, 623, 624, lead 626 to battery through selecting magnet 432. The selecting magnet connects ground to lead 422 as previously described, in order to operate the selecting magnet associated with the first idle outgoing trunk. In this case it is assumed all trunks are busy except the last one, namely trunk 320. The corresponding test relay 727 is therefore normal and the ground on lead 422 thereby extended to battery though selecting magnet 813. Now that both selecting magnets are operated ground is returned to lead 803 for operating relay 223 over a path extending through lower make contact on selecting magnet 432 to multiple lead 423, thence over lead 323 to battery through winding relay 223. The latter relay operated then connects ground to lead 220, traced further through operated upper contact relay 204, lead 221 operated lower contact relay C12, lead 224 to battery through winding of relay 622. Relay 622 operated prepares the circuits for the 10 associated holding magnets. Holding magnet H10, however, is the only one that will operate due to the B10 relay, which connects ground to lead 225, thence over lead 627 through operated contact 628 on relay 622, operated contact 629 on relay 623, operated contact 630 on relay 624, thence over lead 631 to lead 532, right inner break contact test relay 810 to mid-point of holding magnet H10. Line 120 appearing in switch bank PLS2 is therefore connected over link 410 and trunk contacts 815 to trunk 320 in a similar manner to that previously described for line A—1.

From the foregoing description it is obvious that a multiple arrangement of subscriber lines is provided which increases the accessibility to a group of outgoing trunk circuits. It will further be obvious that the particular circuit arrangement disclosed provides means for connecting calling lines one at a time over any one of three connecting channels in a predetermined order to a group of outgoing trunk circuits but it will readily be understood that the circuit arrangement may be varied to suit the particular unit of a telephone system and that other ways of accomplishing the same results might be employed.

What is claimed is:

1. In combination, switches, each having rows of separately operable contact sets, a group of lines appearing in a row of contacts in each of a plurality of said switches, trunks, links, means including a particular one of said trunks for effecting a connection in said group of lines by way of one of said switches, means including any of said trunks and a particular one of said links for effecting a connection in said group of lines by way of a second one of said switches, and means including any one of said trunks and any one of said links for effecting a connection in said group of lines by way of another one of said switches.

2. In combination, switches, each having rows of separately operable contact sets, a plurality of groups of lines, each group of lines occupying a row of contacts in each of said switches, a group of trunks, a plurality of links, means including a particular one of said trunks for establishing a direct connection with a given group of lines by way of a particular one of said switches, means including any one of said trunks and a particular one of said links for establishing a connection with said given group of lines by way of a second one of said switches, and means including any one of said trunks and any one of said links for establishing a connection with said given group of lines by way of a third one of said switches, the particular link used depending upon the line involved.

3. In combination, three switches, each having vertical and horizontal rows of contacts, a group of lines appearing in a vertical row in one of said switches, appearing in a vertical row in the second one of said switches and appearing in a horizontal row in the third switch, a plurality of trunks, one of which appears directly in said vertical row of contacts in said first mentioned switch, and a plurality of link circuits connectible to said trunk lines, one of which appears in said vertical row of contacts in said second switch and all of which appear in the horizontal row of contacts in said third switch.

4. In combination, primary switches, secondary switches, a group of lines appearing in each of said primary switches, trunks appearing in a particular one of said primary switches and in said secondary switches, links appearing in certain of said primary switches and said secondary switches, and means for operating said switches to extend a calling line in said group either through said particular primary switch directly to one of said trunks, or through one of said primary switches and one of said secondary switches by way of one of said links, or through another one of said primary switches and one of said secondary switches by way of another of said links.

5. In combination, first, second and third cross-bar switches, each having vertical and horizontal rows of contacts, groups of lines, each group appearing in a vertical row of contacts in the first and second switches and in a horizontal row of contacts in the third switch, a plurality of trunks appearing respectively in the vertical rows of contacts of said first switch, a plurality of links appearing respectively in the vertical rows of contacts of said second and third switches, and other cross-bar switches in which both said trunks and links appear.

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