

March 2, 1937.

T. A. SPENCER

2,072,434

SWITCHING SYSTEM

Filed Aug. 13, 1935

8 Sheets-Sheet 1

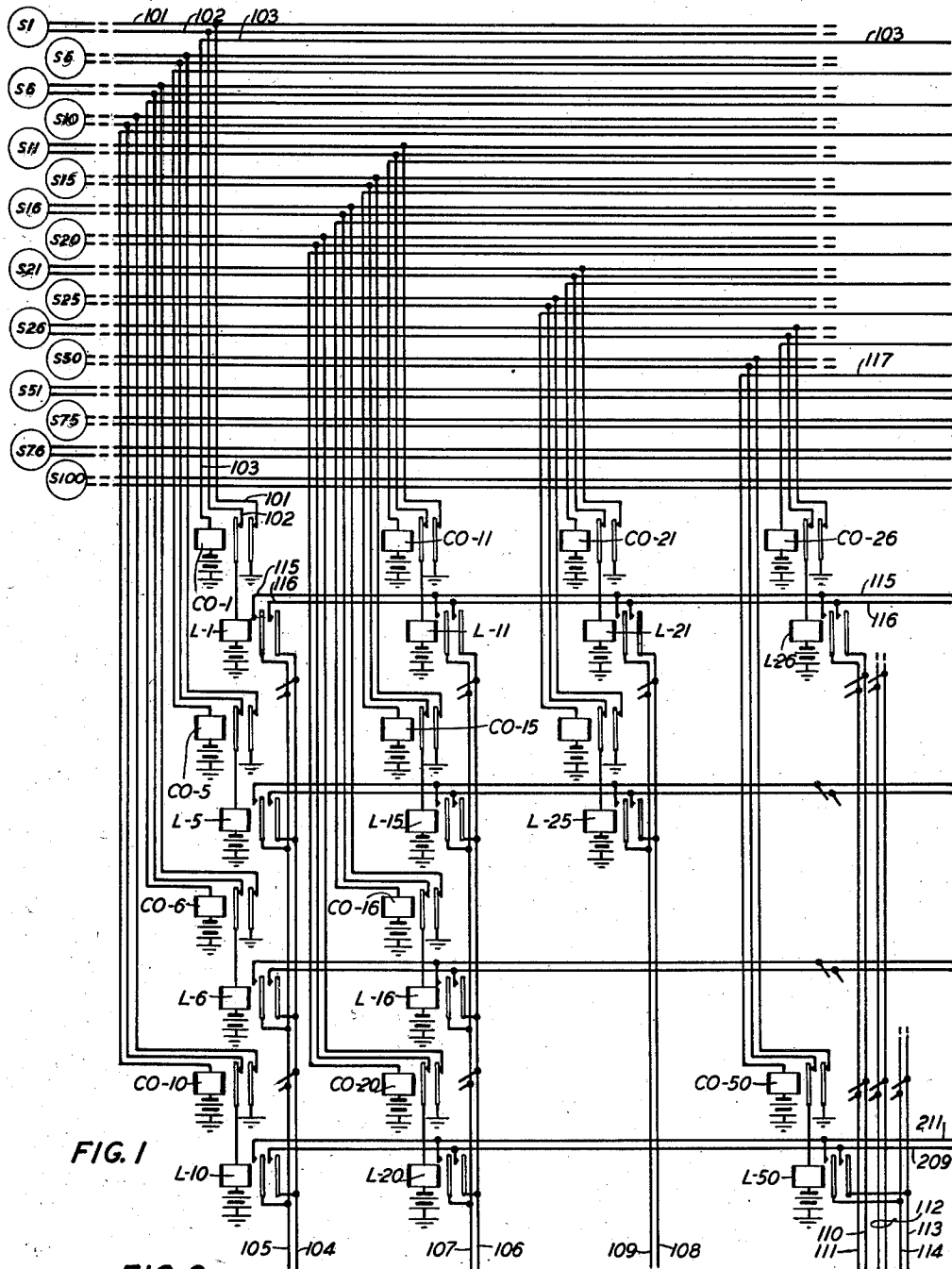


FIG. 1

FIG. 9

|        |        |        |
|--------|--------|--------|
| FIG. 1 | FIG. 2 | FIG. 3 |
| FIG. 4 | FIG. 5 | FIG. 6 |

INVENTOR  
T. A. SPENCER  
BY  
*W. R. McFadden*  
ATTORNEY

March 2, 1937.

T. A. SPENCER

2,072,434

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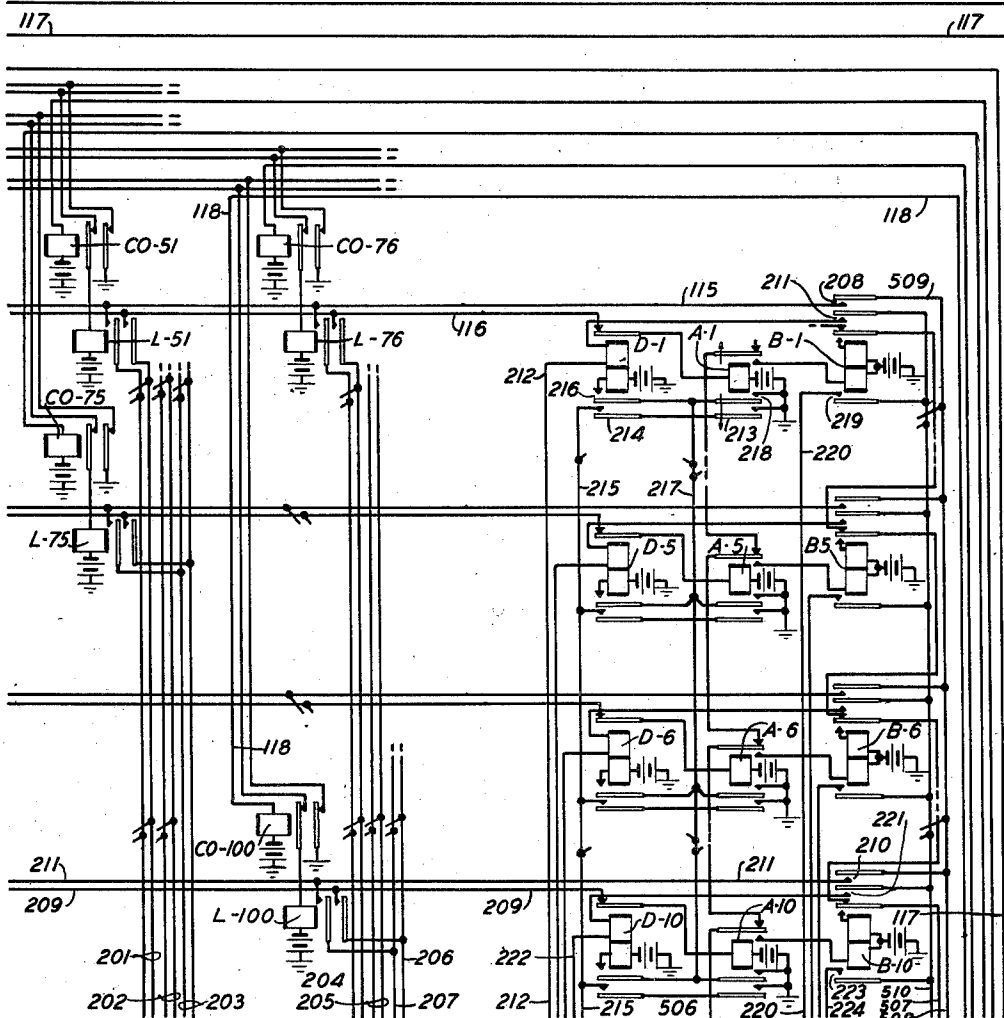
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103<sub>1</sub>

FIG. 2

103<sub>1</sub>



INVENTOR  
T. A. SPENCER  
BY  
*W. P. McFarney*  
ATTORNEY

**2,072,434**

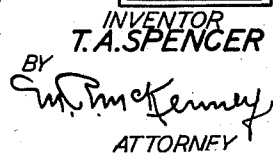
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INVENTOR  
T.A. SPENCER  
BY  
W. P. McNamee  
ATTORNEY

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BY *W. M. Kerney*  
ATTORNEY

**March 2, 1937.**

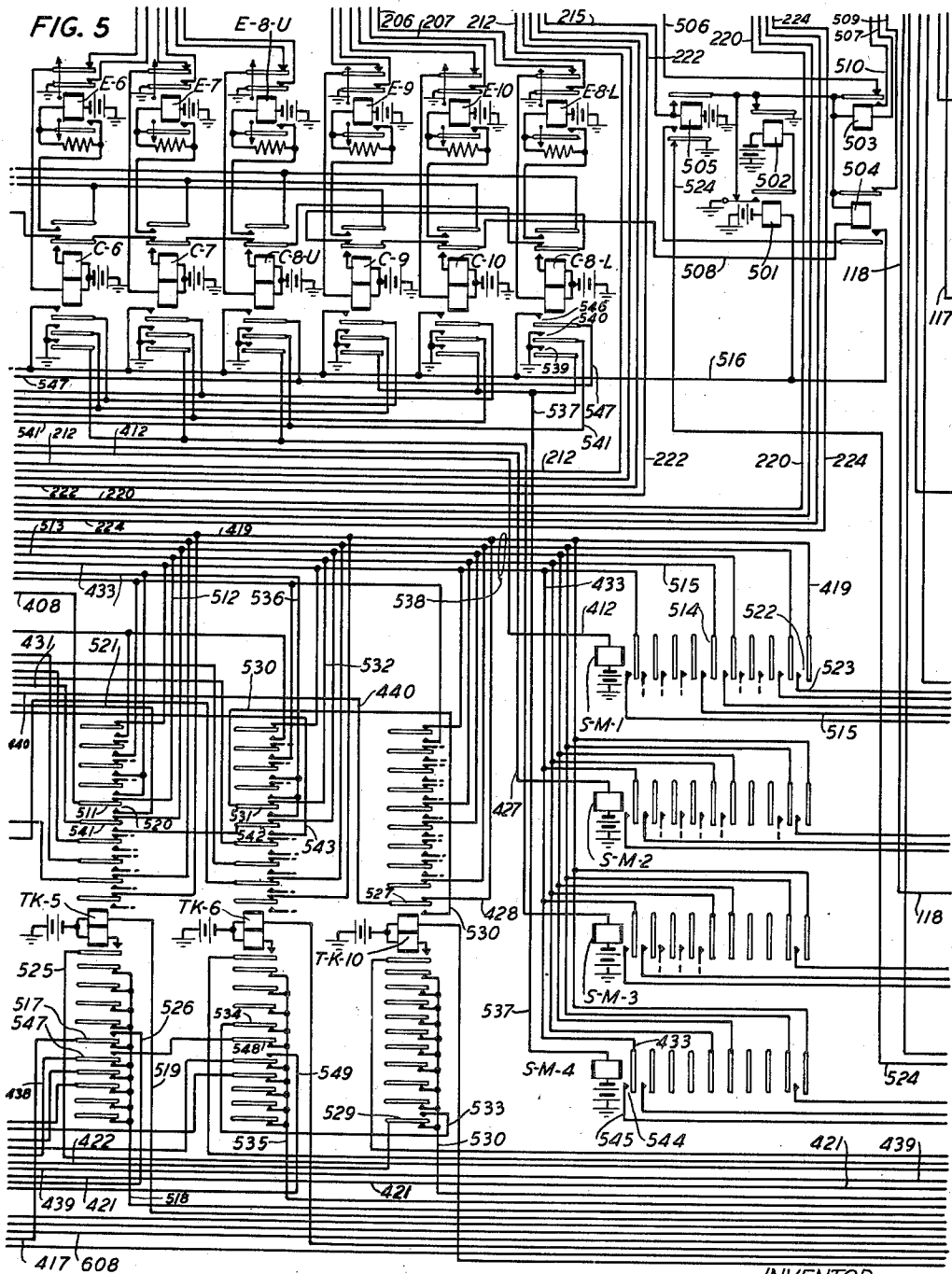
T. A. SPENCER

**2,072,434**

SWITCHING SYSTEM

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INVENTOR  
T.A. SPENCER  
BY  
M. J. McJannet  
ATTORNEY

**March 2, 1937.**

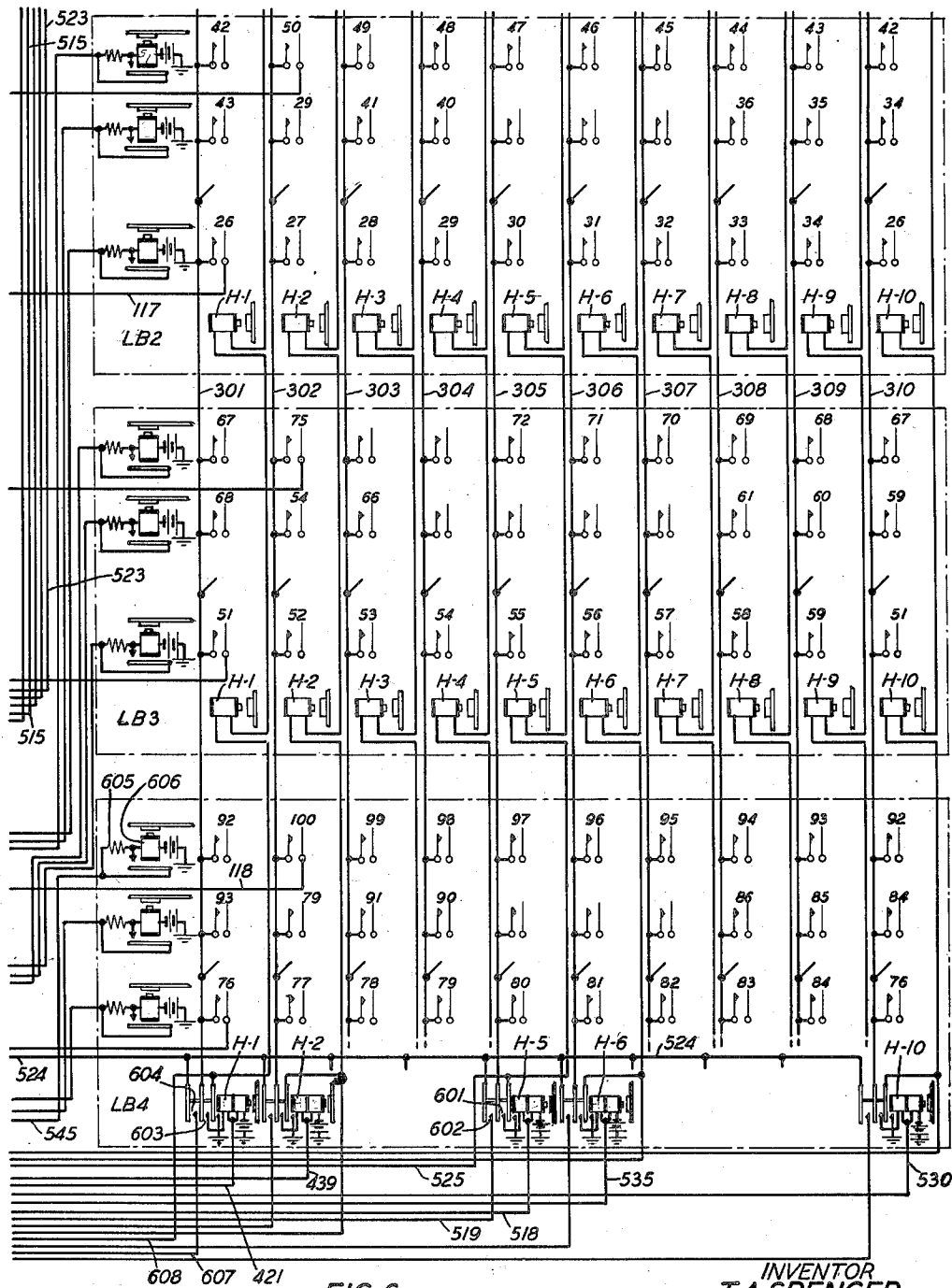
**T. A. SPENCER**

**2,072,434**

## SWITCHING SYSTEM

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INVENTOR  
T.A. SPENCER

BY

ATTORNEY

March 2, 1937.

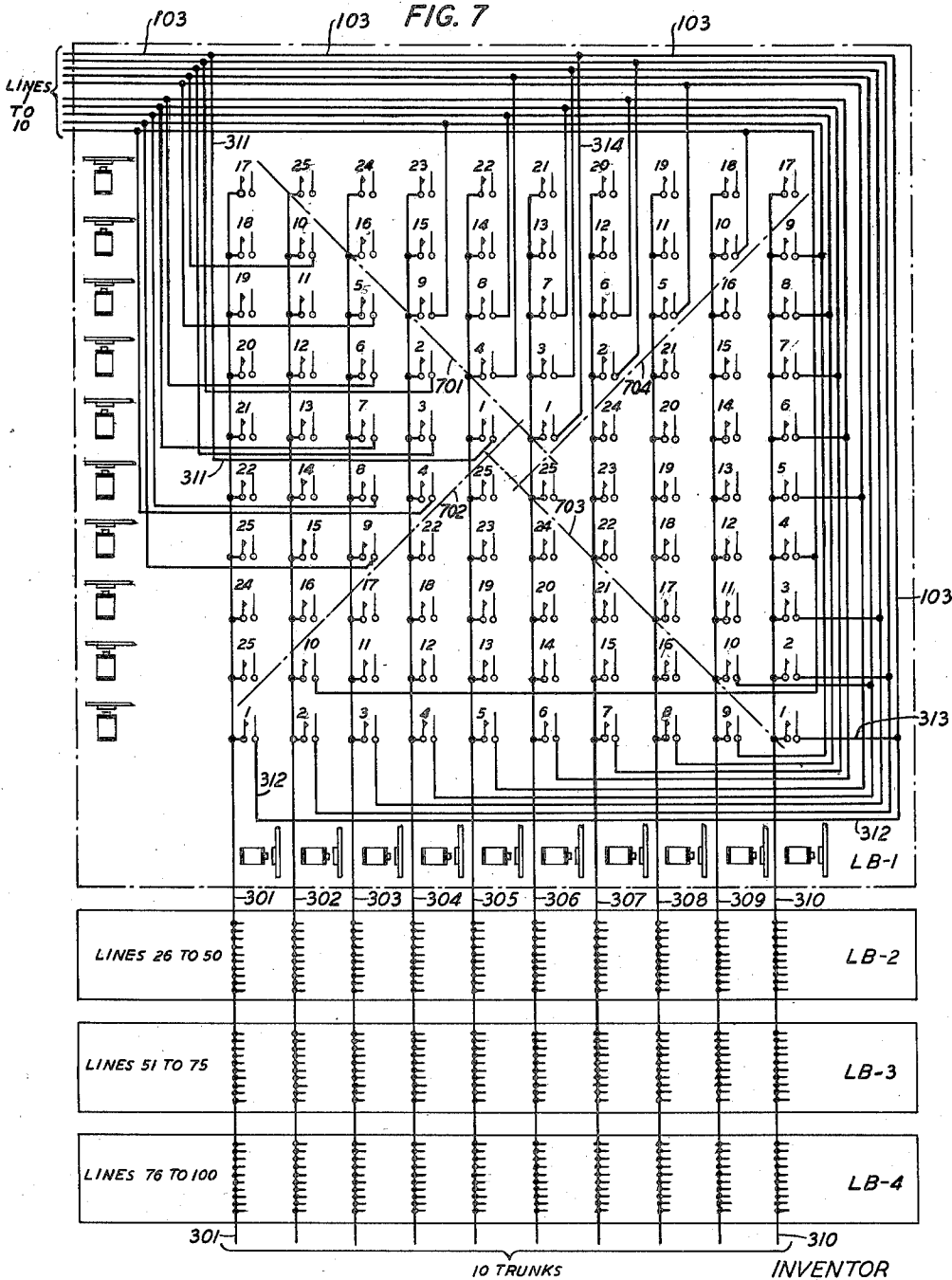
T. A. SPENCER

2,072,434

SWITCHING SYSTEM

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INVENTOR  
T. A. SPENCER  
BY

*W. McSperry*  
ATTORNEY

March 2, 1937.

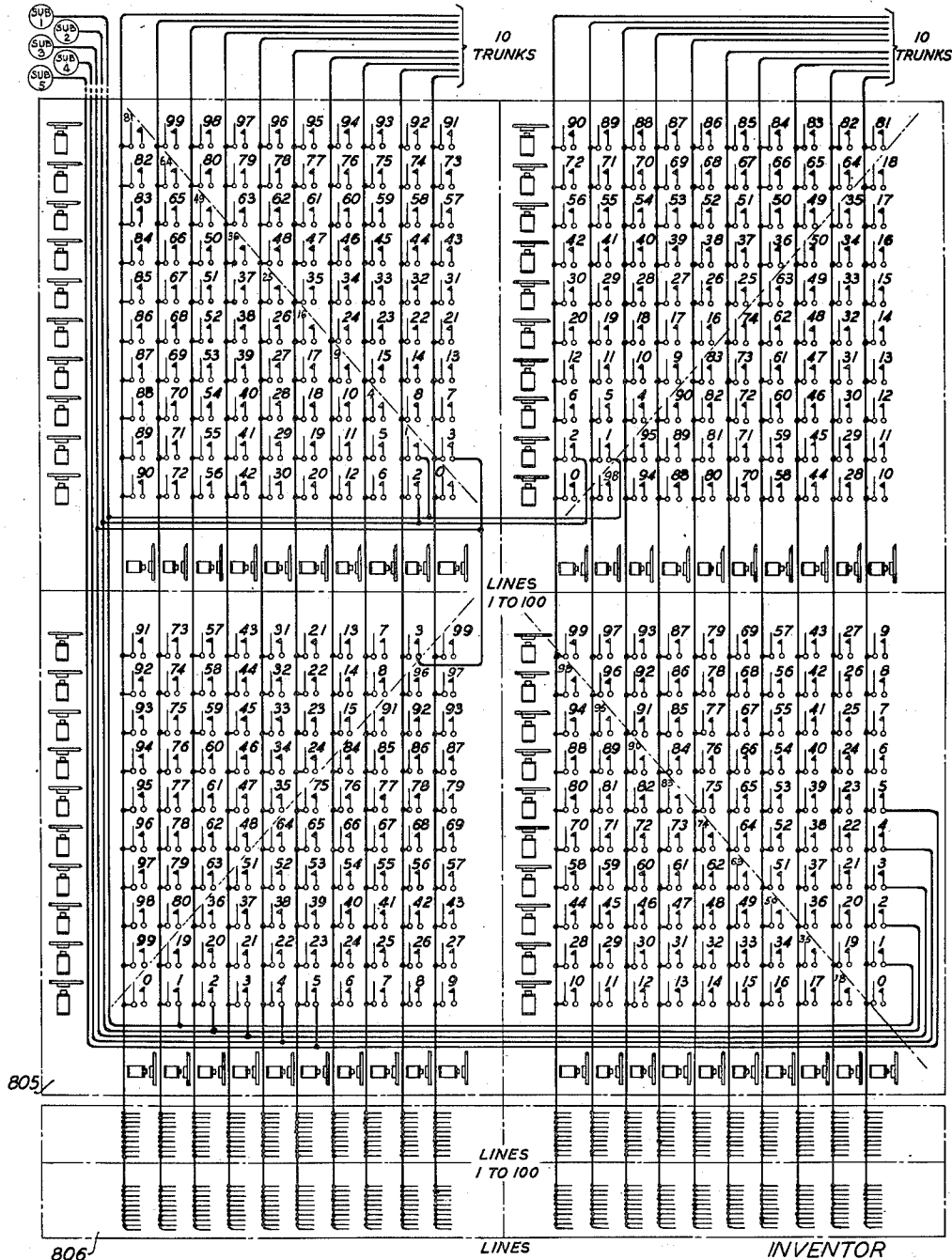
T. A. SPENCER

2,072,434

SWITCHING SYSTEM

Filed Aug. 13, 1935

8 Sheets-Sheet 8



INVENTOR  
T.A. SPENCER  
BY  
*W. M. Kenney*  
ATTORNEY



## UNITED STATES PATENT OFFICE

2,072,434

## SWITCHING SYSTEM

Thomas A. Spencer, Belleville, N. J., assignor to  
Bell Telephone Laboratories, Incorporated, New  
York, N. Y., a corporation of New York

Application August 13, 1935, Serial No. 35,926

9 Claims. (Cl. 179—18)

This invention relates to switching mechanism and particularly to a switching mechanism of the type used in automatic telephone systems.

The object of the invention is to increase the accessibility of the lines of a group by increasing the number of appearances of each line in the switching mechanism, while at the same time preserving a high degree of efficiency in the service given said lines.

A feature of the present invention is an arrangement of lines in a switching mechanism in which the lines are divided in groups of different sizes and assigned to coordinate rows of contacts in said mechanism, each group appearing in rows of contacts in both coordinate directions.

Another feature is an arrangement of lines in a switch mechanism comprising a plurality of cross-bar switches in which the lines are divided into groups of different sizes and assigned to the contacts of said switches in such a way that each group appears in vertical rows of contacts in some of said switches and in horizontal rows in other of said switches.

Another feature of the invention is a switch in which each line occurs in one group comprising a given combination of lines, which group appears both in a horizontal row and in a vertical row, and also occurs in a second group comprising a different combination of lines, which second group likewise appears in a horizontal and in a vertical row.

These and other features will be described more in detail in the following description and will also be set forth in the appended claims.

In the accompanying drawings, Figs. 1 to 6, inclusive, when placed together as indicated in Fig. 9, show complete circuit connections for a line switch arrangement in cross-bar systems in which subscriber stations may be connected with idle trunk circuits leading to selector switches (not shown). Figs. 7 and 8 are schematic illustrations showing how the lines of a group may be assigned to the contacts of a switch mechanism.

The cross-bar switches shown in Figs. 3, 6, 7 and 8 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. While the invention is described in connection with switches of the cross-bar type, it may be practiced in its broader aspects with other kinds of switches. It will also be obvious from further description that the features of this invention need not be confined to a line

switch arrangement of the kind to be described, but may equally well be applied to other switching stages and to trunking systems generally, wherein it is desired to concentrate traffic on a reduced number of trunks or to automatic telephone systems wherein the subscriber lines are made accessible to a smaller number of switching mechanisms.

For the purpose of simplifying this description, 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 and one for the sleeve lead 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 two bars, illustrated in Figs. 7 and 8, 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 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, actuated by a holding magnet shown directly below the vertical row of contact sets in each switch unit.

The schematic of the line switch arrangement above referred to is shown in Fig. 7 in order to illustrate in a general way the manner in which subscriber lines are given access to outgoing trunk circuits. Cross-bar switch LB1 is the same as shown in detail in Fig. 3 and provides for twenty-five subscriber lines wherein each line has four multiple appearances arranged so that each may have access to any one of four trunks out of a total of ten trunks. To accomplish this feature, a definite order of multiplying is employed as will be evident by referring to the dotted lines 701, 702, 703 and 704 which have been drawn to indicate where one set of multiple stops and another begins. Between the lines 701 and 702, for example, as will be hereafter described, each of the twenty-five lines has one appearance and a call from any of these lines will be completed through this multiple appearance as long as the trunk available to the line calling is idle. If said trunk is busy, then the call will be completed through a second appearance of the line. This second appearance is shown

by the enclosure within the dotted lines 702 and 703. When the trunk available to the calling line in this multiple appearance is likewise busy, then the call will be completed through a third multiple appearance as indicated by the enclosure between the dotted lines 703 and 704. If the trunk available to the line that is calling is also busy, then the call will be completed through a fourth multiple appearance as limited by the dotted lines 704 and 701. Line 1, for example, represented by lead 103, would first be connected over lead 311 and corresponding cross-bar switch contact 1 to trunk 305, but if the latter trunk is busy, line 1 will be connected over leads 103 and 312 to trunk 301. If both trunks 305 and 301 are busy, the calling line 1 will be connected over leads 103 and 313 to trunk 310. If trunks 305, 301 and 310 are busy, the line will be connected over leads 103 and 314 to trunk 306. In this manner, the twenty-five lines are arranged so that each has an equal number of trunk accesses which are definitely grouped and numbered as shown.

The number of calls originating on twenty-five subscriber lines as a general thing would not be sufficient to keep ten trunks busy. This invention, therefore, contemplates the desirability of connecting the same trunks to contact points of other cross-bar switch banks shown in Figs. 6 and 7 within the rectangles LB-2, LB-3 and LB-4. It will be obvious from this arrangement that a greater or lesser number of banks may be given access to a given group of ten trunks sufficient to keep them busy. It will also be evident that the associated circuits must be so arranged that a calling line will be directed in a definite order, one at a time, toward the first of the four choices of trunks that are idle. While for descriptive purposes, four groups of twenty-five lines are assumed together with their associated circuits as shown in Figs. 1 to 6, it will be obvious that any number of groups of lines could be provided for by a simple modification or extension of the circuits shown.

In the system of this invention, every line, in general, has access to four different trunk circuits and to avoid interference a definite sequence of access is provided for each line. It is, therefore, necessary to first know or identify the calling line. To do this, a line and cut-off relay is provided for each line as shown in Figs. 1 and 2, said relays being mounted in ten vertical rows of ten line relays L and then cut-off relays CO per row. The drawings, for example, show line and cut-off relays connected to identifying leads 104 and 105 for lines 1, 5, 6 and 10 in the first row; line and cut-off relays connected to leads 106 and 107 for lines 11, 15, 16 and 20 in the second row; line and cut-off relays connected to leads 108 and 109 for lines 21 to 25 in the top half of the third row. These relays provide for the first group of twenty-five lines appearing in cross-bar switch bank LB-1 shown in full in Figs. 3 and 7. Since the sequence of line appearances in the other three groups of twenty-five lines is identical with that of the bank LB-1, only enough line and cut-off relays in Figs. 1 and 2 are shown to illustrate the three additional groups of lines. Line and cut-off relays for line 26 thus represent a fourth row of ten sets of relays connected to identifying leads 110 and 111 for lines 26 to 35; no relays are shown in the next or fifth row for lines 36 to 45 except identifying leads 112; line and cut-off relays for line 50 represent a row of relays connected to

leads 113 and 114 for lines 46 to 50 and would be mounted in the bottom half of the third row with relays for lines 21 to 25. These relays, therefore, represent the line and cut-off relays for the second group of twenty-five lines appearing in cross-bar switch bank LB-2 of Fig. 6. For the third group of twenty-five lines, line and cut-off relay 51 of Fig. 2 represents the sixth row of ten sets of relays connected to identifying leads 201 for lines 51 to 60; no relays are shown in the next or seventh row for lines 61 to 70 but identifying leads 202 are shown; line and cut-off relay 75 represents the top half of the eighth row connected to leads 203 for lines 71 to 75. In like manner for the fourth group of twenty-five lines appearing in line bank LB-4 of Fig. 6, the line and cut-off relay 76 of Fig. 2 represents a ninth row of ten sets of relays connected to identifying leads 204 for lines 76 to 85; no relays are shown in the next or tenth row for leads 85 to 96 but identifying leads 205 are shown; line and cut-off relay 100 represents the bottom half of the eighth row connected to identifying leads 206 and 207 for lines 96 to 100.

A calling line is identified by the location of its line and cut-off relays in a given horizontal and a given vertical row of the L and CO relays just described. The A and B relays of Fig. 2, located opposite each of the ten horizontal rows of L and CO relays, are used to determine the horizontal row, while the C relays at the top of Figs. 4 and 5 are used to determine the particular vertical row in which the calling line is located. These relays, in conjunction with relays 501 to 505 of Fig. 5, also serve to prevent more than one line at a time from being assigned an idle trunk by virtue of the fact that only one set of A and B relays and one set of C relays remains operated during the assignment of a trunk to an incoming call. Trunk busy relays TK-1 to TK-10 are provided as shown in Figs. 4 and 5, one for each outgoing trunk so that if the trunk is busy the circuits to the selecting and holding magnets will be transferred to the next trunk in a given preferential order. Since this order of preference for each of the twenty-five lines in a group is different, relays 401, 403 and 405 are provided for transferring the leads to the selecting magnets and relays 402, 404 and 406 are provided for transferring the holding magnet leads, as will hereinafter be explained. Relays SM-1 to SM-4 of Fig. 5 are provided for connecting the preference leads to selecting magnets associated with the particular group of twenty-five lines in which the call originates.

Thus far, the outline of a telephone exchange system embodying the features of this invention has involved a unit of one hundred lines as indicated in Fig. 7. It will, however, be evident that these features may readily be adapted to serve in telephone exchange systems where the unit is greater than one hundred lines and where a larger group of trunks is available. For example, Fig. 8 has been drawn to show the application of the features of this invention to exchange systems where units of two hundred lines and twenty trunks prove to be the most economical. In this figure, the four multiple appearances of one hundred subscriber lines are spread over four 100-point cross-bar switch banks 805 in such a manner that the lines occur in groups of different sizes the same as in Fig. 7, each such group appearing in a horizontal row of contacts in the switches and also in a vertical row of contacts in the switches. Moreover, there are two sets of these different-

sized groups, the lines which constitute the groups of one set differing from the lines which constitute the corresponding groups of the other set. For example, the group of nineteen lines occupying the bottom horizontal row of contacts in the drawings and also occupying the right-hand vertical row of contacts comprises lines 0 to 18; whereas the group of nineteen lines occupying the upper horizontal and the left-hand vertical rows of contacts comprises lines 81 to 99. Likewise, the group of three lines occupying the middle part of the second horizontal row from the bottom of the two upper switches and also occupying the middle part of the ninth vertical row of the two left-hand switches comprises lines Nos. 1, 2, and 3. An inspection will show that other pairs of corresponding groups are composed of different combinations of lines. Thus the different lines have access to a number of trunks through different groups, and each line has a preference for these trunks the same as in the arrangement of Fig. 7. A second set of four 100-point cross-bar switches 806, identical with the first set 805, provides for four appearances of each of the second group of one hundred lines. While no switching circuit connections are shown for the arrangement of Fig. 8, it will be readily understood that said electrical connections may be made on a basis similar to that shown in Figs. 1 to 6.

The invention having been described generally, a detail description of the operation of the apparatus shown will now be given. For this purpose it will be assumed that the subscriber at substation S1 initiates the call. Upon removal of the receiver a bridge is placed across the line conductors 101 and 102 of Fig. 1, which operates the relay L-1 over a path traced from battery through winding of relay L-1, inner armature and break contact relay CO-1, line conductors 101 and 102, including the subscriber's bridge, then through outer contact and armature relay CO-1 to ground. Operation of relay L-1 at its inner contact prepares a path for operating relay C-1 over conductors 105 and 115, and at its outer contact closes a circuit for operating relay A-1 of Fig. 2. The latter circuit may be traced from grounded battery, through winding of relay A-1, top armature and contact of relay D-1, thence over lead 116 and outer contact relay L-1 to lead 104, to ground through top inner contact and armature relay E-1. Relay A-1 operates and at its upper front contacts connects lead 506 to battery through lower winding relay B-1. Lead 506, being a test lead running through the back contacts on other relays, A-10 to A-2, will be open at left back contact relay 503 if another call in the group of one hundred lines is in the process of selecting a trunk. Assuming, however, that relay 503 is unoperated, the ground from the top break contacts of relays 501 and 502 will be connected through break contact relays 503, lead 506, through armatures and break contacts on relays A-10 to A-2, make contact on operated relay A-1 and through lower winding relay B-1 to battery. Relay B-1 thus operates, but if simultaneous calls had originated on subscriber lines S1 and S2 or S1 and S10, then relays B-2 or B-10 respectively would have operated in the path previously traced in preference to relay B-1. Tracing further the call from line S1, when relay B-1 operates, it closes a circuit from battery through its own top winding and front contact to another test lead 507 running through the armatures and break contacts on other B relays to ground through winding of relay 503. The lat-

ter relay operating then opens lead 506 and prevents later calls from interfering with the handling of the call on line S1. Test leads 506 and 507 thus control the vertical preference by permitting the lowest of the calling lines in any group of ten to search for a trunk and locking out all other lines until an idle trunk is found or until the call is timed out when another attempt is made to select a trunk.

Before a search is made for an idle outgoing trunk for the call on line S1, it is necessary to find out in which vertical group of ten lines the calling line is located, otherwise referred to as the horizontal preference. This is determined by the common relay 504 in upper right corner Fig. 5, and the relays C-1 to C-10, inclusive, together with lead 508. Therefore, immediately after the vertical preference is determined, described in the preceding paragraph, the B-1 relay of Fig. 2 closes a circuit for operating relay C-1 of Fig. 4 over a path traced from ground at the top break contact relays 501 and 502 of Fig. 5, through armature and back contact relay 504, thence over multiple lead 509, contact 208 on relay B-1, multiple lead 115, through operated inner contact on relay L-1, multiple lead 105, top break contact and armature relay E-1, and through bottom winding relay C-1 to battery. Relay C-1, in operating, locks to ground through its upper winding and front contact to lead 508, traced through all the top break contacts and armatures of relays C-2 to C-10 thence through winding of relay 504 to ground at top contacts of relays 501 and 502. Relay 504, in operating, opens its own top contact which breaks the operating circuit previously traced for the lower winding of relay C-1, thus preventing later calls that might originate in other groups of lines from interfering with the handling of the call on line S1. 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, B-1 and C-1 remain operated. Before proceeding to show how this line is actually connected with an idle one of the outgoing trunks, it is thought that this vertical and horizontal preference 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 S1 and S26 lift their receivers about the same time, line relay L-1 and corresponding B-1 and C-1 relays will operate as previously described. Line relay L-26 will also operate and connect ground that is on lead 110 to lead 116. Since both relays L-1 and L-26 connect ground to lead 116, which path is further traced through relay A-1, it is evident that only the B-1 relay will operate. The vertical preference is thus determined by the B-1 relay being operated, both lines being the topmost one in their respective subgroups. When, therefore, ground is placed on lead 115 at contact 208 by relay B-1, a circuit is established for operating both the C-1 and C-4 relays, traced over lead 115 to right inner contact relay L-26, lead 111, top outer contact and armature relay E-4 to battery through lower winding relay C-4; also traced over lead 115 through inner contact relay L-1, lead 105, top outer contact and armature relay E-1, to battery through lower winding relay C-1. In this case, the locking circuit through the upper winding relay C-4 is completed back over the series lead 508 to the winding of relay 504 to ground, while the locking circuit through the upper winding of relay C-1 is held

open at contact 407 on relay C—4. Relay 504 operating, thus opens at its top break contact, the circuit for energizing the lower windings of relays C—1 and C—4 so that relay C—1 releases and relay C—4 remains operated. In this manner, line S26 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 B—1 and C—4 relays remaining operated as will later be described.

Another example is assumed where subscriber lines S1, S26 and S100 lift their receivers nearly simultaneously, in which case relay A—1 operates over lead 116 through contacts on relays L—1 and L—26 as previously traced. Line relay L—100 of Fig. 2, also operating, connects ground that is on lead 206 to lead 209, thence through top contact and armature on relay D—10, through winding relay A—10 to battery. The operation of relay A—10 causes relay B—10 to operate from ground on lead 506, and at the same time the top break contact opens the circuit to the armature relay A—1 and prevents relay B—1 from operating. The failure of relay B—1 to connect ground to lead 115 prevents relays C—1 and C—4 from operating. On the other hand, relay B—10 at contact 210 connects ground to lead 211 for operating relay C—8—L further traced through inner contact relay L—100, lead 207, top break contact relay E—8—L to battery through lower winding relay C—8—L. In this manner line 100 is identified as the calling line to be handled first and search for an idle outgoing trunk is determined by the combination of the B—10 and C—8—L relays remaining operated as will later be described. It should be observed at this point that each of the vertical rows, 3 and 8, of the L and CO relays are divided into two parts with the C and E relays corresponding to the upper set being designated 3—U and 8—U, respectively, and for the lower set 3—L and 8—L respectively. This makes it possible to arrange the four separate twenty-five line groups in two and one-half rows for each group.

Going back to the condition ensuing forthwith upon the identity of calling line S1 being determined by relay B—1 of Fig. 2 and relay C—1 of Fig. 4 remaining in an operated condition, their will now be described in the manner in which a search is made for an idle trunk. Relays 503 and 504 of Fig. 5, it will be remembered, are also in an operated condition at this time which prevents interference from other lines that might originate calls. Since each calling line has four possible chances for reaching an idle trunk, it will be assumed that the first choice trunk 305 is idle. Relay TK—5 of Fig. 5, therefore, is normal because if the trunk 305 were busy it would be operated as it will presently appear.

Relay 503 in addition to opening the circuit of test lead 506 also connects ground from the top break contacts of relays 501 and 502 to multiple lead 510, thence through contact 211 on relay B—1, and through upper winding relay D—1 to lead 212, through inner make contact relay 401, which is operated at this time, lead 408, armature 511, and back contact on relay TK—5 thence over leads 512 and 513 to armature 514 and front contact on operated relay SM—1, thence over lead 515, and through resistance 315 of Fig. 3 to battery through winding of selecting magnet 316. In the path just traced, relay 401 of Fig. 4 is operated because relay C—1 connects ground at contact 409 to multiple lead 410, thence to battery through

winding relay 401. In like manner, relay SM—1 of Fig. 5 is operated because relay C—1 connects ground at contact 411 to multiple lead 412, thence to battery through winding relay SM—1. Having operated the selecting magnet 316 in cross-bar switch LB—1 of Fig. 3 corresponding to the horizontal row in which the multiple of line S1 first appears, contact 317 on the magnet short-circuits resistance 315 thereby causing the marginal relay D—1 of Fig. 2 to operate and open the circuit for slow release relay A—1. The latter relay delays releasing long enough to hold ground on the circuit for operating relay 505 of Fig. 5 over a path traced through its own armature 213, armature 214 and front contact relay D—1, lead 215, through winding relay 505 to battery.

When marginal relay D—1 operated, it established a locking circuit for itself at contact 216 to multiple lead 217 which prevents locking out calls in the upper half of the vertical rows of L and CO relays due to an abnormal number of calls continuing to originate in the lower half of the rows. Thus, if another call is waiting in the first group, for example, when relay D—10 operates on a call, the latter relay remains operated due to lead 217 being grounded by contact 218 on relay A—1. In this manner, during the busy hour, each D relay will remain operated until all D relays have operated or until no more calls are waiting.

Relay 505 operating, locks to ground on contacts of relays 501 and 502 and at its bottom make contact closes a circuit from ground for operating the cross-bar switch holding magnets and for operating relay 501 and in turn relay 502. The latter two relays are slow releasing and slow operating, respectively, timed so that the holding magnet will be assured of sufficient time to fully operate, after which relay 505 will be released and the operating path to the holding magnets broken. The circuit previously mentioned for operating the holding magnet corresponding to first choice trunk 305 for calling subscriber S1, may be traced from ground on lower armature and make contact relay 505 to lower armature and front contact relay 506, lead 516, thence through contact 413 on operated C—1 relay, lead 414 to battery through winding relay 402. The latter relay operates and prepares the ten leads indicated at 415 for operating one of the holding magnets determined by which one of the B—1 to B—10 relays of Fig. 2 is in an operated position and whether any of the TK relays are operated. The circuit for the holding magnet in case of line 1, is determined by relay B—1 and may be traced from ground on the contacts of relays 501 and 502 through operated make contact relay 503, multiple lead 510, contact 219 on relay B—1 to lead 220, armature and contact 416 of relay 402, lead 417 to armature 517 on TK—5 relay of Fig. 5, thence over back contact to lead 518 and battery through right-hand winding holding magnet H—5 of switch LB—4 of Fig. 6. The latter operates in this circuit and at contact 601 establishes a holding path for itself as will later be explained and at contact 602 prepares a path to lead 519 for operating relay TK—5 and at its left inner contact connects ground for operating the corresponding holding magnets on the other three cross-bar switches, namely, LB—3, LB—2 and LB—1 connected in series. Inasmuch as the only selecting magnet operated at this time is 316 of Fig. 3, the contact points at cross-point for line 1 will be the only one closed, thus connecting line 1 directly with trunk 305 traced over lead 103, lead 311, line 1 contacts of cross-bar switch

LB-1, trunk 305 to an incoming selector at T, not shown.

In the system of this invention, upon connecting with an idle trunk, ground is returned over the sleeve or control wire thus traced for holding the connecting switches until the subscriber restores his receiver to the switch-hook, all in a manner well understood in the art. Therefore, upon the closure of contact 1 in the switch LB-1, ground may be traced on the sleeve of trunk 305, back over leads 311 and 103 to battery through CO-1 relay of Fig. 1, thus causing line relay L-1 to release. Ground returned on the sleeve of trunk 305 may also be traced through contact 601 and left winding on holding magnet H-5 to the mid-point of the magnet windings to which direct operating ground was traced in the previous paragraph. Thus, when the timing relays 501 and 502 of Fig. 5 previously referred to operate and remove ground from the lead connected to the midpoint of holding magnet H-5, the magnet continues to remain operated on the trunk holding ground through both windings in series. Furthermore, when relay 505 releases due to the operation of relays 501 and 502, ground will be connected to multiple lead 524 for operating relay TK-5 over a path traced through contact 602 on magnet H-5, lead 519 and battery through upper winding relay TK-5. The latter relay operates, thereby transferring the trunk selecting circuit to the next choice trunk. Relay TK-5 closes a locking circuit for itself back over lead 525 to the sleeve of trunk 305 and thereby remains operated as long as the connection is held by the subscriber. Relay 505, being released, permits relays 501 and 502 to release after a short interval and restore the circuits to normal for the next call.

Having described a call from subscriber line S1 on the assumption that the outgoing trunk 305 was idle, this call will now be described on the assumption that trunk 305 is busy and that the next trunk choice is available. In this case it will be observed that the second choice appearance of line S1 is in switch LB-1 at the lower left corner of Fig. 3 wires to connect with trunk 301 which, for this case, is assumed to be idle. Thus, all cross-bar switch contacts associated with this trunk are open and relay TK-1 of Fig. 4 and holding magnets are unoperated. It will be remembered that removal of the subscriber's receiver from the switch-hook caused the B-1 relay of Fig. 2 and the C-1 relay of Fig. 4 to operate and mark the location of the calling line. These relays, together with relays 503 and 504 of Fig. 5, remain operated until the line is connected to a trunk. Thus, when relay 503 of Fig. 5 first operates and connects ground to a circuit, including lead 510 and top winding relay D-1 of Fig. 2 and leads 212 and 408 as previously described, said ground path is further traced through armature 511 on relay TK-5 which is now operated due to trunk 305 being busy. The path just traced at the front contact 520 relay TK-5 thus may further be traced over lead 521, armature 418, and back contact on relay TK-1, thence over multiple lead 419, through contact 522 on relay SM-1, lead 523, to battery through resistance 318 and selecting magnet 319 of cross-bar switch LB-1.

The selecting magnet 319 operating, short-circuits at its bottom contact resistance 318 thus increasing the flow of current through selecting magnet circuit which includes marginal relay D-1. The latter relay operates, causing relay

505 to operate over lead 215 previously traced. Relay 505 operating, closes a circuit for relay 402 over a path traced from ground on its bottom armature and front contact, bottom armature and front contact relay 504, lead 516, contact 413 on relay C-1, lead 414 to battery through relay 402. Relay 402 operating, prepares the ten leads indicated at 415 for operating one of the holding magnets as previously described. The holding magnet H-1 of switch LB-4 in this case, therefore, is operated by ground through contact 219, relay B-1 to armature 517, relay TK-5 previously traced and further traced over front contact relay TK-5, lead 526, armature 420 and back contact relay TK-1, lead 421, to mid-point on holding magnet H-1 of the switch LB-4. Line 1 is thus connected to trunk 301 at contact 1 on switch LB-1 due to ground at inner contact on magnet H-1 of switch LB-4, being connected to the H-1 holding magnets of the other switches LB-3, LB-2 and LB-1 in series. In the same manner as previously described for trunk 305, ground returned over the sleeve of trunk 301 is connected through contact 603 of holding magnet H-1 of switch LB-4 for maintaining the latter operated during the time it is busy. The magnet H-1 likewise closes a contact 604 for operating busy relay TK-1 over leads 524 and 607 upon the release of relay 505 of Fig. 5 which occurs when the selecting circuits are ready for the next call. Relay TK-1 operated, locks over lead 608 to the sleeve of trunk 301.

It will be evident from the above description of the call on line S1 selecting first trunk 305 and then trunk 301, that the busy relays TK-5 and TK-1 determine which selecting and holding magnets are to be energized in accordance with the trunk choices which each line has. To illustrate further, in the case of line S1, if trunks 305 and 301 are busy and trunk 310 is idle, then relays TK-5 and TK-1 will be operated and relay TK-10 normal when line S1 originates the call. The selecting magnet path in this case at armature 418 on relay TK-1 may further be traced over the front contact, lead 440, armature 527 and back contact relay TK-10, leads 528 and 419, through contact 522 on relay SM-1, lead 523 to the battery through resistance 318 and selecting magnet 319. The holding magnet path at armature 420 on relay TK-1 may further be traced over the front contact, lead 422, armature 529 and back contact relay TK-10, lead 530 to battery through midpoint and right-hand winding on holding magnet H-10 of switch LB-4. Line S1 in Fig. 1 is therefore connected over leads 103 and 313 to trunk 310 at contact 1 in the lower right-hand corner of cross-bar switch LB-1 shown in Fig. 3.

Considering now the case where trunks 305, 301 and 310 are busy, line S1 will be connected with trunk 306. The selecting magnet path in this case at armature 527 on relay TK-10 may further be traced over the front contact, lead 530, armature 531 and back contact relay TK-6, leads 532 and 513, through contact 514 on relay SM-1, lead 515 to battery, through resistance 315 and selecting magnet 316. The holding magnet path at armature 529 on relay TK-10 may also further be traced over the front contact, lead 533, armature 534 and back contact relay TK-6, lead 535 to battery through mid-point and right winding on holding magnet H-6 of switch LB-4. Line S1 of Fig. 1 in this manner is connected over leads 103 and 314 to trunk 306 at contact 1 on the switch LB-1.

It may happen that all four trunks to which line S1 has access are busy. In this event, the selecting magnet path at armature 531 on relay TK-6 may further be traced over the front contact, lead 536 to multiple lead 523, in Fig. 4, thence through contact 424 on relay C-1, resistance 425, to battery through relay E-1. The latter relay is slow releasing and functions in the place of what would have been the selecting magnet of the next choice trunk by closing a short circuit around resistance 425, thus permitting marginal relay D-1 to operate and energize the holding magnet path, thereby permitting relays 501 and 502 to function by timing out the call, the holding magnet path at this time being held open. Relay E-1 operating, also opens the circuit at its top contacts over leads 104 and 105, preventing other calls in the vertical row of L and CO relays from getting a trunk assignment until after the slow release E-1 relay releases. This release period is relatively short but it is sufficient to prevent calls whose trunk choices are all busy, from delaying those calls where trunks are available. Said E-1 relay may also be used for registering an all-trunks busy condition or for giving an alarm if desired.

Referring now to that assumption in a previous paragraph of the two lines S1 and S26 calling simultaneously, it was shown that line S26 would first receive a trunk assignment. It will further be observed that line S26 which is the first line in the second group of twenty-five lines, appears in the bank of cross-bar switch LB-2 in the same relative multiple positions as line 1 did in the bank of switch LB-1. Thus, identically the same circuit paths are employed for assigning the same trunks in the same order as for line 1. However, in place of operating the selecting magnets of cross-bar switch LB-1, the selecting magnets of switch LB-2 are energized due to the SM-2 relay of Fig. 5 being operated in place of relay SM-1. This is brought about due to relay C-4 being operated instead of C-1, so that ground at contact 426 on relay C-4 is connected to lead 427 and thence through winding of relay SM-2 to battery. Line S26 is, therefore, connected over lead 117 to the first idle one of the trunks 305, 301, 310 or 306, the same as line S1 would be. Likewise, lines S51 and S76 being the first line in their respective third and fourth groups have the same trunk assignment as for lines S1 and S26.

When three lines, such as S1, S26 and S100, originate calls simultaneously, as previously discussed, it was shown that line S100 would receive a trunk assignment first. It will further be observed that compared with line S1, line S100 not only has its multiple appearances in a different cross-bar switch LB-4, but that the position of its multiple appearances is also different, such that the line may have access to trunks 301, 305, 306 and 302 in the order shown. The switching of the selecting and holding magnet leads to accomplish this, as before stated, is dependent on relays B-10 and C-8-L. Tracing further the call on line S100 under the above conditions and under the further assumption that only trunk 302 is idle, it will first be noted that all selecting magnet leads indicated at 538 are connected to the magnets of switch LB-4 due to relay SM-4 being operated over lead 537 by relay C-8-L at contact 539. The latter relay at contact 540 also connects ground to lead 541 for operating relay 405, the function of which is to prepare the paths to the selecting

magnets for control by the B and D relays. When, therefore, relay 503 of Fig. 5 operates, ground at back contact relays 501 and 502 is connected to lead 510, traced further through contact 221 on relay B-10, upper winding relay D-10, thence over leads 222 and 428, contact 429 on relay 405, armature 430 on TK-1 relay and front contact to lead 431, armature 541 on TK-5 relay and front contact to armature 542 on TK-6 relay and front contact to lead 543, armature 432 on relay TK-2 and back contact to lead 433 through contact 544 on SM-4 relay, lead 545 to battery through resistance 605 and selecting magnet 606 of cross-bar switch LB-4. The operation of the selecting magnet in the path just traced, short-circuits the resistance 605 causing marginal relay D-10 to operate and close a ground path for operating the holding magnet H-2 of switch LB-4. Relay D-10 first operates relay 505 over lead 215 which locks to ground on contacts of timing relays 501 and 502. Relay 505 at its bottom make contact connects ground to lead 516 for operating timing relays 501 and 502 as previously described. Ground on lead 516 also operates relay 406 of Fig. 4 over a path traced through contact 546 on relay C-8-L, thence over lead 547 to battery through relay 406. The latter relay prepares the holding magnet circuit and together with the B-10 relay causes holding magnet H-2 to operate. This path is traced from ground on contacts of relays 501 and 502, operated contact relay 503, lead 510, contact 223 on relay B-10, leads 224 and 434, contact 435 on relay 406, armature 436 on relay TK-1, and front contact to lead 438, armature 547 on relay TK-5 and front contact, armature 548 on relay TK-6 and front contact to lead 549, armature 437 and back contact to lead 439, to the mid-point of windings on holding magnet H-2 and battery through its right-hand winding. Line S100 of Fig. 2 will thus be connected over lead 118 to trunk 302 at contact 1 in the upper left corner of cross-bar switch LB-4 shown in Fig. 6.

It will further be understood from the foregoing description that a multiple arrangement of subscriber lines is provided which gives every subscriber line four equal chances for being connected to an incoming selector or district junctor circuit and at the same time, for maintenance reasons, allows for the numbering of the multiple appearances in each switch in a simple uniform manner.

What is claimed is:

1. The combination in a switch comprising co-ordinate rows of separately operable switch contacts of lines arranged in groups of different sizes, said groups appearing in respective horizontal rows of said contacts and also in respective vertical rows of said contacts, and means for selectively operating said contacts.

2. The combination in a switch having horizontal and vertical rows of separately operable switch contact sets, all of said rows having the same number of contact sets therein, of a number of groups of lines appearing respectively in horizontal rows and respectively in vertical rows of said switch, each of said groups occupying a different number of contact sets in the row to which it is assigned, and cross-bar means for operating said contact sets.

3. The combination in a switch comprising vertical and horizontal rows of separately operable contact sets of a group of lines comprising a particular line in combination with certain other



lines appearing in a vertical row and also in a horizontal row of said contact sets, and a second group of lines comprising said particular line and a different combination of other lines appearing in a vertical row and also in a horizontal row of said contact sets.

4. In combination, a plurality of cross-bar switches, vertical and horizontal rows of contact sets in said switches, and a plurality of groups of lines, each group appearing in a horizontal row in a number of said switches and also in a vertical row in a number of said switches.

5. In combination, a plurality of cross-bar switches, vertical and horizontal rows of contact sets in said switches, and a plurality of line groups of different sizes, each group appearing in vertical rows of contacts in some of said switches and in horizontal rows in other of said switches.

6. In combination, an automatic switch having a plurality of separately operable contact sets arranged in vertical rows and horizontal rows, lines arranged in groups of different sizes, each line group appearing in a vertical row and also in a horizontal row of contacts, said lines appearing individually in a plurality of said groups, and means for operating said contacts.

7. In combination, an automatic switch having a plurality of separately operable contact sets arranged in vertical rows and in horizontal rows,

subscribers' lines arranged in groups of different sizes, each line group appearing in a vertical row of contacts and multiplied to appear in a horizontal row of contacts, each line appearing individually in a plurality of said groups, connecting circuits appearing in said contact sets, and means for operating said contact sets to connect a particular line to one of said connecting circuits either through a set of contacts in a vertical row or through a set of contacts in a horizontal row.

8. The combination in a switch for extending subscribers' lines in telephone connections comprising coordinate rows of separately operable switch contacts, subscribers' lines arranged in groups of different sizes, said groups appearing in respective horizontal rows of said contacts and also in respective vertical rows of said contacts, and means for selectively operating said contacts.

9. The combination in a switch for extending subscribers' lines in telephone connections comprising coordinate rows of separately operable switch contacts, subscribers' lines arranged in groups of different sizes, the lines of said groups being connected to the contacts in respective horizontal rows of said contacts and also connected to the contacts in respective vertical rows of said contacts, and means for selectively operating said contacts.

THOMAS A. SPENCER,