

Feb. 14, 1928.

1,659,083

E. H. CLARK

TELEPHONE EXCHANGE SYSTEM

Filed June 27, 1925

9 Sheets-Sheet 1

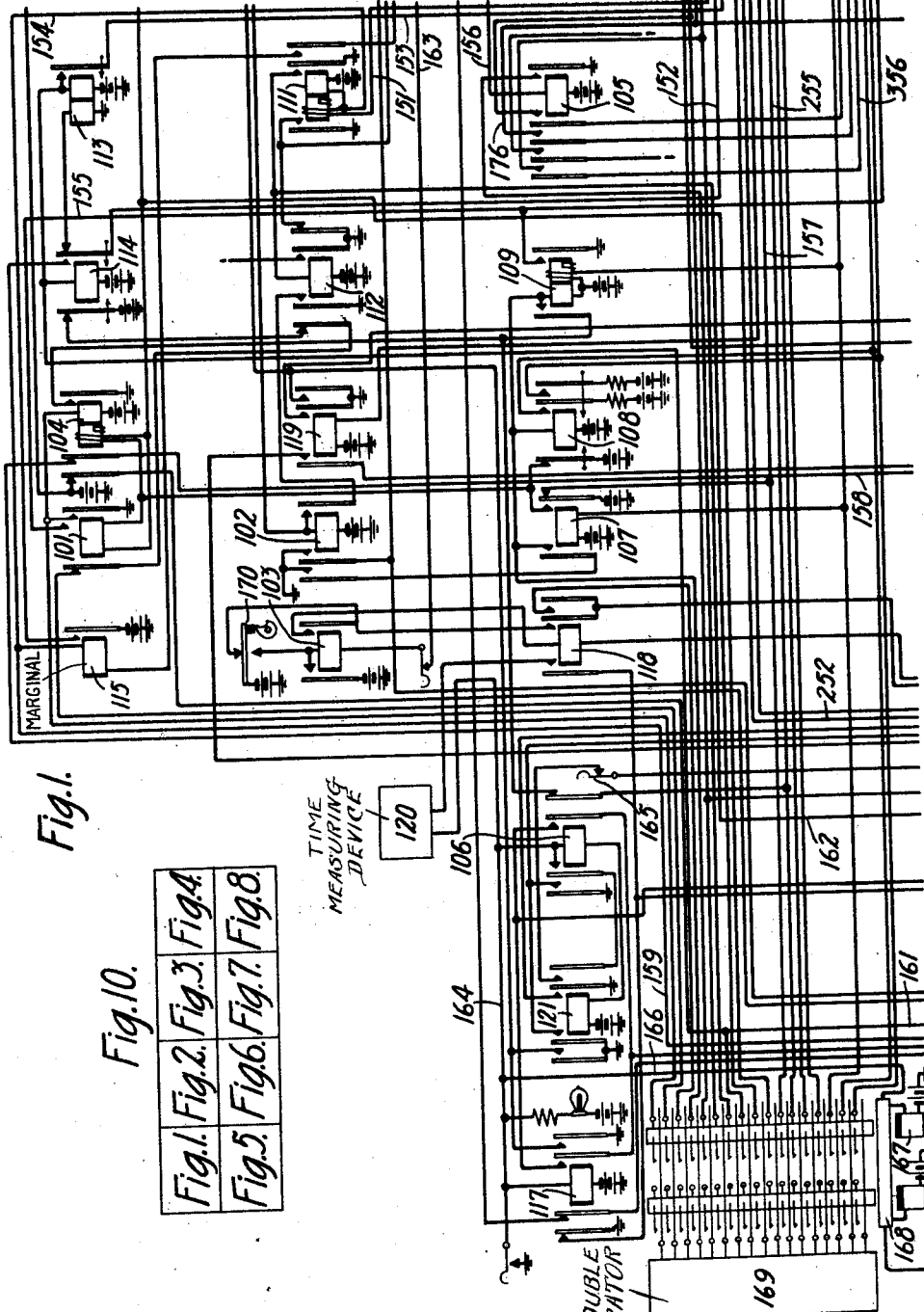


Fig. 1.

Fig. 10.

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

TIME
MEASURING
DEVICE

120

TROUBLE
INDICATOR

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by

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Feb. 14, 1928.

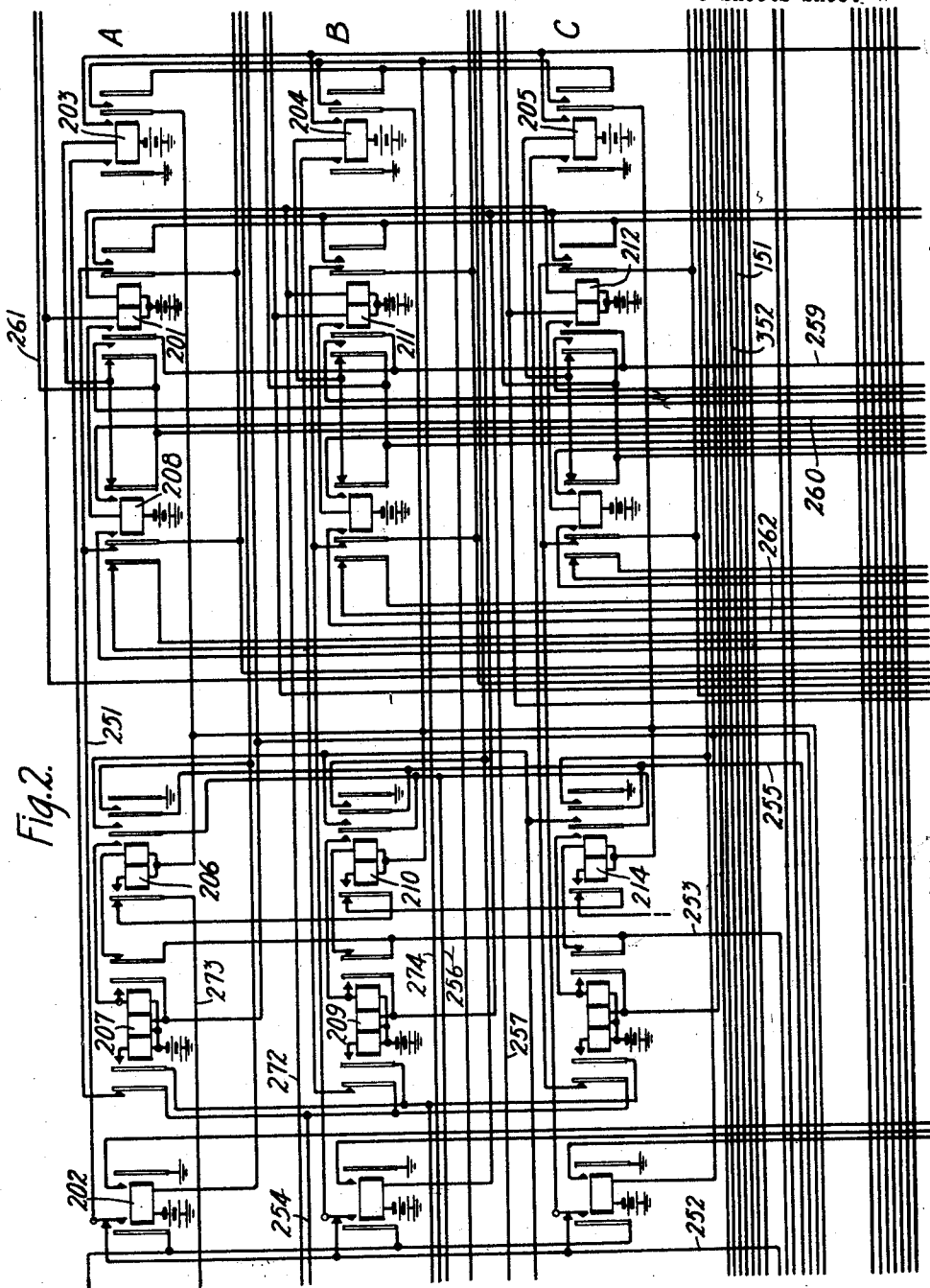
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9 Sheets-Sheet 2



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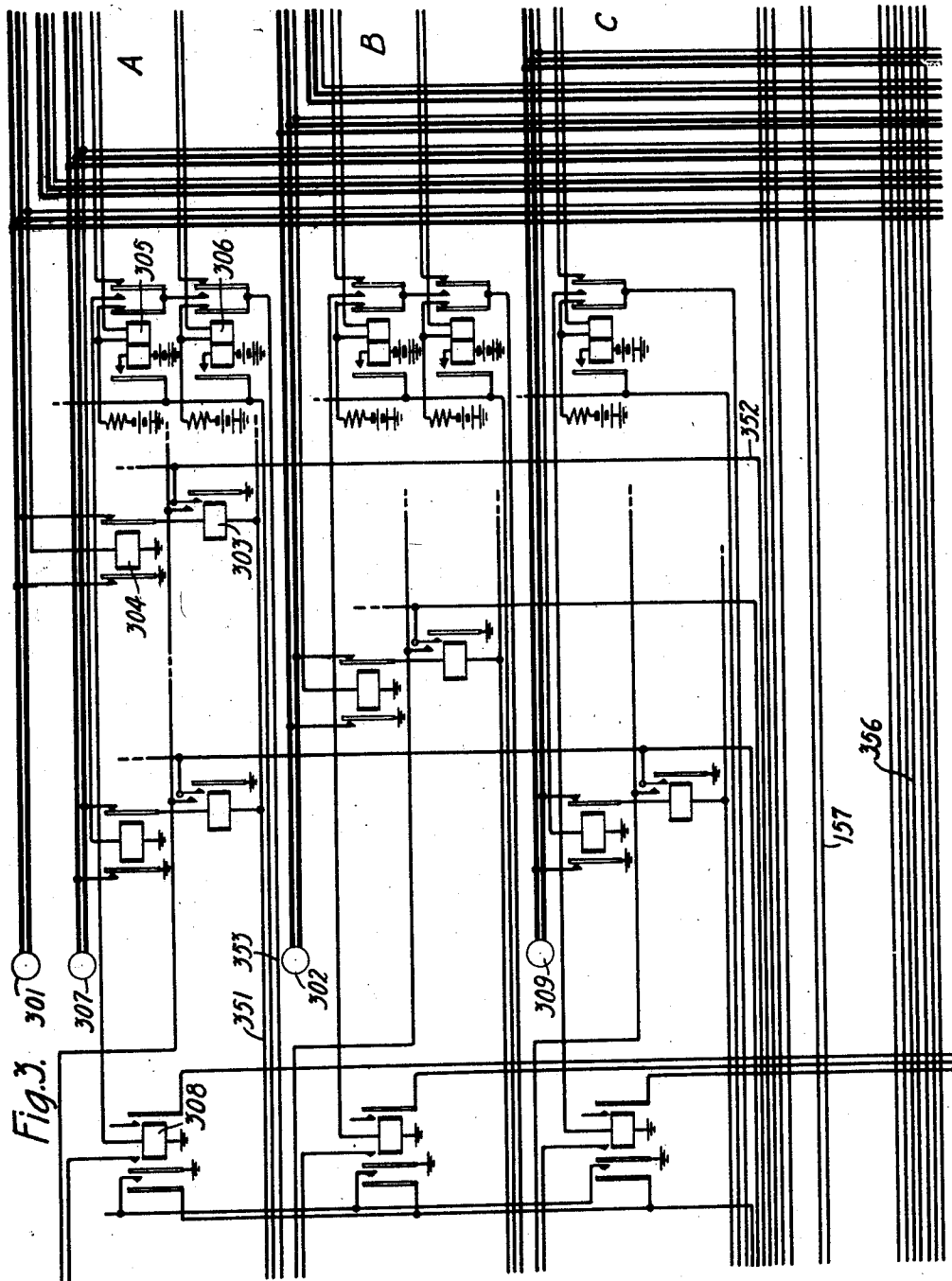
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9 Sheets-Sheet 3



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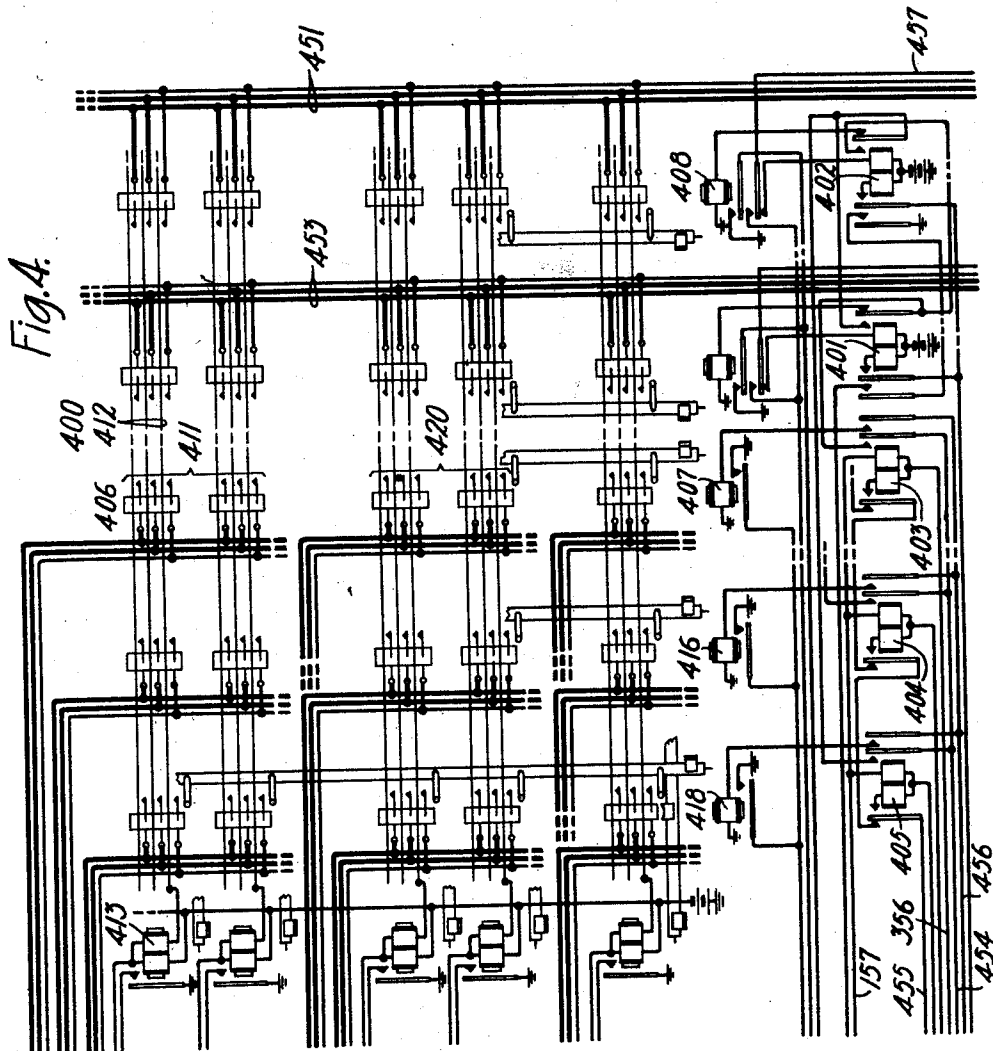
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TELEPHONE EXCHANGE SYSTEM

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9 Sheets-Sheet 4



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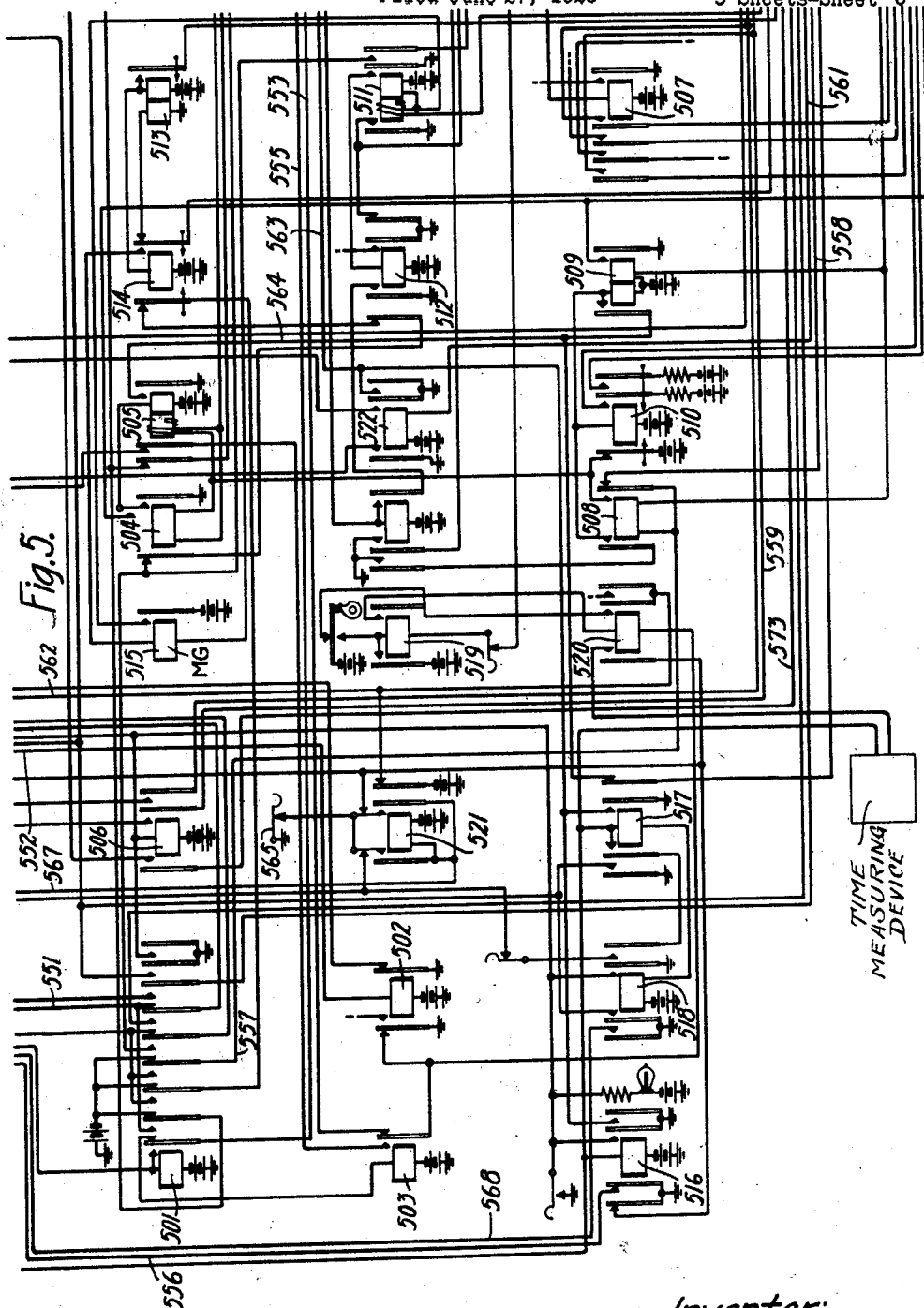
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TELEPHONE EXCHANGE SYSTEM

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9 Sheets-Sheet 5



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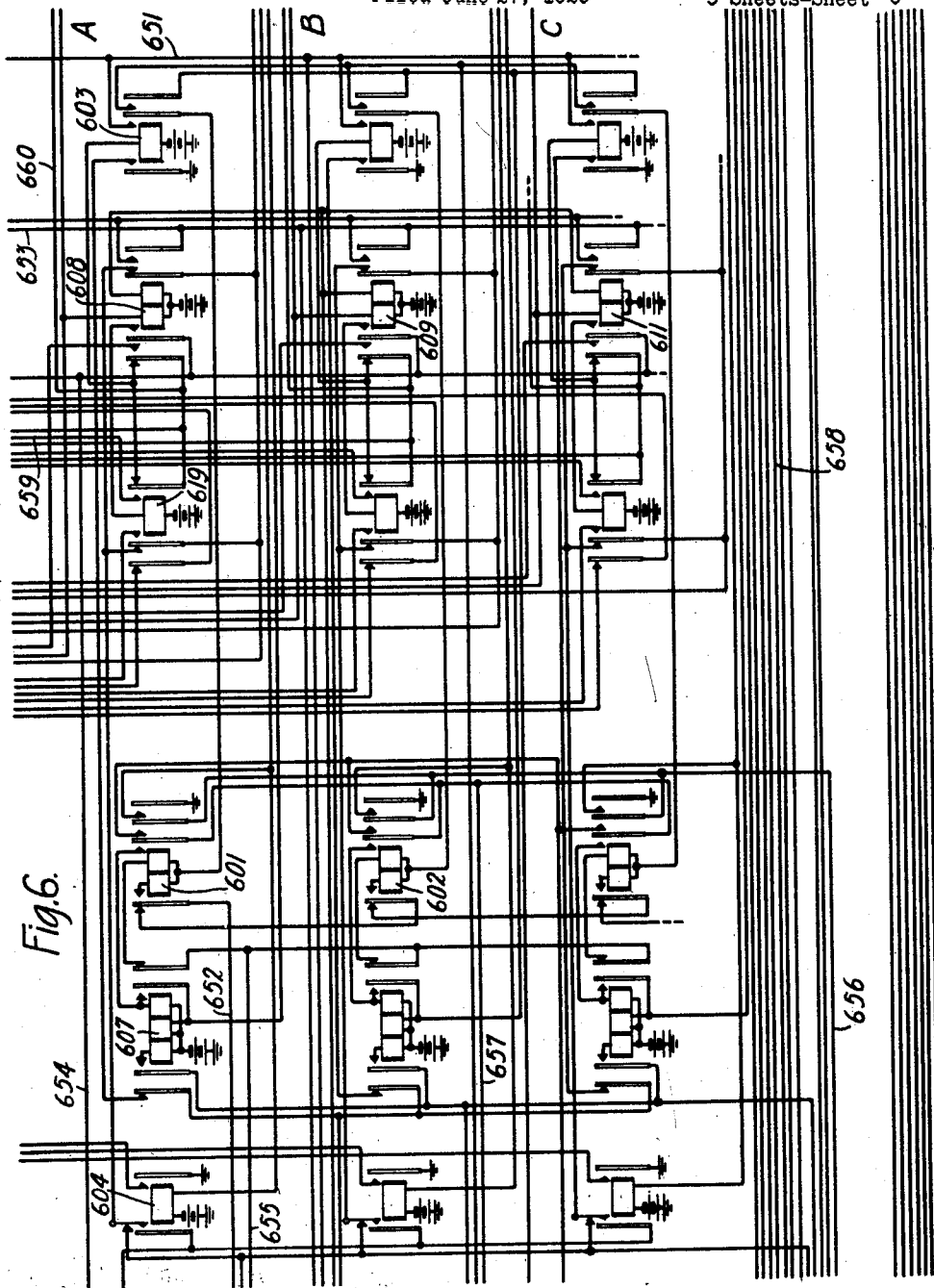
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9 Sheets-Sheet 6



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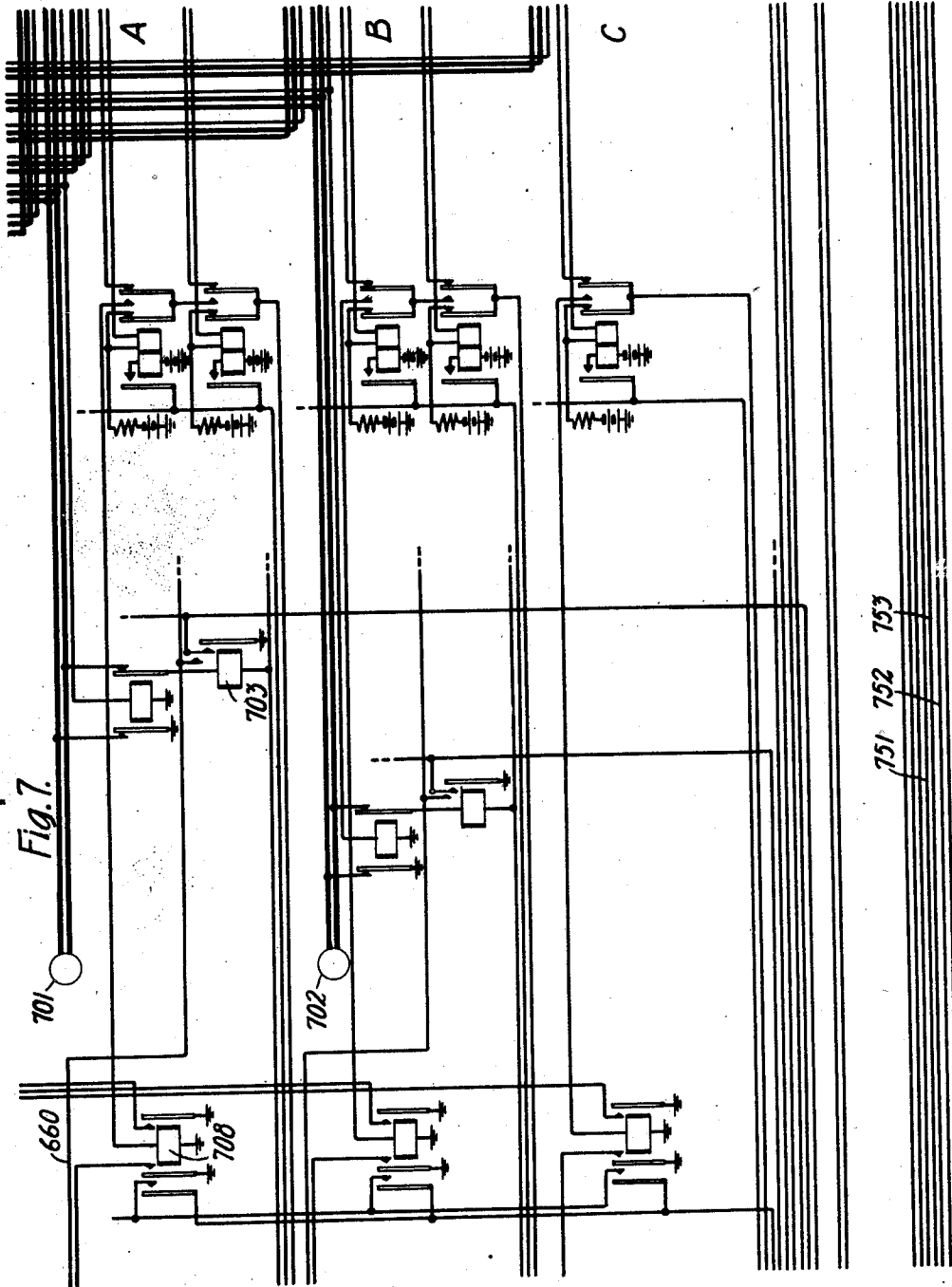
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9 Sheets-Sheet 7



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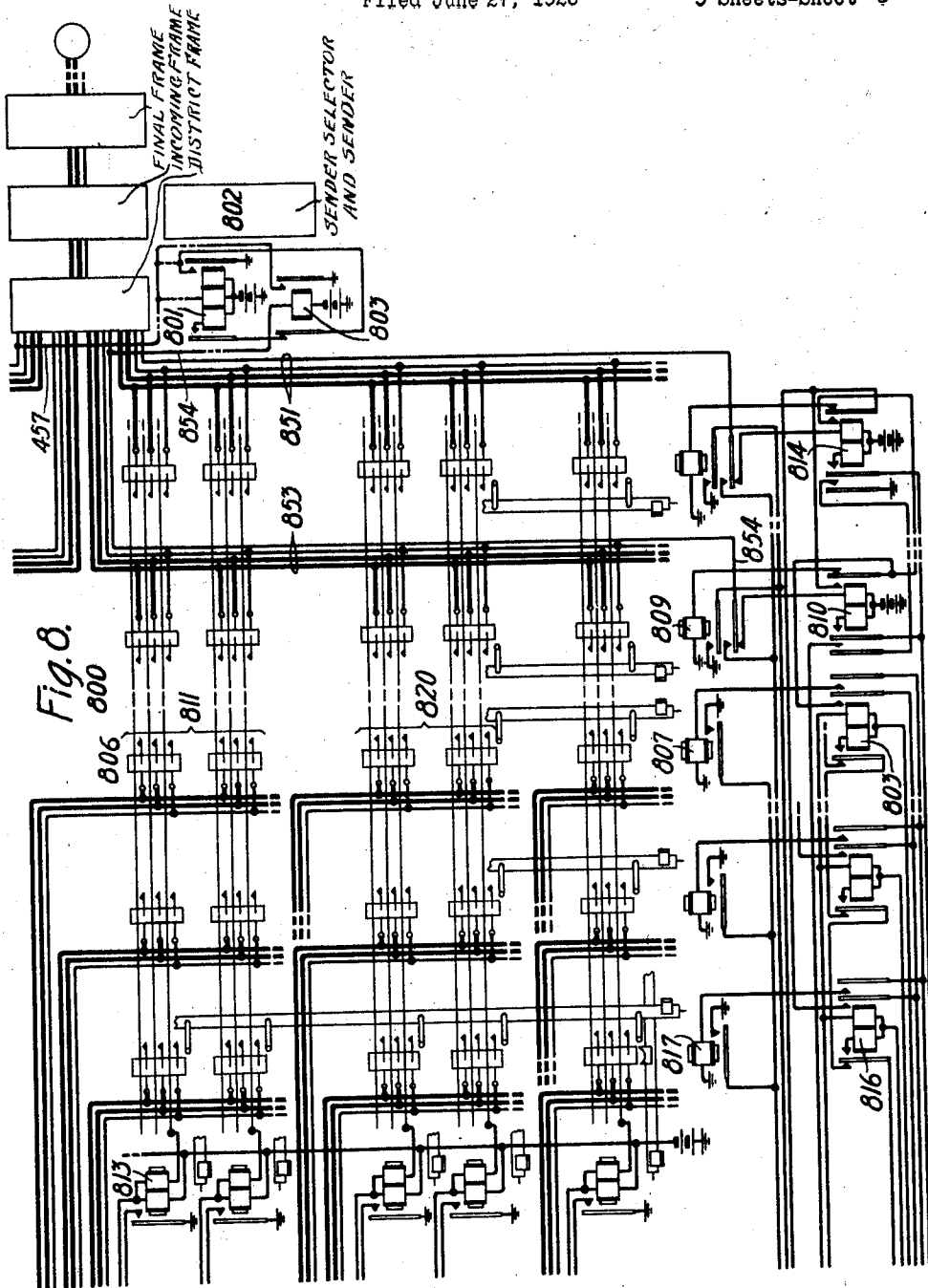
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TELEPHONE EXCHANGE SYSTEM

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9 Sheets-Sheet 8



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TELEPHONE EXCHANGE SYSTEM

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9 Sheets-Sheet 9

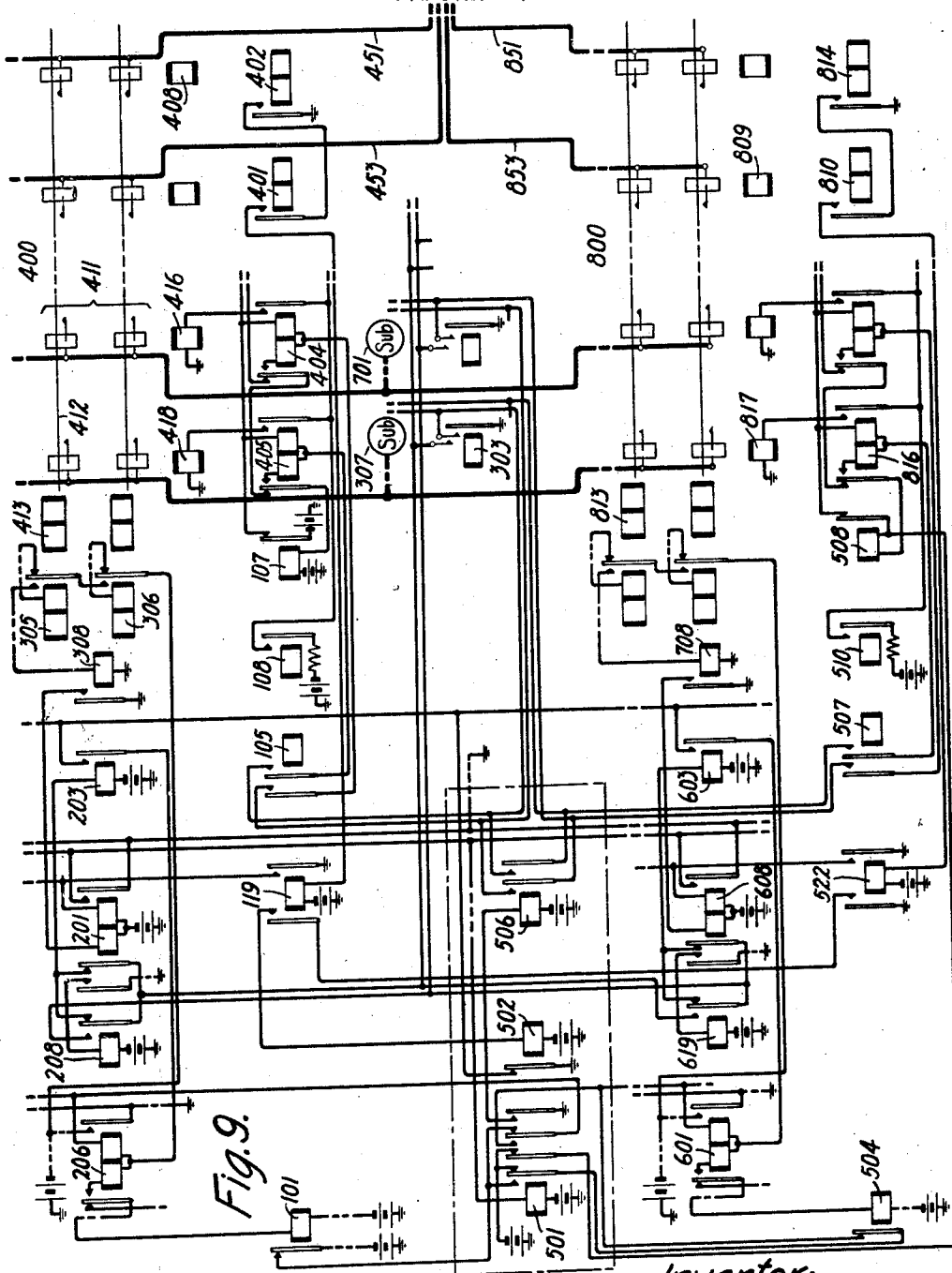


Fig. 9.

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UNITED STATES PATENT OFFICE.

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TELEPHONE-EXCHANGE SYSTEM.

Application filed June 27, 1925. Serial No. 39,883.

This invention relates to telephone exchange systems and more particularly to telephone systems wherein automatic switches are employed for the establishing and controlling of connections.

Heretofore in telephone systems employing switches of the coordinate type such as the system disclosed in U. S. patent to S. B. Williams, Jr., No. 1,517,331, issued December 2, 1924, it has been the practice to arrange subscribers' lines as calling lines in groups, each group of lines appearing before a single line switch. Associated with each line switch for controlling the operation thereof is a master control circuit. When for any reason the master circuit becomes inoperative it has been the usual practice to replace such circuit by an emergency or substitute circuit. Under such conditions it necessarily follows that the emergency apparatus is employed at comparatively infrequent intervals. Furthermore in such systems each calling line, for the purpose of extension, has access to the horizontal links of one line switch alone, and to only those trunks appearing in this switch. Accordingly when a calling line encounters either an "all links" or an "all trunks" busy condition in the switch before which it appears the extension of such line may be temporarily retarded until an idle link or an idle trunk occurs.

It is an object of this invention therefore to provide a highly efficient arrangement of line switches and controlling circuits therefor.

According to one feature of the invention each subscriber's line has an appearance before a plurality of coordinate line switches, one switch acting as a preferred choice in extending said line.

Another feature of the invention relates to the means for extending a calling line through a second choice line switch when all the available links in the first choice switch are busy, or when all the trunks appearing in the first choice switch are busy.

A further feature of the invention relates to the means for extending a calling line through a second choice line switch when either the first choice switch or the master circuit associated therewith encounters trouble.

A still further feature relates to a master control circuit which comprises the functions

of a regular and an emergency master switch.

Another feature of the invention relates to the means whereby repeated attempts are made to extend a calling line when trouble exists in both the first choice switch and in the second choice switch.

Other features and advantages of the invention not specifically enumerated above will become apparent after a consideration of the following descriptions and the appended claims.

Referring to the drawing, Fig. 1 shows a portion of a master control circuit associated with a particular line switch. This figure also represents schematically a trouble indicator, and means for connecting the trouble indicator to the control circuit.

Fig. 2 shows the remaining portion of the master circuit partially shown in Fig. 1.

Fig. 3 shows a plurality of groups of calling lines together with certain allotting and controlling relays.

Fig. 4 illustrates a portion of a coordinate line switch.

Figs. 5 and 6 show a second master control circuit associated with a corresponding line switch.

Fig. 7 shows groups of subscribers' lines and associated allotting and control relays.

Fig. 8 shows a second coordinate line switch.

Fig. 9 is a schematic representation of one form of carrying out the invention.

Fig. 10 represents the manner in which the various sheets of the drawing are to be arranged for the purpose of obtaining a unitary disclosure of the invention.

General description of circuits and apparatus.

The line switches 400 and 800 are of the coordinate type such as shown and described in U. S. patent to J. N. Reynolds 1,507,140, September 2, 1924, and further shown and described in U. S. patent to S. B. Williams, Jr., 1,517,331, December 2, 1924. Each switch comprises groups of vertical rows of contacts, one group being allotted to lines and another group allotted to trunks. Each vertical row of contacts has an operating magnet individual thereto for preparing the associated row. For the purpose of interconnecting the lines and trunks there are

provided groups of horizontal link circuits, each link circuit having a corresponding operating magnet. When a line vertical magnet, a trunk vertical magnet and a horizontal connecting magnet are operated in sequence a connection is established through the switch. The operated line and trunk magnets may thereupon be released and the established connection maintained by the continued energization of the horizontal connecting magnet as described in the above mentioned U. S. patents.

It will be noted that the link circuits in switches 400 and 800 are divided into groups, and calling subscribers' lines may also be considered as arranged in groups corresponding to the groups of link circuits. For example, lines 301 and 307, etc., appearing before group 811 constitute the A group of subscribers' lines. Similarly the group including line 302 constitutes horizontal group B, and so on for succeeding horizontal groups. Each master circuit may be considered divided into horizontal and vertical group controls. For example, the portion of the master circuit appearing in the upper portion of Fig. 2 is effective when any line in group A initiates a call. The portion of the control circuit shown in the central portion of Fig. 2 controls the extending of lines in horizontal group B. A similar arrangement exists in connection with the groups of links in switch 800 and the horizontal control groups of Fig. 6. The calling subscribers' lines may furthermore be considered as divided into vertical groups, each vertical group comprising all the lines appearing in a particular row of vertical contacts. Each vertical row of contacts has associated therewith a relay, as relay 403, controlling the operation of the corresponding vertical magnet. The portion of the master circuit shown in Fig. 1 is common to all the horizontal control circuits of Fig. 2 and all the vertical control circuits. Similarly the portion of the master switch shown in Fig. 5 is common to the horizontal group control circuits of Fig. 6 also to the vertical control circuits.

Each subscriber's line has an appearance before corresponding rows of contacts in both switch 400 and in switch 800. For example, line 301 appears in vertical row 406 in switch 400 and in vertical row 806 in switch 800. It will be noted in addition that each line appears before the corresponding groups of link circuits in both switches. Line 301 thus appears before group 411 and group 811, line 302 before group 420 and 820. Each line switch acts as a first choice switch for certain of the subscribers' lines and as a second choice line switch for other of the subscribers' lines. For example, lines 301, 302, 307, etc., shown in Fig. 3 have switch 400 as their first choice line switch

and switch 800 as their second choice line switch. In a similar manner lines 701, 702, etc., shown in Fig. 7 have switch 800 as their first choice switch and switch 400 as their second choice. The arrangement of the master circuits corresponds to the arrangement of the line switches. For example, the master circuit of Figs. 1 and 2 is the normal or first choice master circuit for controlling the extension of lines having switch 400 as their first choice whereas the master circuit of Figs. 5 and 6 is normally associated with switch 800 and serves as the first choice master circuit in controlling the extension of lines having as their first choice switch 800. Should any of the lines shown in Fig. 3, upon initiating a call, encounter an "all links" busy or an "all trunks" busy condition in switch 400 the master circuit of Figs. 1 and 2 is replaced by the master circuit of Figs. 5 and 6 and the calling line is extended through switch 800 under the control of the master circuits of Figs. 5 and 6. Similarly should an "all trunks" busy or "all links" busy condition exist in switch 800 when lines 701, 702, etc., initiate calls, then the master circuit in Figs. 1 and 2 is appropriated and these calling lines are extended through switch 400.

The master circuits are so arranged that each can control simultaneously the extension of lines appearing in their respective switches. For example, the master circuit of Figs. 1 and 2 may be controlling the operation of switch 400 at the same time that the master circuit of Figs. 5 and 6 is controlling the operation of switch 800.

General description of method of operation.

Referring to Fig. 9 a general description will now be given of the arrangements shown in detail in Figs. 1 to 8. It will be noted that the designations employed in Fig. 9 are the same as those employed for corresponding apparatus illustrated in the detailed drawing. In Fig. 9 two coordinate line switches 400 and 800 are shown, as well as two subscribers' lines 307 and 701. Each line is multiplied to appear before switch 400 and switch 800. Switch 400 serves as a first choice switch for the extension of line 307, while switch 800 is a second switch for line 307. On the other hand switch 800 is the first choice switch for line 701 while switch 400 is the second choice switch for line 701. But one group of links in each switch is shown. In practice, however, each switch comprises a plurality of groups of horizontal link circuits.

Should a call be initiated on line 307, line relay 303 operates and in turn operates start relay 203 by means of a circuit through left back contacts of relay 201. Relays 201 and 203 are each common to the group of links 411 in switch 400. Should the master control

circuit which is individual to switch 400 be idle when relay 203 operates, relay 101 is normal, and battery is extended through the contacts of relay 101, back contacts of relay 501, right winding of horizontal group relay 206, contacts of relay 203, to ground at the contacts of relay 502. Relay 206 immediately locks in series with relay 101 and renders the master circuit busy. The cut-in relay 105 is now operated and closes a circuit for the particular vertical group relay which is individual to the row of contacts of switch 400 wherein line 307 appears. In this case relay 405 is operated by means of a circuit including battery at the contacts of relay 107, right winding of relay 405, inner contacts of relay 105, to ground at the contacts of line relay 303. Relay 405 immediately locks in series with relay 107. Shortly thereafter relay 108 operates and causes the operation of vertical magnet 418. At this time magnet 408 corresponding to an idle trunk, such as 451, is also operated. A horizontal magnet such as 413 corresponding to an idle link in group 411 is thereupon operated, and line 307 is extended to trunk 451 by means of this idle link circuit. Vertical magnets 408 and 418 as well as the master control circuit may be released for use in extending other lines.

Should the call be initiated on line 701, this line would normally be extended by means of switch 800 under control of the master circuit which is individual thereto. It will be seen therefore that if calls are initiated on lines 307 and 701 simultaneously that each of these lines may be extended through its first choice switch without awaiting the extension of the other line.

The portion of the control circuit within the dotted rectangle represents switch-over apparatus for allowing a calling line to be extended through its second choice switch when any of the following conditions exist at the first choice switch.

1. All trunks busy.
2. All links busy.
3. Unstandard or trouble conditions.

The switching over to a second choice line switch is under control of relays, such as 201 and 208, there being a set of these relays for each group of horizontal links in the line switch. Should all the links in group 411 be busy when the call is initiated, the link allotting relays 305, 306, etc., are all operated and a series circuit exists through the front contacts of these relays for operating "links-busy" relay 308. Relay 308 in turn operates relay 201 by means of the left-hand winding of this latter relay. Relay 201 also operates relay 208. Relays 201 and 208 open the energizing circuit of start relay 203 and closes the energizing circuit of the start relay 603. Relay 603 is individual to the group of link circuits in switch 800

before which calling line 307 also appears. The circuit for operating relay 603 includes back contacts of relay 619 and front contacts of relays 208 and 303. Line 307 may now be extended through switch 800 as a result of operation of start relay 603. "Single call" relay 501 is operated at this time by means of a circuit including right front contacts of relay 201. Horizontal group relay 301 is thereupon energized by means of a circuit including battery through the contacts of relay 101, front contacts of relay 501, contacts of relay 504, right winding of relay 601, front contacts of relay 603, to ground at relay 502. The cut-in relay 507 is now operated and vertical group control relay 816 is energized under control of the line relay 303. The circuit for energizing relay 816 may be traced through front contacts of relays 506 and 507. When relay 510 subsequently operates the vertical operating magnet 817 is energized. Assuming trunk 853 to be idle, trunk vertical magnet 809 is energized. A short interval later horizontal magnet 813 operates and line 307 is extended to trunk 853.

If instead of an all links-busy condition, the calling line encounters an all trunks-busy condition, a series circuit is traceable through the front contacts of the trunk allotting relays 401, 402, etc., to operate relay 119. Relay 119 in turn causes the operation of relay 201 by means of the right winding of this latter relay. Relay 201 releases relay 203 and operates relay 603 as already described and the calling line 307 may be extended to an idle trunk appearing before switch 800.

The circuits are also arranged in such a manner that if a calling line is not extended through its first choice switch within a period of time counted by a time measuring device, the circuit will be closed for all the relays similar to relay 201 associated with the first choice switch. Accordingly when any lines which have this switch for their first choice have calls initiated thereon, these same lines will be extended through the second choice switch as will appear from the detailed description given hereinafter.

Detailed description of a connection involving a first-choice switch alone.

It will be assumed that the subscriber of line 301 has initiated a call by the removal of the receiver from its switch-hook, and that at the time the call is initiated, trunk 451, alone, is idle. As noted hereinbefore the group of links 411 in switch 400 serve as a first choice group for the extension of line 301, while group of links 811 in switch 800 constitute a second choice group. For the present it will be assumed that link 412 in the first choice switch 400 is idle. When the subscriber's loop circuit is closed by the removal of the receiver, line relay 303

operates by means of a circuit including the closed calling line and the back contacts of cut-off relay 304. A circuit is thereupon completed for start relay 203 which is common to the subscribers' lines appearing before group of links 411. In a similar manner relays 204 and 205 are each common to their respective horizontal groups of lines. For the present it will be assumed that line 301 is the only line upon which, at this time, a call is being initiated. Accordingly, relay 203 completes a circuit for horizontal group relay 206, this circuit being traced from ground at the left back contacts of relay 502, back contacts of relay 503, conductor 553, conductor 651, inner front contacts of relay 203, right winding of relay 206, right outer contacts of relay 207, conductor 253, back contacts of relay 501, conductor 101, left contacts of relays 101 and 112, to battery at the contacts of relay 114. A circuit is also completed at this time for relay 102. This circuit may be traced from battery through the winding of relay 102, conductor 254, left outer contacts of relay 207, to ground at the left contacts of relay 203. The function of relay 102 will be described in detail hereinafter. With relay 206 operated a locking circuit is completed for said relay, this circuit including the left winding and locking contacts of relay 206, winding of relay 101, and battery at the left contacts of relay 108. Relay 101 operates over this circuit. Relay 206 also completes an obvious operating circuit for relay 202. Relay 202 by means of its make-before-break contacts closes a substitute holding circuit for relay 303. This circuit may be traced from battery at the left outer contact of relay 104, left front contacts of relay 202, conductor 251, back contacts of relays 201, 208 in parallel, conductor 351, winding of relay 303, to ground as hereinbefore traced. Relay 101 in operating as above described, closes an obvious energizing circuit through the right winding of vertical group start relay 104. Relay 101 also extends ground through its right inner contacts over conductor 155 to provide a temporary locking circuit for the trunk relays 401 and 402, etc. This locking circuit is provided to prevent a previously operated trunk relay from releasing during the selection of an idle trunk as will appear from the following descriptions.

Circuits are now prepared for the vertical group relays 403, 404, etc., by means of the multi-contact relay 105. The circuit for operating relay 105 may be traced from battery through the winding of said relay, conductor 156, right middle contacts of relay 206, conductor 255, right outer contacts of relay 106, to ground at the right contacts of relay 104. Since line relay 303, alone, is operated, a circuit is completed for vertical group relay 403 which is individual to ver-

tical row of contacts 406 wherein the calling line appears. The circuit for operating relay 403 may be traced from battery at the right back contacts of relay 107, conductor 157, right winding of relay 403, conductor 356, left outer contacts of relay 105, conductor 352, to ground at the contacts of relay 303. Relay 403 locks by means of a circuit which includes the grounded conductor 356, left winding and locking contacts of relay 403, left back contacts of relays 404 and 405, conductor 455 and battery through the winding of relay 107. Relay 107 operates in this circuit to prevent the operation of any other of the vertical group relays 404, 405, at this time. Relay 107 now causes the operation of relays 108 and 109 by means of a circuit including the operating windings of these relays in parallel and left front contacts of relays 107 and 102. Line vertical magnet 407 is now energized over a circuit traceable from ground through the winding of said magnet, right outer front contacts of relay 403, conductor 456, to battery at the contacts of relay 108. Since the trunk 453 is busy, relay 401 individual thereto is operated and a circuit is completed at this time for trunk vertical magnet 408. This circuit may be traced from ground through the winding of magnet 408, right back contacts of relay 402, right front contacts of relays 401 and 403, conductor 454, to battery at the contacts of relay 108. Line vertical control relay 111 is now energized over a circuit traceable from battery through both windings of said relay in series, conductor 151, to ground at the contacts of magnet 407. Relay 111 in turn closes an obvious operating circuit for relay 112. Trunk vertical control relay 113 is also operated at this time over a circuit traceable from ground through the left winding of said relay, right back contacts of relay 114, conductor 152, lower front contacts of magnet 408, conductor 457, to battery through the middle winding of sender selector start relay 801. Both relays 801 and 113 operate in this circuit. Relay 801 locks under control of relay 803. The operation of relay 801 serves to bring about operation of a sender selector switch shown schematically by the rectangle 802. For a detailed description of the manner in which the relay 801 may function to cause the operation of a coordinate sender selector switch, reference may be had to the U. S. patent to S. B. Williams, Jr., No. 1,517,331, issued December 2, 1924.

After an interval relay 113 closes its front contacts and extends ground from the lower middle contacts of magnet 408, through the said front contacts of relay 113 through the winding of relay 114 which begins to attract its armature. After an interval, the contacts of relay 114 close and a circuit is completed from battery through the right

winding of relay 207, right innermost contacts of relay 206, conductor 256, right outer contacts of relay 111, winding of relay 115, right front contacts of relay 114, conductor 152, lowermost front contacts of magnet 408, conductor 457, to ground through the contacts of relay 801. When the sender selector switch 802 has operated conductor 854 is grounded as described in the patent to S. B. Williams, Jr., hereinbefore referred to. Relay 803 operates and opens the holding circuit of start relay 861 which releases. Relay 115 being marginal does not operate in series with the resistance of the right-hand winding of relay 207. When relay 207 closes its innermost front contacts, the resistance of the right winding is short-circuited and a circuit may now be traced from battery through the middle winding of relay 207, innermost right contacts of said relay, and thence to ground through the winding of relay 115 as above described. A circuit may now be traced from battery through the left-hand low resistance winding of magnet 413, right outer back contacts of relay 305, right outer front contacts of relay 306, conductor 353, innermost right front contacts of relays 207 and 206, and thence through the winding of relay 115, over conductors 152, and 457 to ground at the contacts of relay 803. Relay 115 receives sufficient current by means of this circuit to enable said relay to operate. This last traced circuit for operating magnet 413 acts as a shunt around the right winding of relay 305. When magnet 413 has completely operated, a circuit is completed from battery through both windings of said magnet in series, thence through contacts of switch 400 to the sleeve conductor of trunk 451 which may be grounded at a succeeding selective stage in a manner similar to that described in the above mentioned patent to S. B. Williams, Jr. This same ground is extended by means of switch 400 to the sleeve conductor of line 301 causing relay 304 to operate. Relay 304 in turn brings about the release of relay 303.

If there are no other calling lines awaiting extension, then the release of relay 303 brings about the release of relay 203. Relay 303 also removes ground from conductor 352, whereby the holding circuit of relays 403 and 107 is broken and these relays release. Relay 403 in releasing causes the deenergization of line vertical magnet 407. Relay 203 opens the holding circuit of relays 206 and 101, both of these relays now being deenergized. With relays 107 and 104 normal, both relays 108 and 109 release. Release of relay 108 removes the operating battery for trunk vertical magnet 408 which in turn deenergizes. As soon as magnet 408 closes its lowermost back contacts, the grounded conductor 457 is ex-

tended through the right winding of relay 402 which operates to render trunk 451 busy. The multi-contact relay 105 was released when group relay 206 opened its right middle contacts. Relay 206 upon opening its inner right contacts removes ground from conductor 353. Conductor 353 being thus disconnected from ground the shunt is removed from around the right winding of relay 305 which now operates over an obvious circuit to ground at the left contacts of magnet 413. Magnet 413 remains operated through both windings in series as hereinbefore described. The master circuit associated with switch 400 is thus completely restored, and line 301 is extended through link 412 to trunk 451.

Should calls be initiated simultaneously on two or more lines in the same horizontal group but in different vertical groups, one line will be given the preference as regards extension by switch 400. For example, should lines 301 and 307 call simultaneously, then line 307 would be extended first. As described hereinbefore the operations will proceed as far as the point where the vertical group relays 403, 404, etc., have their locking circuits prepared. It will be noted, however, that relay 404 being nearer to the grounded conductor 455 will remain locked in series with relay 107, thus causing the release of relay 403. Should all links in second choice group 811 be busy at this time relay 403 remains normal until line 307 is extended through switch 400, whereupon the master circuit shown on Figs. 1 and 2 may be taken into use again for the extension of line 301.

Should calls be initiated on two or more lines, in different horizontal groups but in the same vertical group, for example, lines 307 and 309, the corresponding horizontal group relays 206 and 214 are operated, but relay 206 being nearer the holding conductor 273, this relay locks in series with relay 101 as already described. Relay 206, therefore, remains locked and brings about the release of relay 214. Thus line 307 may be extended first, after which, line 309 may be extended. Should however the master circuit of switch 800 be available, line 309 need not wait but may be extended through its second choice switch as will be described hereinafter.

When a calling line must await its turn as above described, the line and start relays 303 and 203 are retained operated ready to cause the energization of the corresponding horizontal group relay such as 206 as soon as the master circuit is cleared and the previously operated vertical magnets are released as indicated by the restoration to normal of relays 111, 112 and 107, 108.

Provision is also made for giving equal service to the different horizontal groups of

lines regardless of the preference above mentioned. For example, should calls be initiated simultaneously on line 302 in horizontal group B and on lines 301 and 307 in group A, then as above noted, the preference will be given to that one of the lines in group A whose vertical group relay is nearest to the holding conductor 455, consequently line 307 will be extended first. During the process of extending line 307, relays 101 and 206 are operated as already described. Since a call is now awaiting in group B, relay 204 is operated, consequently relay 102 remains energized until the line in group B is extended. So long as relay 102 is operated a locking circuit is provided for relay 207 through the left winding thereof. Therefore, relay 207 remains locked until line 302 in group B has been extended. As long as relay 207 remains locked, the operating circuit of horizontal group relay 206 is opened and line 301 in group A cannot be extended until the waiting line 302 in group B is extended, whereupon relay 210 remains locked under control of relay 204. With relays 207 and 209 simultaneously locked, relay 102 releases, in turn bringing about the release of relays 207 and 209. Line 301 in group A may now be extended.

Description of a connection involving a second choice switch.

It will now be assumed that when the call is initiated on line 301 that all links in group 411 to which this line has access are busy, accordingly relays 305, 306, etc., are operated. Under this condition a circuit is completed from battery through the middle winding of relay 207, conductor 353, right outer front contacts of relays 306, 305, etc., to ground through the winding of relay 308. Both relays 207 and 308 operate in this circuit. The operation of relay 207 serves as an indication to the master circuit that all links in group 411 are busy. Relay 308 at its left inner contacts closes an obvious operating path through the left winding of switch-over relay 201. Relay 201 at its left outer back contacts opens the circuit of relay 203 which thereupon releases. It will be assumed that the master circuit associated with switch 800 is idle at this time. A circuit may, therefore, be traced from battery through the winding of slow releasing relay 503, innermost back contacts of relay 501, conductor 555, conductor 653, right outer contacts of relay 201, conductor 257, left inner contacts of relay 117, conductor 556 to ground at the contacts of relay 516. Relay 503 completes a circuit from ground at the left contacts of relay 502, front contacts of relay 503, left inner contacts of relay 505, conductor 158, left inner contacts of relay 104, conductor 159, to battery through the winding of multi-contact relay 501. Relay 501 im-

mediately closes a locking circuit for itself traceable from battery through the winding and locking contacts of said relay, conductor 555 to ground over conductor 653 as above traced. Relay 208 now operates by means of a circuit which is completed from battery through the winding of said relay, left inner contacts of relay 201, conductor 259, conductor 654, to ground at contacts of relay 501. Relay 208 in turn causes the energization of start relay 603 which is common to those lines appearing before group 811 in switch 800. The circuit for operating relay 603 may be traced from battery through the winding of said relay, left outer back contacts of relay 608, conductor 260, right front contacts of relay 208, conductor 261 to ground at the contacts of relay 303. It will be noted that the operating circuit for relay 303 now extends from battery at the left contacts of relay 104, conductor 551, next to innermost front contacts of relay 501, left outer back contacts of relay 505, normal contacts of relay 604, left inner back contacts of relay 619, left inner front contacts of relay 208, winding of relay 303, to ground at the contacts of relay 304. When relay 501 operated, the energizing circuit of relay 503 was broken and this relay began to release. After the interval measured by the release of relay 503, a circuit is closed for horizontal group relay 601. This circuit may be traced from ground at the left back contacts of relay 502, back contacts of relay 503, conductor 553, right inner contacts of relay 603, right winding of relay 601, right back contacts of relay 607, conductor 655, left contacts of relay 504, left back contacts of relays 504, 512 and 514, front contacts of relay 501, conductor 553, left contacts of relays 101 and 112, to battery at the left contacts of relay 114. When relay 601 closes its contacts, the grounded conductor 651 is extended through the left winding and locking contacts of relay 601, thence through the winding of relay 504 to battery at the left contacts of relay 510. Relays 601 and 504 operate in this circuit and render the master circuit of switch 800 busy. Relay 601 closes and obvious energizing circuit for relay 604 and relay 504 completes an obvious circuit for relay 505.

The circuits are now in condition to cause the operation of a line vertical magnet and a trunk vertical magnet associated with switch 800. For this purpose relay 507 is energized over circuit traceable from battery through the winding of said relay, left middle contacts of relay 601, conductor 656, right outer contacts of relay 517, conductor 564, to ground at the contacts of relay 505. Since line relay 303 is operated a circuit is closed for vertical group relay 803 which is individual to the vertical row of contacts 806 wherein line 301 appears. The circuit

for operating relay 803 may be traced from battery at the left contacts of relay 114, (hence through the left back contacts of relays 112 and 101, conductor 161, front contacts of relay 501, conductor 557, right back contacts of relay 508, conductor 558, right winding of relay 803, conductor 751, left outer contacts of relay 507, conductor 559, innermost contacts of relay 506, conductor 162, conductor 352, to ground at the contacts of relay 303. Relay 803 locks through its left winding and locking contact in series with the winding of relay 508. Relays 509 and 510 now operate in a manner similar to that described for relays 108 and 109. Line vertical magnet 807 is now energized by means of a circuit traceable from ground through the winding of said magnet, right outer contacts of relay 803, conductor 752, to battery at the contacts of relay 510. Assuming trunk 853 to be idle then the associated trunk relay 810 is normal, and trunk vertical magnet 809 operates over circuit from ground through the winding of said magnet, right back contacts of relay 810, right inner contacts of relay 803, conductor 753, to battery at the contacts of relay 510. It will be noted that vertical magnet 807 causes the successive operation of vertical control relays 511 and 512 over circuits similar to those described for relays 111 and 112. Similarly the trunk vertical magnet 809 completes circuits for operating relays 513 and 514, these circuits being similar to those described for relays 113 and 114. With relays 511 and 514 operated, a circuit is closed from battery through the right winding of relay 607, thence through the right inner contacts of relay 601, conductor 657, right outer contacts of relay 511, winding of relay 515, right front contacts of relay 514, conductor 658, lowermost front contacts of magnet 809 to conductor 854. Conductor 854 may be connected to battery through the middle winding of a sender selector start relay similar to relay 801 for the purpose of associating an idle sender with the trunk 853, as described in connection with trunk 451. The operation of a horizontal magnet such as 813 corresponding to the first idle link in group 811 is similar to that described in connection with magnet 413 and it is believed that further description of this method of operation is unnecessary. Assuming that magnet 813 has been thus operated, the grounded sleeve conductor of trunk 853 is extended through contacts of switch 800, thence over the sleeve conductor of line 301 to operate relay 304. Relay 304 causes the successive release of relays 303 and 603. With relay 603 restored to normal, the release of the master circuit shown in Figs. 5 and 6 is similar to that described in connection with the master circuit of Figs. 1 and 2 and further description is not

deemed necessary. It will be noted, however, that switch-over relay 201 and multi-contact relay 501 remain operated so long as all links in group 411 are busy.

In the preceding description it has been assumed that the master circuit associated with switch 800 was idle when the call was initiated on line 301. Should the master circuit have been busy at the time, then relay 504 would be operated and line 301 would await the release of the second choice master circuit. While thus waiting it may happen that one of the links in group 411 becomes idle, whereupon relays 308, 208, 201, and 501 release. The calling line 301 under this condition may be extended over the idle link in group 411 under control of the master circuit associated with switch 400 as described hereinbefore.

Should the call be initiated on a line, for example line 701, whose first choice switch is switch 800, and assuming there to be an idle link in the corresponding group of links, then line 701 will be extended under control of the master circuit which is individual to switch 800 and shown in Figs. 5 and 6. The sequence of operations in such a case is substantially similar to that described in connection with the extension of line 301 through link 411 under control of the master circuit of Figs. 1 and 2.

Should all the links in group 811 be busy when the call is initiated on line 701, then relays 708, 608, 619 and 501 are operated similarly to the manner in which relays 308, 201, 208 and 501 were operated when an all links busy condition existed in group 411. Should there be an idle link in group 411 when line relay 703 operates, relays 201 and 208 associated with group 411 are normal. Accordingly when relay 703 operates a circuit may be traced from ground through the front contacts of relay 703, thence over conductor 660, right front contacts of relay 619, conductor 659, left outer back contacts of relay 201, to battery through the winding of start relay 203. When relay 203 operates a circuit is closed for group relay 206, traceable from ground at the back contacts of relays 502 and 503, conductor 553, conductor 651, inner front contacts of relay 203, right winding of relay 206, right back contacts of relay 207, conductor 253, front contacts of relay 501, back contact of relays 504, and 512 and 514, front contact of relay 501, conductor 553, left contacts of relays 101 and 112, to battery at the contacts of relay 114. Relay 206 immediately locks in series with relay 101 whereupon relays 104, 105 and 202 operate as hereinbefore described. Vertical group relay 404 is now operated by means of a circuit traceable from battery at the back contacts of relay 107, conductor 157, right winding of relay 404, left front contacts of relay 105, conductor 176, left front

contact of relay 506, conductor 573, to ground at the front contacts of relay 703. Relay 404 locks in series with relay 107 whereupon relays 108 and 109 operate as already described. Line vertical magnet 407 and a trunk vertical magnet corresponding to an idle trunk appearing in switch 400 are now operated. The further selection of an idle link in group 411 and the operation of the corresponding horizontal magnet is controlled in the same manner as that described in connection with the extension of line 301 through switch 400.

All trunks busy.

Should all the trunks appearing in the first choice switch be busy when a line initiates a call, all the trunk relays associated with said switch are operated. For example, should all the trunks appearing in switch 800 be busy when line 701 initiates the call, then relays 810, 814, etc., are operated. A circuit is thereupon completed for relay 522 traceable from battery through the winding of said relay, conductor 561, left outer contacts of relays 810, 814, etc., to ground. Relay 522 extends ground through its outer front contacts over conductor 563, thence in parallel through the right windings of relays 608, 609, 611, etc., to battery. The operation of relay 608 brings about the operation of multi-contact relay 501 as hereinbefore described and the calling line 701 is extended through switch 400 under control of the master circuit of Fig. 1 as already described.

Should all the trunks appearing in switch 400 also be busy when the switch over relays 608 and 619 are operated, then relay 119 is operated over a circuit similar to that described for relay 522. With both relays 119 and 522 operated, a circuit is completed for relay 502 traceable from battery, through the winding of said relay, conductor 552, left contacts of relays 119 and 522, to ground. Relay 502 in operating disconnects the control ground and no calls can be started under control of either of the master circuits until a trunk becomes idle as indicated by the release of relay 502.

Extension of a call under trouble conditions.

The circuits are so arranged that a predetermined lapse of time is allowed between the energization of a start relay and the operation of a horizontal magnet. If, therefore, the control circuit is not cleared within this measured time, the switch and controlling circuit are automatically removed from service and connected to a trouble indicating device where a complete record of the conditions existing at the time trouble is encountered is recorded and may cause a printed record to be made thereof. For example, as soon after start relay 203 operates, when interrupter 170 closes its

lower contacts, a circuit is completed from battery through said contacts, winding of relay 103, conductor 163, outer front contacts of relay 203, conductor 274 to ground at either the back contact of relay 112, or at the front contact of relay 111. Relay 103 completes an obvious locking circuit for itself. After the predetermined interval interrupter 170 closes its upper contacts and a circuit is completed from battery, through said contacts, right contacts of relay 103, winding of relay 118 to ground at the right contacts of relay 502. A locking circuit is thereupon completed for relay 118 traceable from battery at the right outer contacts of relay 521, conductor 562, inner right contacts of relay 118, right contacts of relay 103, winding of relay 118, to ground as above traced. With relay 118 operated a circuit is completed from ground at the left outer contacts of relay 117, through the left contacts of relay 118, and thence to the time measuring device 120 whose operation is thereby initiated. The measuring device 120 may be of any well known type and at the end of an interval measured thereby, relay 118 remains operated and conductor 164 is grounded, causing the operation of relays 117, 121 and 106. Relays 121 and 106 immediately lock over a circuit traceable from battery through the windings of these relays in series, locking contact of relay 106, right outer contacts of relay 121, contacts of key 165, right normal contacts of relay 521, to ground at the contacts of key 565. Relays 106 and 121 thus remain operated independently of the time measuring device 120. The above traced ground is also extended over conductor 166 to operate the multi-contact relay 167 by means of the non-interfering start circuit 168, as described in the copending application of E. B. Craft and L. Keller, Serial No. 747,174, filed Nov. 1, 1924, Patent No. 1,614,285, dated January 11, 1927. The various trouble indicating leads from the master circuit of switch 400 are connected to a trouble indicator 169. This trouble indicator may be of the general type disclosed in the patent to E. B. Craft and L. Keller referred to above. With relay 121 operated, circuits are completed from battery through the right windings of relays 201, 211, 212, etc., in parallel, and thence over conductor 272 to ground at the left outer contacts of relay 121. Thus by means of the operation of relays 201, 211, etc., the entire switch 400 and its associated master circuit are removed temporarily from service. With relay 201 thus operated, the start relay 203 releases, and relay 603 operates. The calling line 301 may therefore be extended through switch 800 under control of the master circuit of Figs. 5 and 6 as hereinbefore described.

It will now be assumed that when the line

301 initiates the call that both the master circuit associated with switch 400 and the master circuit associated with the switch 800 encounter trouble. Therefore, relays 517, 518, 519 and 520 are operated as described for the corresponding relays of the first master circuit. A circuit is now completed from battery through the winding of relay 521, conductor 567, right inner contacts of relay 106, conductor 568 to ground at the left front contacts of relay 518. Relay 521 immediately locks under control of the key 565. In addition relay 521 opens the locking circuits of relays 517, 518 and 106, 121. It will be noted that relays 103 and 118 have their locking circuits opened when the start relay 203 is released by the operation of relays 201 and 208. When relay 121 releases as above described, it in turn causes the release of the switch over relays 201, 211 and 212 and the calling line 301 may make another attempt to be extended through switch 400. The circuits are so arranged that this process of repeating attempts to extend the calling line may be continued until the end of the interval determined by the complete operation of the time measuring device 120, whereupon an alarm may be given to an attendant who may ascertain the source and nature of the trouble by means of a printed record, as described in the patent to Craft and Keller referred to hereinbefore.

What is claimed is:

1. In a telephone exchange system, telephone lines arranged in groups, a plurality of line switches each acting normally as a first choice switch for the lines of one group and as a second choice switch for the lines of another group, a plurality of equivalent trunks appearing in each of said switches, means responsive to the initiation of a call on one of said lines for causing the operation of a first choice switch to the exclusion of a second choice switch to extend said line, and means responsive to the initiation of a call on said line for causing the operation of a second choice switch to the exclusion of a first choice switch to extend said line.
2. In a telephone exchange system, a calling line, a first choice line switch, a second choice line switch each of said switches comprising links for extending said line, means effective when an idle link exists in said first choice switch for operating said switch to extend said line, and automatic means responsive to an all links busy condition in said first choice switch for operating said second choice switch to extend said line.
3. In a telephone exchange system, a calling line, a first choice line switch, a second choice line switch each of said switches comprising link circuits for extending said line, a master circuit for each of said switches, the master circuit of said second choice

switch being normally unable to control the extension of said line, and automatic means effective in response to an all links busy condition in said first choice switch for associating said second master circuit with said line to cause said line to be extended through said second choice switch.

4. In a telephone exchange system, a calling line, a plurality of switches in which said line appears, each switch comprising a plurality of links for extending said line, a plurality of master circuits each individual to one of said switches for controlling the operation thereof, one of said master circuits being normally associated with said line, another of said master circuits being normally disassociated from said line, means effective when all the link circuits in one of said switches are busy for disassociating said one of said master circuits from said line and for associating said other of said master circuits with said line to cause the same to be extended through the switch corresponding to said other master circuit.

5. In a telephone exchange system, a calling line, a first choice line switch, a second choice line switch, a group of trunks appearing in said first choice switch, a group of equivalent trunks appearing in said second choice switch, a master circuit for each switch, the master circuit of said second switch being normally unable to control the extension of said line, and means effective when all the trunks appearing in said first switch are busy for associating the master circuit of said second switch with said line to cause said line to be extended by means of said second switch to an idle trunk in said second mentioned group of trunks.

6. In a telephone exchange system, groups of calling lines, a plurality of line switches each adapted to act as a first choice switch for one group of lines and as a second choice switch for another group of lines, groups of trunks, each group appearing in one of said switches, means responsive to the initiation of a call on a line for causing one of said switches to act as a first choice switch to extend said line to an idle trunk in the corresponding group, and means independent of the line effective when all the trunks in said corresponding group are busy for causing another of said switches to act as a second choice switch to the exclusion of a first choice switch to extend said line to an idle trunk.

7. In a telephone exchange system, a calling line, a plurality of line switches in which said line terminates, groups of trunks, each group appearing in a corresponding line switch, one of said groups acting as first choice trunks for said line and another of said groups acting as second choice trunks for said line, means responsive to the initiation of a call on said line for operating one

of said switches to seize an idle trunk in the first choice group, and automatic means independent of the calling line effective when all the trunks in said first choice group are busy for causing another of said switches to operate to the exclusion of said first switch to seize an idle trunk in said second choice group.

8. In a telephone exchange system, a calling line, a first line switch, a second line switch, said line appearing in both of said switches, a group of links in said first switch adapted to act as first choice links for said line, a group of links in said second switch adapted to act as second choice links for said line, means responsive to the initiation of a call on said line for causing said first switch to extend said line by means of an idle link in the first choice group, and automatic means independent of the calling line effective when all the links in said first choice group are busy for causing said second switch to extend said line by means of a link in said second choice group.

9. In a telephone exchange system, a first calling line, a second calling line, a first line switch, a second line switch, both of said lines appearing in both of said switches, a group of trunks appearing in said first switch serving as first choice trunks for said first line and as second choice trunks for said second line, a group of trunks appearing in said second switch serving as first choice trunks for said second line and as second choice trunks for said first line, means responsive to the initiation of a call on said first line for operating said first switch to extend said first line to a trunk appearing in said first switch, means effective when all trunks appearing in said first switch are busy for operating said second switch to extend said first line to a trunk appearing in said second switch, means responsive to the initiation of a call on said second line for operating said second switch to extend said second line to a trunk in said second group, and means effective when all the trunks in said second switch are busy for causing said first switch to operate to extend said second line to a trunk in said first switch.

10. In a telephone exchange system, a plurality of calling lines, a first choice line switch, a second choice line switch, each of said lines appearing in both of said switches, a master control circuit for each of said switches, means for operating said first choice switch to extend one of said lines, and means effective when said one of said lines is not extended by said first choice switch within a predetermined time for causing said second choice switch to operate to extend said one of said lines.

11. In a telephone exchange system, a plurality of calling lines, a first choice line

switch and a second choice line switch, each of said lines appearing in both of said switches, a master control circuit for each of said switches, means for operating said first choice switch to extend one of said lines, and means effective when an unstandard condition exists either in said first choice switch or the associated master circuit for causing said second choice switch to operate to extend said one of said lines.

12. In a telephone exchange system, a first calling line, a second calling line, a first line switch, a second line switch, said lines appearing in both of said switches, a master control circuit for said first switch, a master control circuit for said second switch, said first master circuit adapted to serve as a normal control in the extension of said first line and as an emergency control in the extension of said second line, said second master circuit serving as a normal control in the extension of said second line and as an emergency control in the extension of said first line.

13. In a telephone exchange system, a calling line, a first line switch, a second line switch, a master control circuit for said first line switch, a master control circuit for said second line switch, means normally effective to associate said first mentioned master circuit with said line, and automatic means effective in response to an unstandard condition in either said first line switch or the associated master circuit for causing said second mentioned master circuit to be associated with said line to control the operation of said second line switch to extend said line therethrough.

14. In a telephone exchange system, a calling line, a first choice line switch, a second choice line switch, said line appearing in both of said switches, means for operating the first choice line switch to extend said line, means for operating said second choice switch to extend said line when the same cannot be extended through said first choice line switch, means effective when said second choice switch is also unable to extend said line for causing said first choice switch to make a second attempt to extend said line, and means for causing said first and second choice switches to make repeated attempts in succession to extend said line.

15. In a telephone exchange system, a calling line, a first choice line switch, a second choice line switch, trunks appearing in both of said switches, means responsive to the initiation of a call on said line and effective when all said trunks are busy for causing said first and said second choice switches to make repeated trials in succession to extend said calling line until one of said trunks becomes idle and means for causing the switch in which said idle trunk appears to operate to extend the calling line thereto.

16. In a telephone exchange system, a calling line, a first choice line switch, a second choice line switch, links in both of said switches for extending said calling line, means responsive to the initiation of a call on said line and effective when all available links in both of said switches are busy for causing said first and said second choice switches to make repeated attempts in succession to extend said line until a link in one of said switches becomes idle, and means for causing the switch in which the idle trunk is located to operate to extend the calling line therethrough.
17. In a telephone exchange system, a calling line, first choice means for extending said line comprising a line switch and a master control circuit therefor, second choice means for extending said line comprising a second line switch and a master control circuit therefor, means effective when an unstandard condition exists in said first choice, means for causing said line to be extended by said second choice means, and means effective when an unstandard condition exists in both of said first and said second choice means for causing repeated attempts to be made to extend said line through said first and said second switches.
- In witness whereof, I hereunto subscribe my name this 26 day of June A. D., 1925.
- EDGAR H. CLARK.