

Dec. 29, 1925.

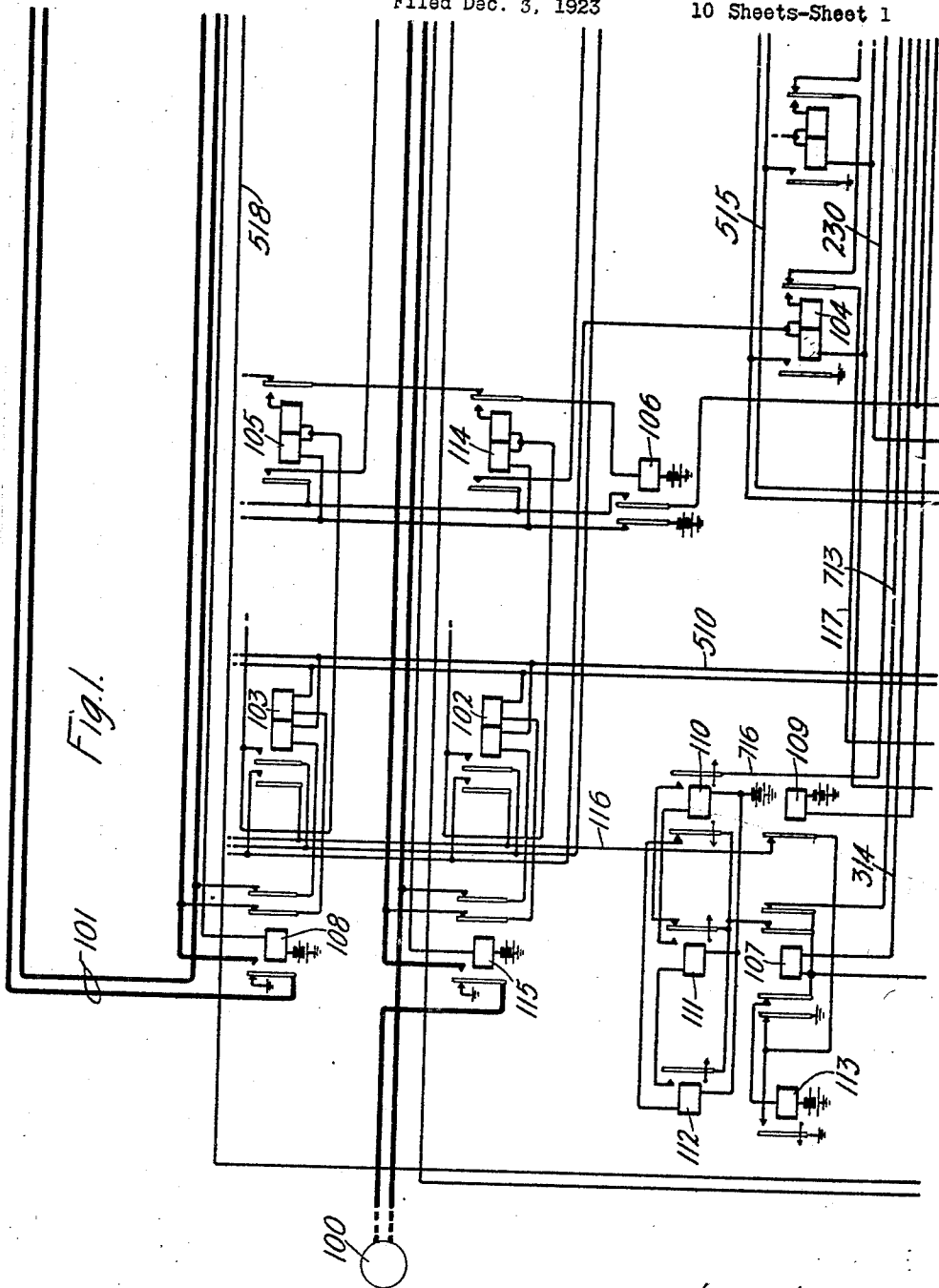
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1,567,265

TELEPHONE EXCHANGE SYSTEM

Filed Dec. 3, 1923

10 Sheets-Sheet 1



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TELEPHONE EXCHANGE SYSTEM

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10 Sheets-Sheet 2

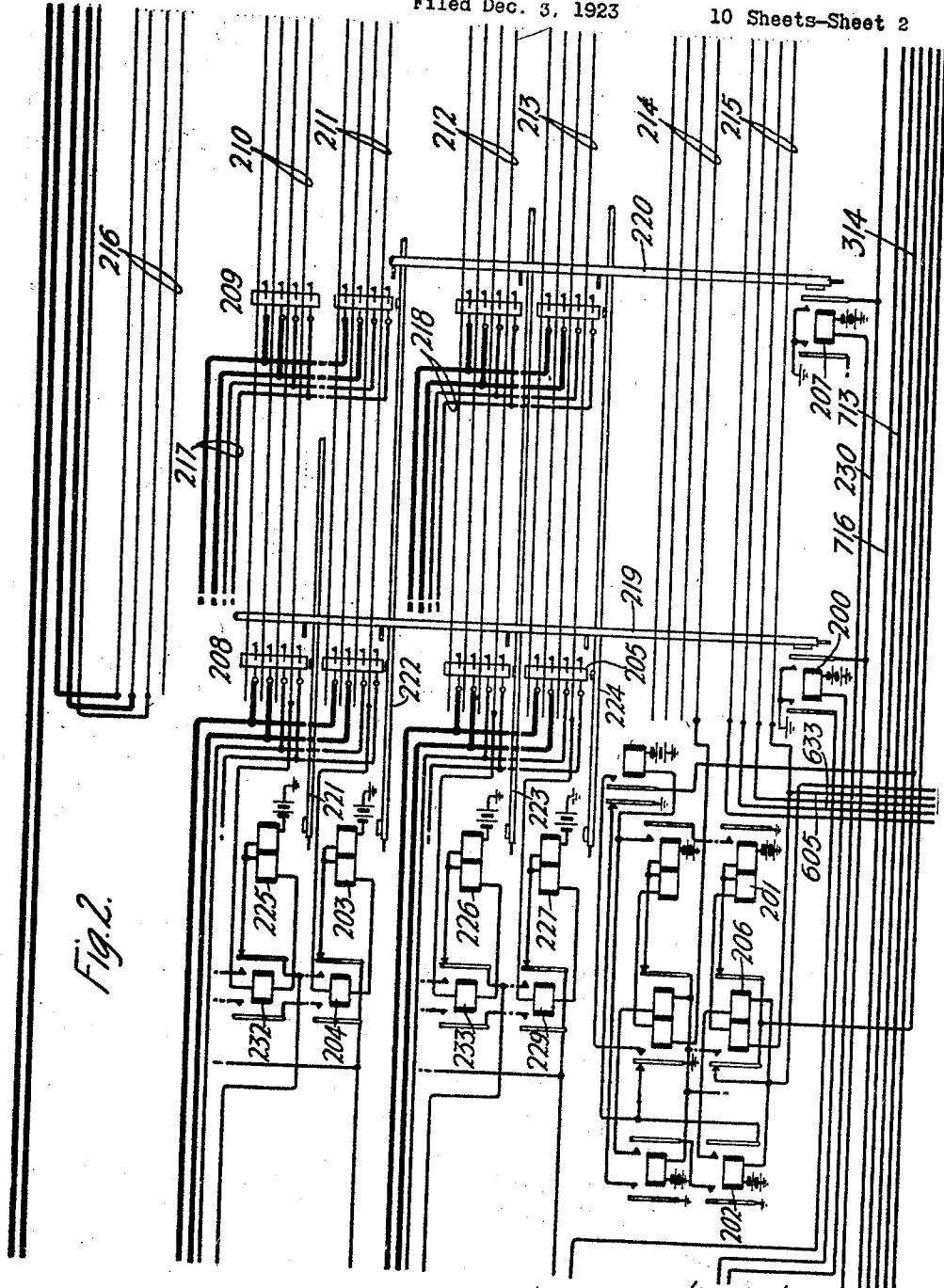


Fig. 2.

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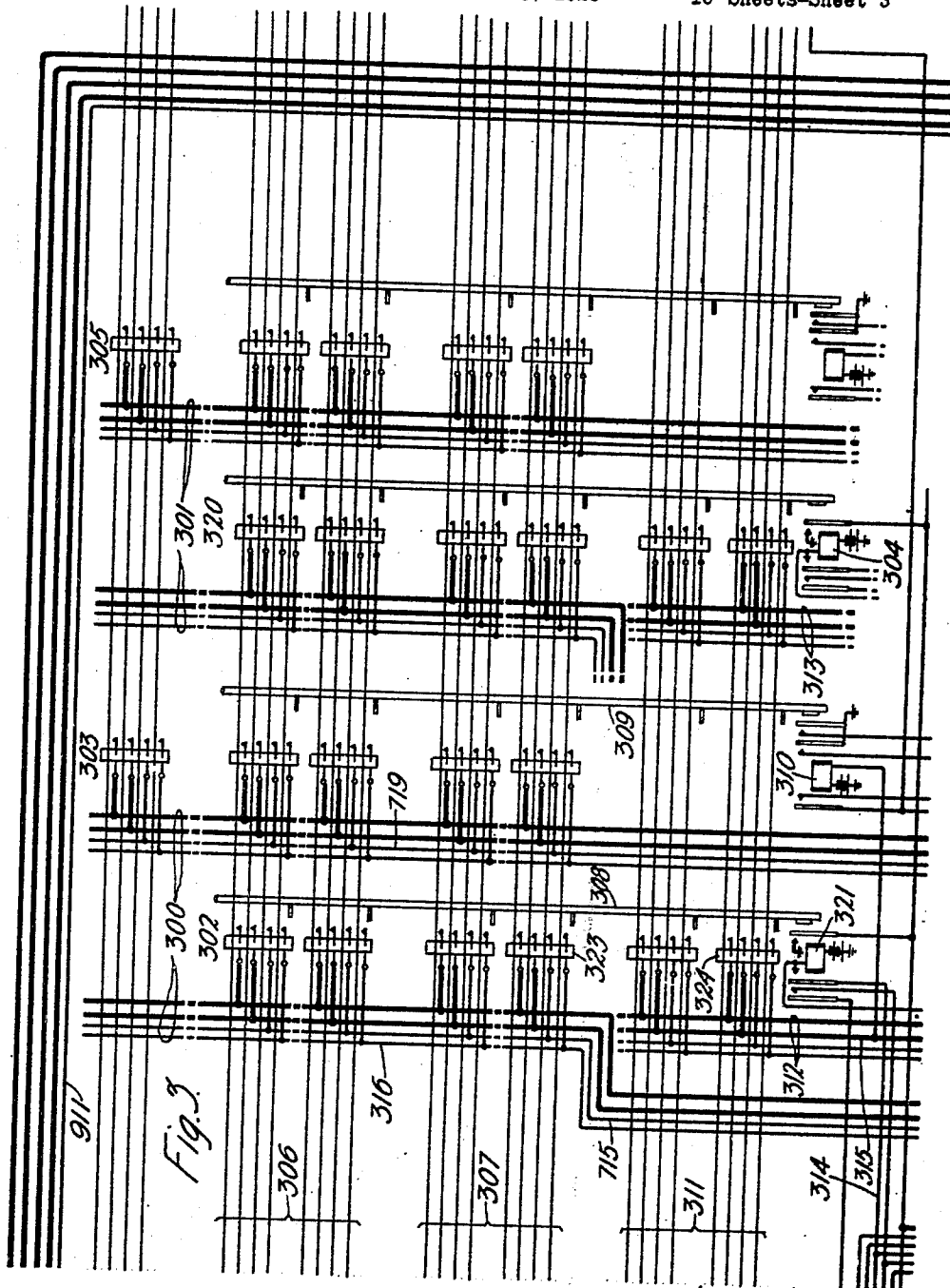
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TELEPHONE EXCHANGE SYSTEM

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10 Sheets-Sheet 3



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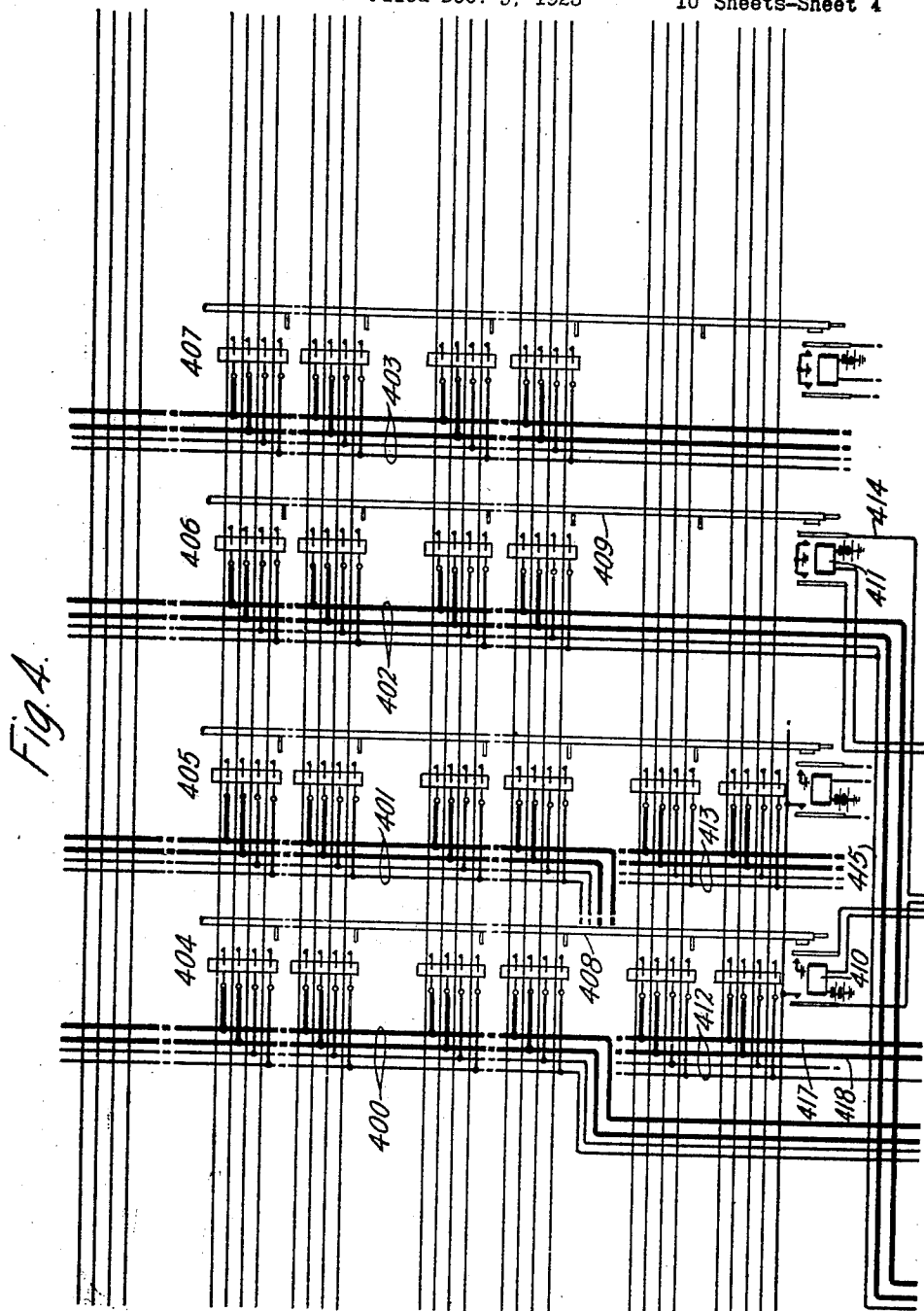
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TELEPHONE EXCHANGE SYSTEM

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10 Sheets-Sheet 4



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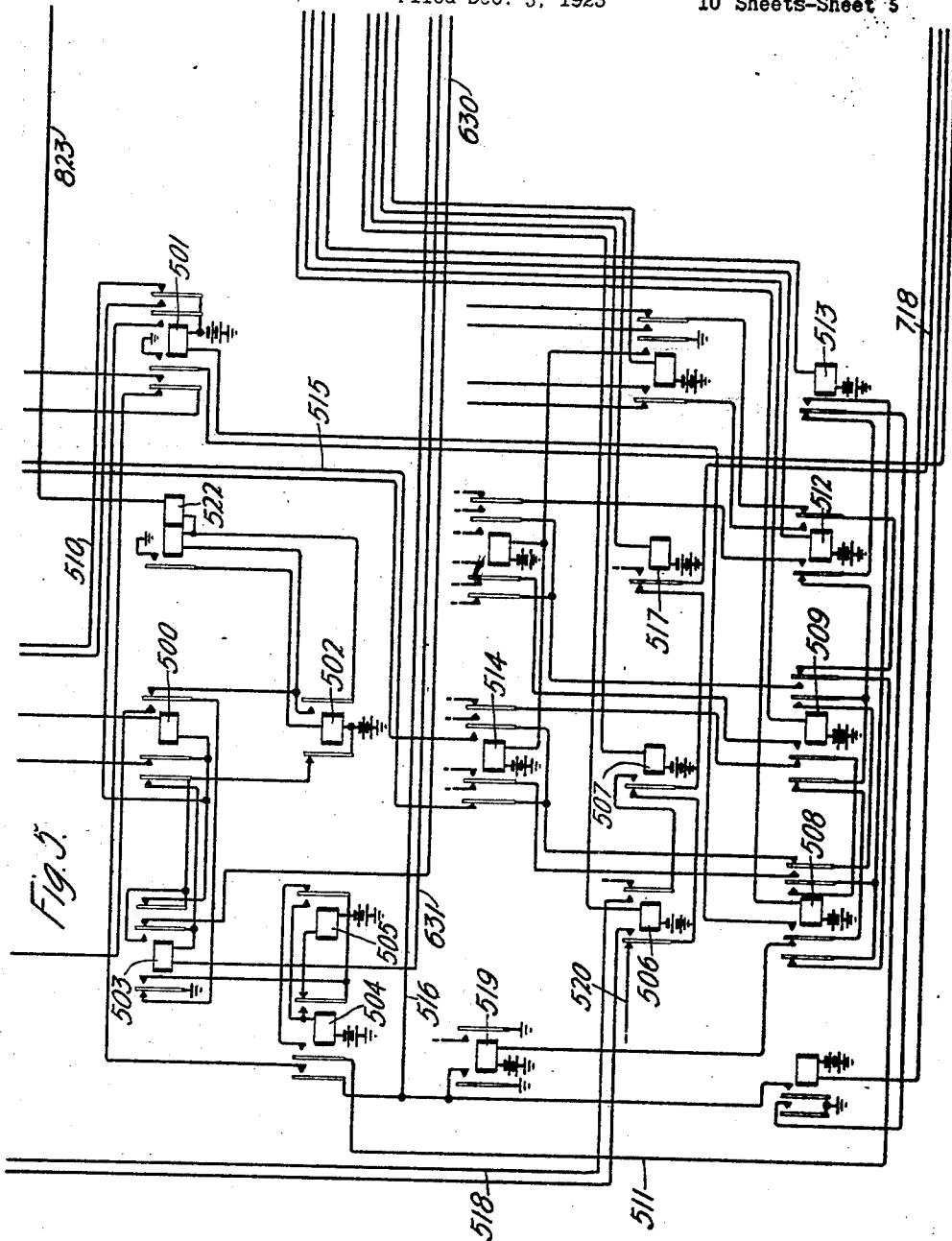
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10 Sheets-Sheet 5



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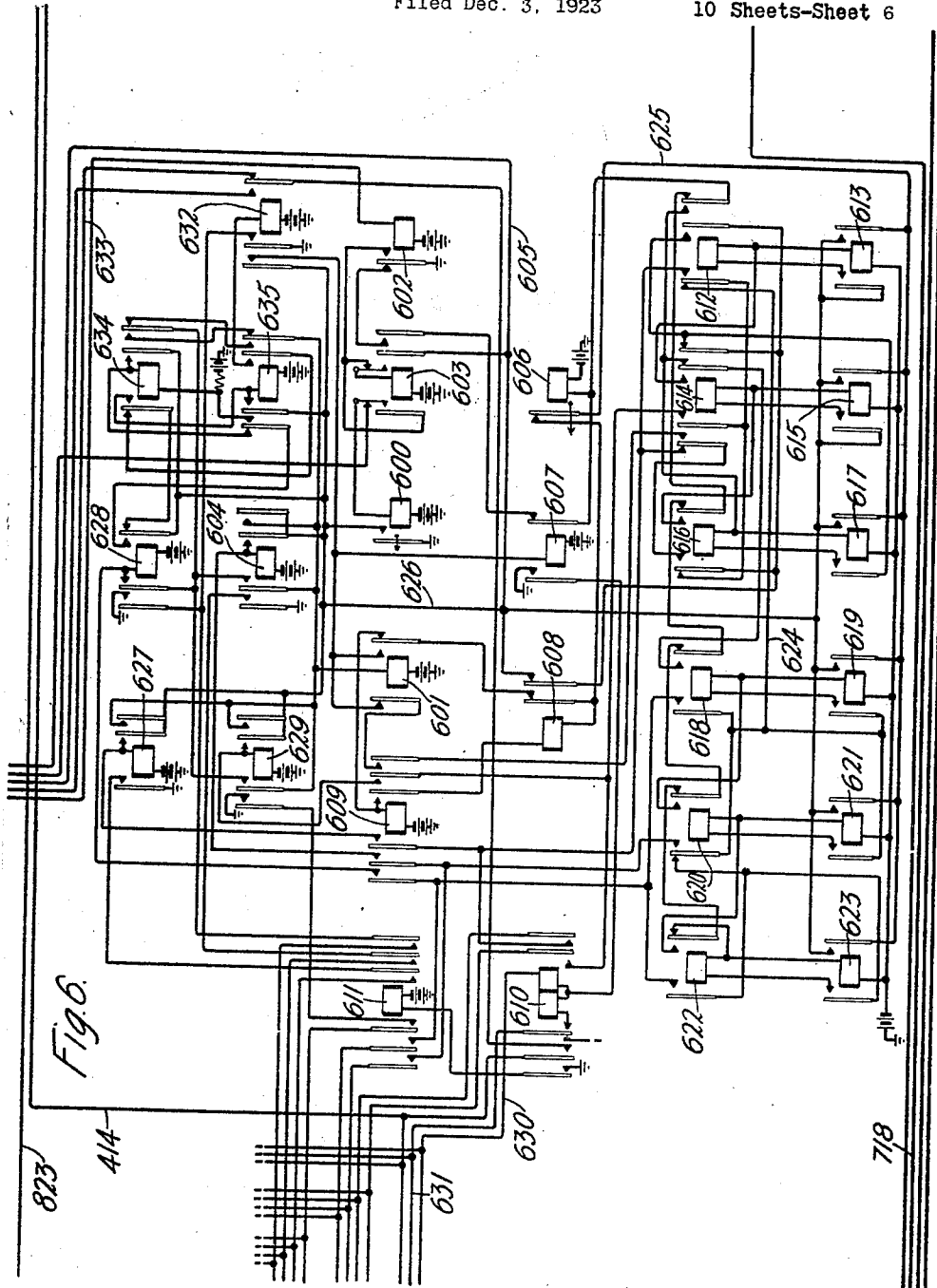
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10 Sheets-Sheet 6



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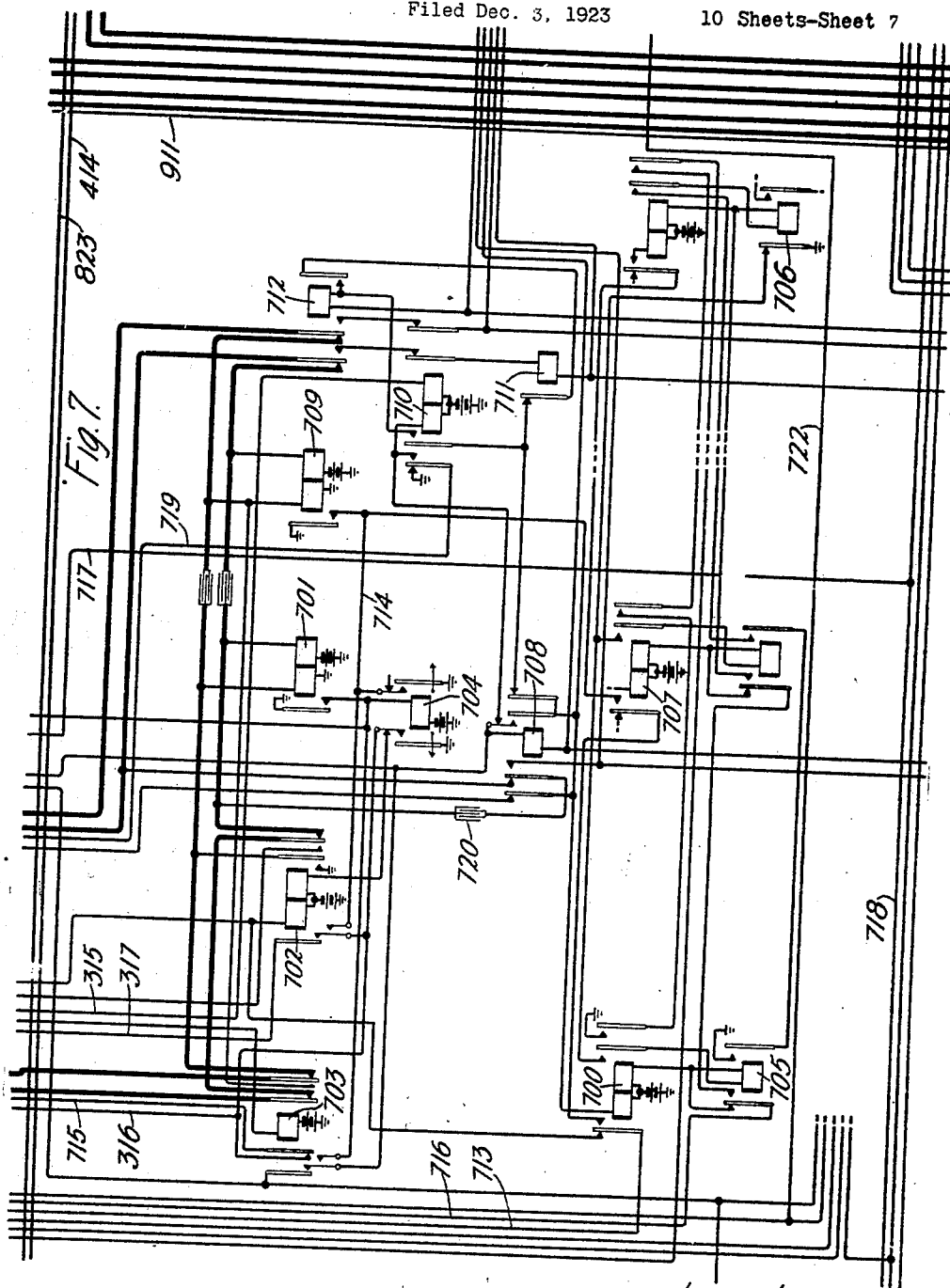
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10 Sheets-Sheet 7



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TELEPHONE EXCHANGE SYSTEM

1,567,265

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10 Sheets-Sheet 8

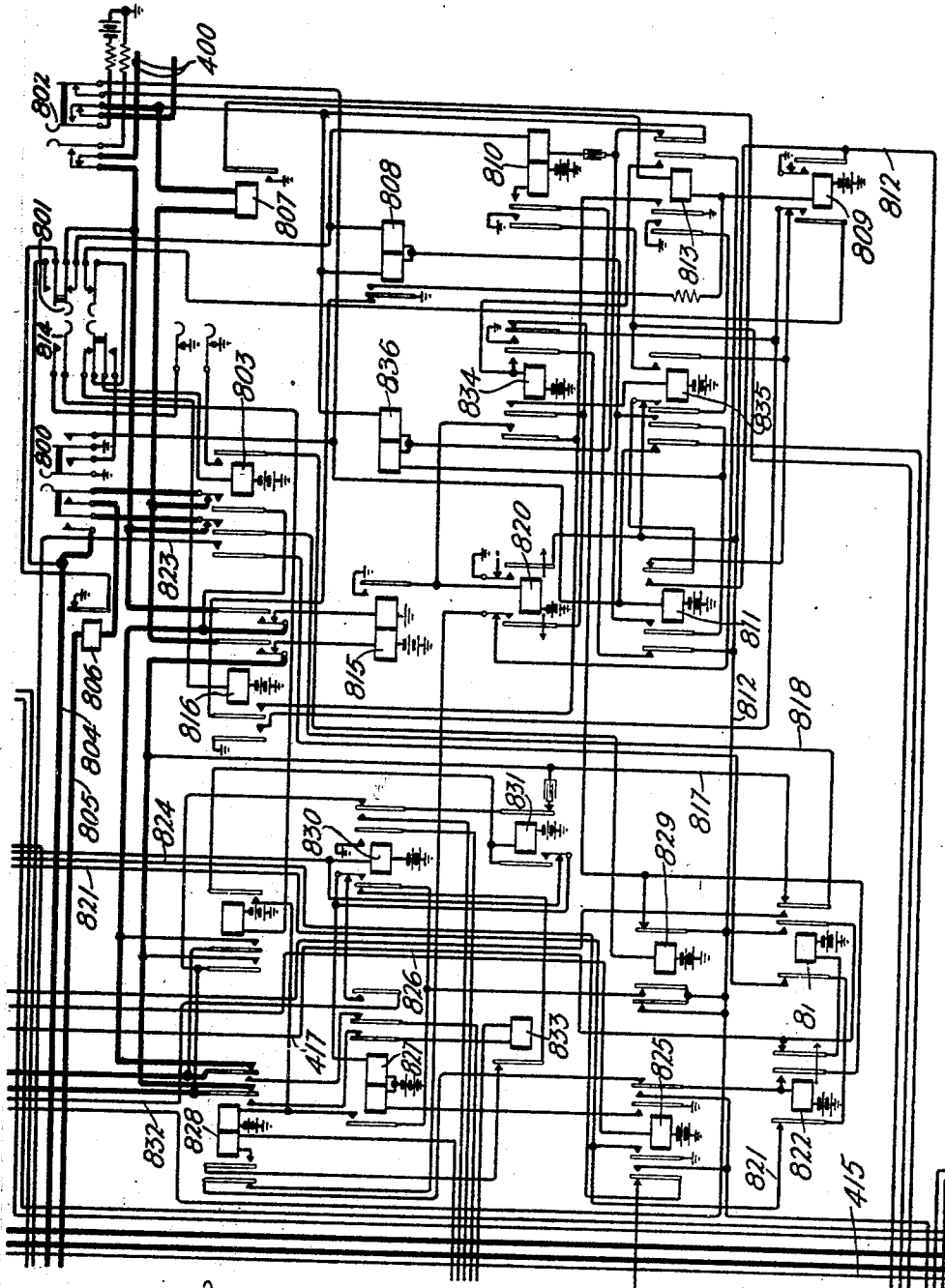


Fig. 8

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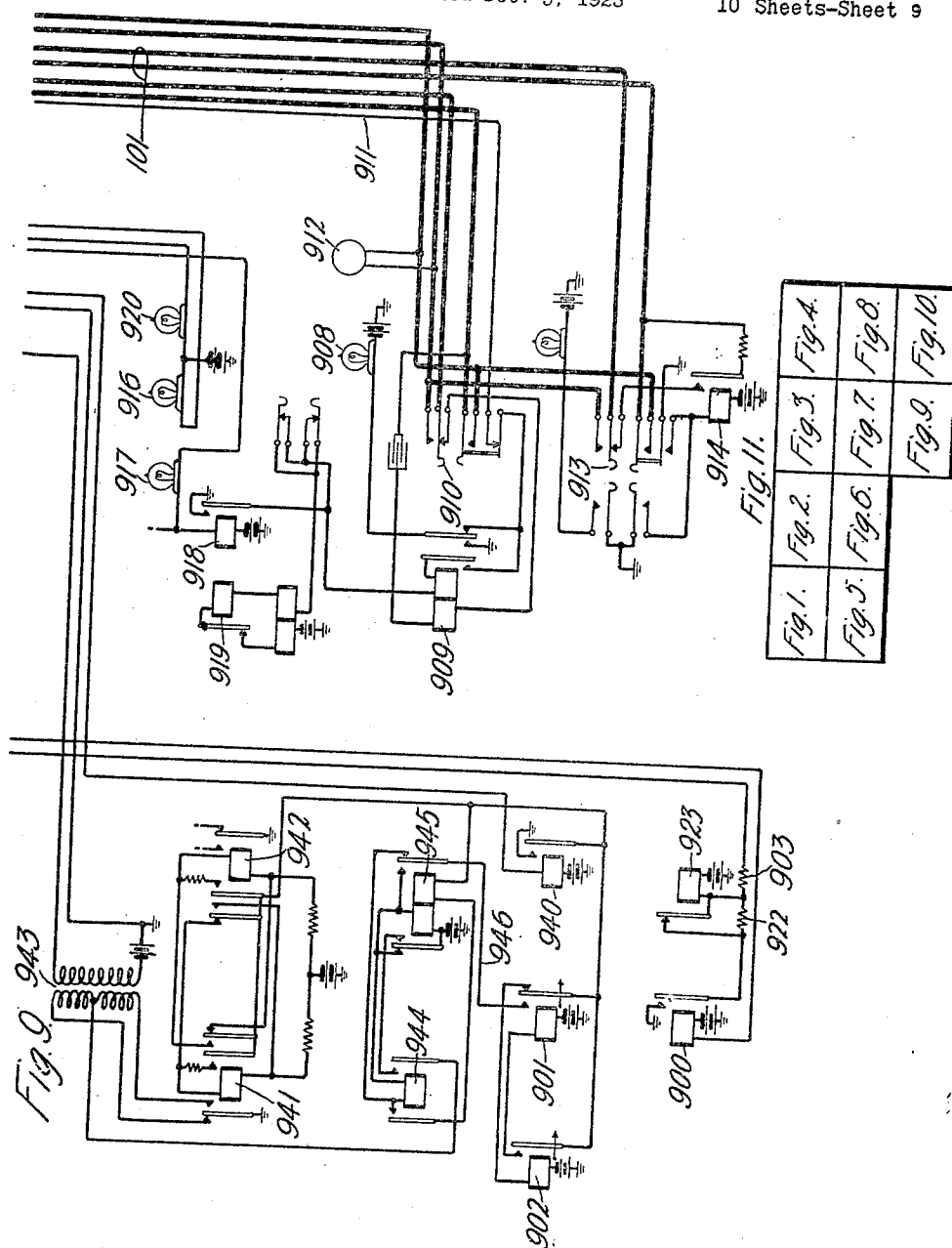
Dec. 29, 1925.

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TELEPHONE EXCHANGE SYSTEM

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Filed Dec. 3, 1923

10 Sheets-Sheet 9



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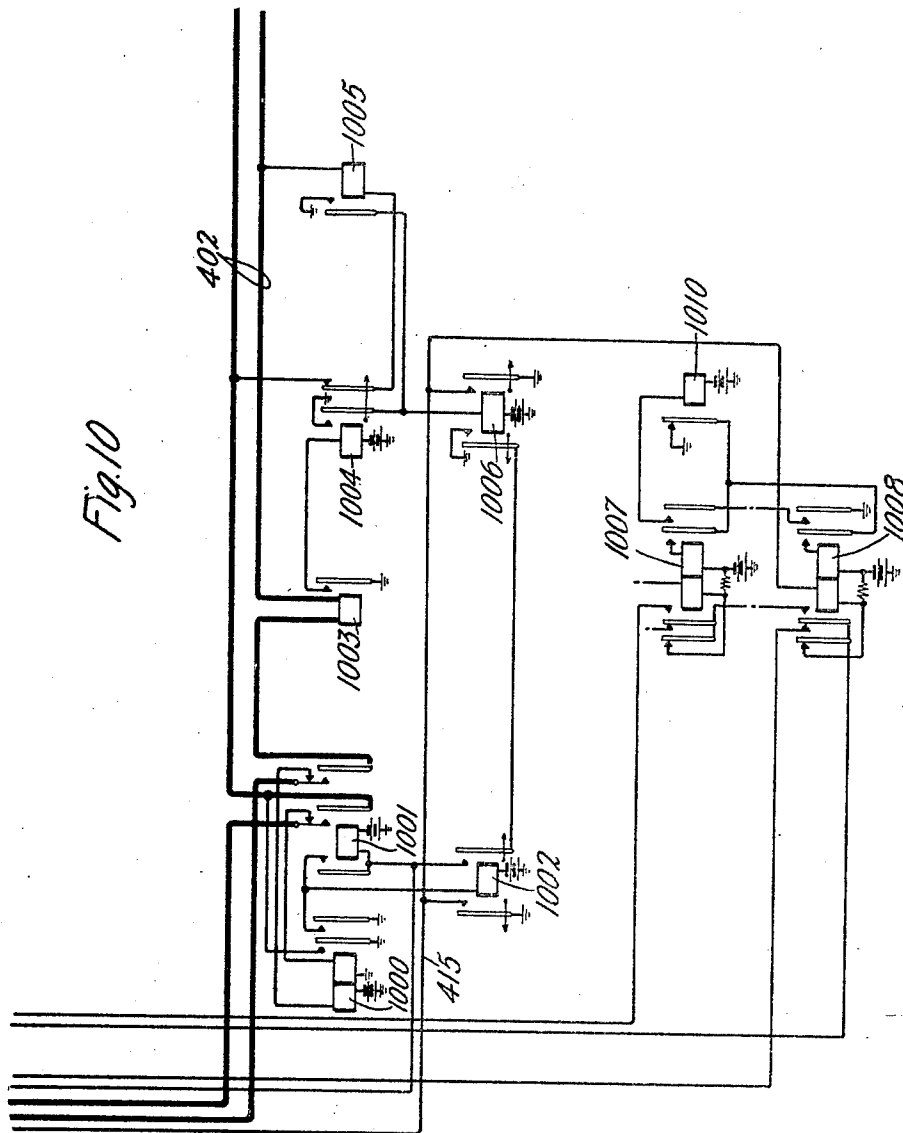
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TELEPHONE EXCHANGE SYSTEM

Filed Dec. 3, 1923

10 Sheets-Sheet 10



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# UNITED STATES PATENT OFFICE.

EDWARD E. HINRICHSSEN, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

## TELEPHONE-EXCHANGE SYSTEM.

Application filed December 3, 1923. Serial No. 678,142.

*To all whom it may concern:*

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

This invention relates to telephone systems and especially to systems involving the use of automatic switching equipment for establishing conversational connections.

The object of the invention is to improve small automatic telephone systems, such as private branch exchanges, by performing the various local and inter-office switching functions with a unitary and compact arrangement of structure and circuits.

A feature of the invention relates to the employment of a single switching structure for setting up connections between local subscribers' lines, incoming connections from central office and outgoing connections to central office.

Another feature of the invention relates to a switch having intermediate links for interconnecting incoming and outgoing circuits wherein said links may be used for both local and central office connections.

Still another feature relates to a switch in which certain links are used for establishing conversational connections and other links serve to associate switch controlling mechanisms.

A further feature relates to a switch of the foregoing character wherein a part of the intermediate link circuits are used for connections to a private branch exchange attendant.

Still another feature relates to a system, as outlined above, having a single marker and a number of common senders for controlling all of the classes of connections through the switch.

These and other features of the invention will be taken up in detail hereinafter.

Referring to the drawings, Figs. 1 to 10 inclusive, when taken in the order illustrated in Fig. 11, represent a private branch exchange embodying the features of the present invention.

Fig. 1 shows a local subscriber's telephone

line and also a portion of the attendant's line.

Figs. 2, 3 and 4 show a single switch structure of the coordinate type comprising horizontal links and vertical rows of contacts in which appear the subscribers' and operators' lines, the vertical or intermediate link circuits and also the incoming and outgoing central office trunks.

Fig. 5 illustrates the marking mechanism which is individual to the switching structure and serves to control said switch in the establishment of the various types of connection.

Fig. 6 shows one of a number of common register senders which cooperates with the marker.

Fig. 7 illustrates, in detail, one of a number of vertical link circuits used for the establishment of local connections.

Fig. 8 shows the details of an incoming trunk circuit from the central office.

Fig. 9 shows certain of the operator's equipment together with a ringing device.

Fig. 10 shows one of the talking trunks to central office.

The switching device employed in this system is of the coordinate type comprising a number of horizontal or intermediate link circuits which serve to establish connections between incoming and outgoing circuits. The incoming circuits terminate in vertical rows of contacts having access to the horizontal links on one side of the switch while the outgoing circuits terminate likewise in vertical rows of contacts on the other side of the switch.

For instance, the subscriber's line 100 and the operator's line 101 are seen appearing in the vertical row of contacts 208 of the switch. The operator's line 101, has access to the group of horizontal links containing the links 210 and 211 while the subscriber's line has access to the group of links containing the links 212 and 213. Likewise, other lines appear in other vertical rows of contacts, such as the lines 217 and 218 appearing in the vertical row 209.

Referring to Fig. 3, the link circuits 200 and 301 are seen to appear in the vertical rows of contacts of the switch. The link 300 has its outgoing end appearing in the vertical row of contacts 302 before the two

groups 306 and 307 of horizontal links. The incoming end of the link circuit 300 appears in the vertical row 303 before the horizontal links of the groups 306 and 307 and also before the horizontal link 216. In a similar manner the second link circuit 301 appears in the vertical rows of contacts 320 and 305 of the switch.

In Fig. 4, the incoming trunk 400 appears in the vertical row of contacts 404 while a second incoming trunk 401 similarly appears in the vertical row 405. Also, two outgoing trunks 402 and 403 are illustrated appearing respectively in the vertical rows of contacts 406 and 407.

The vertical rows of contacts are controlled by the vertical operating bars actuated by means of individual operating magnets. Several of these bars, 219, 220, 308, 309, 408 and 409, individual respectively to the vertical rows 208, 209, 302, 303, 404 and 406 are operated and controlled by the magnets 200, 207, 321, 310, 410 and 411. It is to be understood that each of the vertical rows is provided with one of these operating bars. Horizontal links circuits are each provided with a horizontal operating bar, such as the bars 221, 222, 223 and 224 controlled by the respective operating magnets 225, 203, 226 and 227. Similarly, each of the horizontal links in the entire structure is equipped with one of these bars. For a more thorough understanding of the structure and operation of switches of this character, reference is made to the patents to C. L. Goodrum and J. N. Reynolds, No. 1,515,735, issued November 18, 1924, and S. B. Williams, No. 1,517,331, issued December 2, 1924.

For the purpose of controlling the switching structure there are provided a plurality of common register senders, one of which is shown in full detail in Fig. 6. Each of these senders is represented in the switch by a horizontal link all of which comprise the group 311. The particular sender shown is individual to the horizontal link 215 and by the agency of said link may be connected through the vertical rows of contacts to one of the vertical links used for local connections or to one of the incoming trunks from the central office. When taken for a local connection, the sender shown may be connected through the vertical row of contacts 302 to the circuit 312 which is individual to the vertical link circuit 300. Likewise, this sender may be connected through the circuit 313 with the vertical link circuit 301. Moreover, the sender may be connected through the vertical row of contacts 404 and the circuit 412 to the incoming trunk circuit 400 or through the vertical row 405 and the circuit 415 to the incoming trunk circuit 401. In any of these cases after the register sender has been associated and com-

pleted its function in setting up the connection it is released without interfering with the connection established through the switch.

Moreover, there is provided a single switch controlling marker shown in Fig. 5 which is common to all the senders and may be connected to any one thereof through the contacts of the relays. This marker serves to select and operate the vertical magnets in the switch for establishing the connections represented by the designations recorded on the senders.

*Connection from one private branch line to another.*

A detailed description will now be given of the system in which it will first be assumed that the subscriber of line 100 of the private branch exchange wishes to converse with the subscriber of the line 217 in the same P. B. X. It will also be assumed that the number of the subscriber's line 217 is 23. The subscriber of line 100 in initiating the call, causes the operation of the line relay 102 in a circuit traceable from battery, through the outer right back contact of relay 501, conductor 510, left-hand winding of relay 102, contact of the cut-off relay 115 over the subscriber's line and returning over the other side of the line to ground at the left back contact of relay 115. Relay 102 operates the vertical group relay 104 which is individual to the vertical group of lines appearing in the row of contacts 208 of the switch. The circuit for this relay leads from ground through the outer left contact of relay 107, contact of relay 109, conductor 116, outer contact of relay 102, left winding of relay 104, inner left contact of relay 500, outer right contact of relay 503, contact of relay 502 to battery. Relay 104 locks in series with the relay 500 in a circuit traceable from ground, over conductor 116, through the contact of relay 102, right winding and front contact of relay 104, conductor 117, winding of relay 500, outer right contact of relay 503, to battery at the contact of relay 502. Relay 500 operates in this circuit and opens the original energizing circuit for the group relay 104.

The energization of relay 104 results in the energization of line magnet 200 over a circuit from ground and battery, winding of line magnet 200, front contact and left-hand armature of relay 104 to ground. Line magnet 200 rotates bar 219 and prepares the contact devices shown vertically above it, for operation. At the same time that line magnet 200 is operating, line magnet 321 is being energized over a circuit from battery, winding of line magnet 321, left-hand armature and back contact of relay 700, conductor 713, back contact and outer right-hand armature of relay 107,

front contact and right-hand armature of relay 500, back contact and left-hand armature of relay 503 to ground. Relay 702 whose left-hand winding is in parallel with the winding of magnet 321 also becomes energized at this time. Vertical magnet 321 rotates the bar 308 and prepares the contact devices shown above it, for operation and upon its energization becomes locked in a circuit from battery, winding of magnet 321, front contact and inner left-hand armature of magnet 321, conductor 314, winding of relay 107 to ground over the circuit just traced. This locking circuit, however, is ineffective as long as the original energizing circuit of magnet 321 is maintained.

Upon the energization of magnet 200, a circuit is established from ground, front contact and left-hand armature of magnet 200, inner left-hand armature and front contact of line relay 102, left-hand winding of horizontal group relay 114 back contact and outer left-hand armature of relay 106 to battery and ground. Relay 114 immediately becomes locked through its right-hand winding in series with relay 106, whereupon the original energizing circuit of relay 114 and other similar group relays is opened, thereby preventing for the time being the further extension of other similar calls.

Upon the joint energization of magnets 200 and 321, a circuit is established from ground, front contact and right-hand armature of magnet 200, outer left-hand armature and front contact of magnet 321, inner left-hand armature and front contact of relay 106, left-hand armature and front contact of group relay 114, right-hand armature and back contact of relay 229, the right-hand winding of magnet 227 to battery and ground. Magnet 227, becoming operated, rotates the horizontal bar 224 and causes the operation of the contacts which were prepared for operation by magnets 200 and 321, respectively.

Simultaneously therewith and before either magnets 200 or 321 are returned to normal, a circuit is established from ground, front contact and right-hand armature of magnet 321, right-hand armature and back contact of relay 206, right-hand winding of magnet 201, to battery and ground. Magnet 201 causes the operation of contact device 324 also prepared for operation by magnet 321. Line 100 is now extended to the link circuit of Fig. 7, and therefrom further extended through the switching device 324 and horizontal link 215 to the sender of Fig. 6.

The ground extended from the front contact and right-hand armature of magnet 321 for the operation of magnet 201 is also extended over the left-hand armature and back contact of relay 206 to the winding of relay 202, and in parallel therewith through

the normal contacts of the left-hand armature of relay 603, the winding of holding relay 600, to battery and ground.

Through the operation of relay 600, a ground is placed on the holding conductor 605, and this ground is extended through the left-hand winding of relay 206, and the left-hand winding of magnet 201 in series, but is ineffective at this time to cause the energization of relay 206 on account of the direct ground placed on the other terminal of the left-hand winding of magnet 201. The holding conductor 605, however, is extended over the fourth conductor of the horizontal link 215 through the corresponding contacts of contact device 324, the left-hand armature and front contacts of relay 702, the normal contacts of the left-hand armature of relay 704, the right-hand winding of relay 702 to battery and ground, locking this relay independently of the magnet 321.

This ground is also extended from the first front contact of relay 702 over the fourth conductor of the incoming link circuit through the corresponding contacts of horizontal link 213, winding of relay 229, left-hand winding of magnet 227, but this circuit is ineffective in the same manner and for the same reason that the circuit through the left-hand winding of relay 206 was ineffective. The ground on the first front contact of relay 702 is also extended through the back contact and inner left-hand armature of relay 703 over the third conductor 715 of the incoming end of the link circuit through the corresponding contacts of contact devices 323 and 205, the third conductor of the subscriber's line to the winding of cut-off relay 115 which now becomes operated to cut off the line relay. As another result of the extension of the calling subscriber's line through the horizontal link 213, the line relay 602 of the sender is operated in a circuit from battery, winding of line relay 602, the uppermost conductor of the horizontal link circuit 215 leading to the sender, corresponding contacts of contact device 324, the front contact and outer right-hand armature of relay 702, the back contact and inner right-hand armature of relay 703, the corresponding contacts of contact devices 323 and 205, over the loop of the line 100, back through the corresponding contacts of contact devices 205 and 323, outer right-hand armature and back contact of relay 703, inner right-hand armature and front contact of relay 702 to ground. Relay 602 becomes operated in this circuit and causes the energization of relay 603 in a circuit from ground, armature and front contact of relay 602, normal contacts of the inner right-hand armature of relay 603, winding of relay 603 to battery and ground. Relay 603 attracts its armatures and locks up

through the alternate contacts of its inner right-hand armature to the ground on conductor 605. The original energizing circuit for relay 600 is opened and relay 600 is placed now under the direct control of the line relay 602.

The energization of cut-off relay 115 causes the deenergization of relay 102 whereupon the original energizing circuit of group relay 104 and the circuit of relays 114 and 106 are opened, with a result which will be explained hereinafter.

Upon the extension of ground to the left-hand armature of relay 702, a connection is made through the second front contact, conductor 714, to the left-hand winding of relay 700. Relay 700 becomes operated and opens the original energizing circuit of magnet 321, so that now the circuit through relay 107 will become effective. Upon the energization of relay 700, a circuit is also closed for the energization of relay 705, which may be traced from ground, armature and back contact of relay 706, front contact and inner right-hand armature of relay 700, winding of relay 705, right-hand winding of relay 700 to battery and ground. It will be noted that the conductor 716 leading to the left-hand armature of relay 705 extends from the timing relays (Fig. 1) and should ground be connected to it at this instant, relay 700 will be energized through its right-hand winding and the energization of relay 705 will be prevented. However, if relay 700 is energized before ground is extended from the timing relays, then relay 705 will become energized in a circuit from ground, left-hand armature and back contact of relay 706, front contact and inner right-hand armature of relay 700 winding of relay 705, right-hand winding of relay 700 to battery and ground.

The action of the timing relays should be noted. Upon the energization of relay 500 through the extension of ground to the left-hand terminal of relay 107, such ground is further extended through the inner right-hand armature and back contact of relay 107, left-hand armature and back contact of relay 110, winding of relay 112 to battery and ground. Relay 112 becoming energized, extends this same ground connection through its right-hand armature and front contact to the winding of relay 111, which in turn becomes energized. This is effective to extend the ground through the right-hand armature and front contact of relay 111 to the winding of relay 110, which thereupon cuts off the connection to the winding of relay 112. Relay 112 being slow to release, delays the opening of the circuit of relay 111 for a short period. Relay 111, thereupon, which is also slow to release, delays the opening of the circuit of relay 110 for another slight interval. When relay 111 does

become deenergized, relay 110 being slow to release, maintains its armatures operated for a short interval, whereupon the ground supplied over the inner right-hand armature and back contact of relay 107 is now extended over the armature and back contact of relay 111, the front contact and right-hand armature of relay 110, the left-hand armature and back contact of relay 705, right-hand winding of relay 700 to battery and ground. Thus, if upon the energization of magnet 203, relay 600 does not become immediately energized, the timing relays 110 to 112 will cause the energization of relay 700, which will extend the operating ground on the left-hand armature of relay 700 to the left-hand armature of relay 707, which will cause the seizure of the next idle link circuit. Through the energization of relay 700, magnet 321 becomes deenergized, thus opening the circuit for magnet 203, releasing the contact devices so that upon the energization of the next corresponding vertical magnet 304, for example, the circuit for horizontal magnet 203 will be again established subsequently to and dependent upon the operation of magnet 304. Under ordinary conditions, however, the relay 600 will become operated, causing in turn the operation of relay 700 before the timing relays 110 to 112 have completed their entire cycle of operations.

Upon the energization of relay 700, as hereinbefore mentioned, the original energizing circuit of magnet 321 is opened, whereupon the circuit through relay 107 becomes effective, and if the timing relays have not completed their function, then the ground for operating them will be removed at the inner right-hand armature of relay 107. It will also be noted at this time that upon the extension of ground to the winding of relay 107 through the operation of relay 500, that a circuit was extended through the inner left-hand armature and back contact of relay 107 to the winding of slow releasing relay 113, whereby this relay in attracting its armature maintained a ground on the conductor leading through the outer left-hand armature of line relay 102 to the winding of group relay 104.

Upon the energization of relay 107 in series with magnet 321, the energizing circuit of relay 113 is opened and in a short interval this relay retracts its armature, thereby opening the locking circuit of relay 104 and the circuit of relay 500, whereupon these relays return to normal, and since the line relay 102 is not now operated, they remain at normal. Upon the deenergization of relay 104, the ground is removed from the winding of magnet 200, whereupon this magnet becomes deenergized. Upon the deenergization of relay 500, the locking circuit for magnet 321 is opened and this magnet

returns to normal. Thereupon the original circuit for the energization of magnet 227 is opened and the substitute circuit through its two windings in series with the winding of relay 229 becomes effective and relay 229 attracts its armatures. The connection from the subscriber's line 100 over the horizontal link 213 to vertical link circuit 300 is now maintained by the continued energization of the horizontal magnet 227.

The apparatus is now in condition for the transmission of the tens and units series of impulses representing the number of the called line 217. Accordingly, the subscriber manipulates his dial to send first a series of two impulses. Upon the first opening of the line, line relay 602 releases and a circuit is closed for operating the first counting relay 623 from ground, through the back contact of relay 602, the outer right front contact of relay 603, right contact of relay 607, outer right back contact of relays 612, 616, 618, 620 and 622, winding of relay 623 to battery. In parallel with this circuit the slow release relay 606 is also operated. This relay being slow, remains energized during these impulses. Relay 623 operates and prepares a circuit for the mate relay 622. Relay 622, being shunted, does not operate at this time. When the line closes, the shunt is removed and relay 622 operates in a circuit traceable from battery, through the winding of relay 623, winding of relay 622, left contact of relay 623, left back contact of relay 620, conductor 624, left back contact of relay 612, left back contact of relay 616, outer contact of relay 608, to the grounded conductor 605. Upon the next line interruption, the impulse circuit is extended through the right front contact of relay 622, winding of relay 621 to battery. At the end of the interruption, relay 620 operates in series with relay 621 to the grounded conductor 624. Relay 620 opens the holding circuit of relays 622 and 623 and these latter relays release.

After an interval following the first series of impulses, slow relay 606 releases and closes a circuit for relay 609. This circuit may be traced from battery, through the winding of relay 609, right back contact of relay 601, inner contact of relay 608, contact of relay 606, conductor 625, right contact of relay 621, conductor 626 to ground at the contact of holding relay 600. Relay 609 operates and locks in series with relay 608. Relay 608, being shunted, does not operate at this time. Since the second pair of counting relays are operated a circuit is closed for the register relay 604 and this relay operates. Such circuit may be traced from battery, through the winding of said relay, middle left contact of relay 609, left front contact of relay 620 thence to the grounded conductor 624. Relay 604

locks directly to the grounded conductor 626. Relay 604 closes a circuit for relay 601 and this latter relay operates to open the shunt around the winding of relay 608. Relay 608 thereupon operates in series with relay 609. Relay 608, in operating, opens the circuit of counting relays 620 and 621 and these relays release.

It will be noted that the relays 604, 627, 628 and 629 constitute a register. For the particular digit under consideration the relay 604 is operated to record the record. For other tens digits, however, various combinations of these four relays may be energized.

Since the units digit is 3, the subscriber now manipulates his dial to transmit a series of three impulses. For the first opening and closure of the line circuit, counting relays 622 and 623 are operated as already described. For the next impulse, relays 620 and 621 operate and relays 622 and 623 are released. Upon the next opening of the line, the impulse circuit is extended over the front contact of relay 620, winding of relay 619 to battery. When the line closes, relay 618 operates in series with relay 619 but relays 620 and 621 remain energized. Relay 606, in operating in the impulse circuit, opens the holding circuit of relays 609 and 608 and these relays become released. After an interval slow relay 606 releases and operates relay 607 in a circuit from battery, through the winding of said relay, right front contact of relay 601, inner contact of relay 608, contact of relay 606, conductor 625, contact of relay 619, to the grounded conductor 626. Relay 607 opens the impulse circuit and operates the relay 610 in a circuit traceable through the right-hand winding of relay 610, conductor 630, inner right back contact of relay 503, outer left contact of relay 500 to battery at the contact of relay 502. Relay 610, in operating, closes a holding circuit through its left-hand winding and contact, thence over the conductor 631, winding of the marker start relay 503 to battery at the contact of relay 502. Relay 503 operates in this circuit. Relay 610, in operating, closes an obvious circuit for relay 611. The relay 503 opens up the circuit to prevent the operation of any vertical group relay, such as the relay 104 while the marker is functioning. Relay 503 also closes a circuit for relay 505 which operates and closes a circuit for the operation of relay 504. Relay 504 locks directly to ground at the left contact of relay 503. Relay 504, in operating, releases relay 505.

While the relays 504 and 505 are functioning, the record of the tens and units digit is transferred from the sender in Fig. 6 through contacts of the relays 610 and 611 to the common marker and there recorded on relays. Since the relay 604 in the sender

is operated, indicative of the tens digit, a circuit may be traced for the operation of the tens register relay 509. This circuit leads from ground, through the outer left contact of relay 604, contact of relay 611, winding of relay 509 to battery. Since the counting relays 620 and 618 are both operated, circuits are completed for the operation of the units register relays 506 and 507. The circuit for relay 506 may be traced from the grounded conductor 624, left contact of relay 618, middle left contact of relay 611, winding of relay 506 to battery. The circuit for relay 507 may be traced from the grounded conductor 624, left front contact of relay 620, outer left contact of relay 611 and winding of relay 507 to battery.

With the tens and units register relays operated in the marker, a circuit is closed for operating the vertical magnet 207 which controls the vertical row of contacts 209 in which appears the called line 217. This circuit may be traced from ground, at the left front contact of relay 503, back contact of relay 505, inner left contact of relay 504, conductor 511, left back contacts of relays 513 and 512, inner right contact of relay 509, outer right back contact of relay 508, outer left contact of relay 514, conductor 515, winding of the vertical magnet 207 to battery. Magnet 207 rotates the bar 220 and prepares the contacts in the row 209 for operation. Magnet 207 also closes a circuit for operating the vertical magnet 310 which controls the row of contacts 303 in which appears the other end of the link circuit 300. This circuit may be traced from ground, through the contact of magnet 207, conductor 230, outer left back contact of relay 501, outer left contact of relay 504, conductor 516, middle left contact of relay 610, right back contact of relay 632, conductor 633 thence through contacts of the horizontal link 215 in the row 302, conductor 315, and thence in parallel through the winding of vertical operating magnet 310 and the right-hand winding of test relay 710 to battery. The test relay 710 also operates in this circuit. The magnet 310 rotates the vertical bar 309 to prepare the contacts in the row 303 for operation. With the magnet 310 operated, the circuit is closed as determined by the second of the units register relay 507 in the marker for operating the first idle horizontal magnet in the group having access to the called line 217. This circuit may be traced from ground, through the inner right contact of magnet 310, conductor 717, conductor 718, back contact of relay 517, front contacts of relays 507 and 506, conductor 518, right back contact of relay 232 (assuming the link 210 to be idle), right-hand winding of the horizontal operating magnet 225 to battery. The magnet 225 rotates the horizontal bar 221 and effects connection between the called subscriber's line 217 and the hori-

zontal link 210 and between the horizontal link 210 and the outgoing end of the vertical link circuit 300. In this manner the calling line 100 is connected to the called line 217 through the horizontal link 213, vertical link 300 and the horizontal link 210. With the connection established through the switch, a circuit is completed from battery, through both windings of magnet 225, winding of relay 232, thence through contacts in the row 302, conductor 316 of the link 300, left contacts of relay 702, conductor 317, through contacts in the row 302 over the horizontal link 215, through the grounded conductor 605 in the sender. The relay 232, however, does not operate at this time since its winding is shunted by the original energizing circuit of the magnet 225.

Magnet 310, in operating, also closes a circuit for the slow release relay 704. Relay 704 at its right contact applies ground potential to the ground conductor 714 and at its left contact opens the holding circuit through the right winding of relay 702, permitting this latter relay to release. Relay 704 at its left contact also applies a substitute holding ground to the conductor 316.

Upon the release of relay 702, the calling subscriber's line 100 is extended through to the windings of relay 701. Relay 701 operates and closes a holding circuit for relay 704. At the same time, relay 702 on releasing opens the circuit of the impulse relay 602 in the sender. Relay 602 on releasing opens the circuit of relay 600 which, after an interval, becomes deenergized and removes ground from the various holding conductors in the sender. This causes the release of relays 603, 607, 601, 604 and the energized counting relays. Relay 607 on releasing causes the release of relays 610, 611 and the marker start relay 503. Relays 610 and 611 disconnect the marker from the sender and the register relays 506, 507, 509 are released. Relay 503 releases the relay 504 and also places the apparatus in condition for the initiation of subsequent calls.

Upon the release of the sender, the operating circuit of the vertical magnet 207 is opened and this magnet becomes deenergized and restores the vertical switching bar 220. Magnet 207 opens the circuit of the vertical magnet 310 and the circuit through the right-hand winding of the test relay 710. The magnet 310 restores the switching bar 309 to its normal position. Connection through the switch is now held by the maintained operation of the horizontal magnets 227 and 225. The shunt having been removed, the relay 232 operates in series with the magnet 225.

The sender having completed its function is also released and disconnected from the switch. This release takes place by deenergizing the circuit through the horizontal magnet 201 and the relay 206. The hold-

ing circuit is opened at the time that ground potential is removed from the conductor 605 by the release of the holding relay 600 in the sender.

5 The apparatus is now in condition to apply ringing current to the called subscriber's line 217. During the time relay 710 was operated, a circuit is closed from ground on conductor 714, through the outer right contact of relay 708, inner left contact of relay 10 710, winding of relay 712, through the winding of relay 940 to battery. Relays 940 and 712 operate and a locking circuit is closed through the winding and right front contact of relay 712, contact of relay 711, thence 15 to the grounded conductor 714 as traced. Assuming the called line to be idle at the time connection is made therewith, the relay 710 releases as above described and closes a circuit as follows for applying holding 20 ground potential to the test conductor of the called line: ground, through the outer left back contact of relay 710, conductor 719, thence through contacts of the switch to the holding conductor of the called line 25 217. The ringing circuit is also established as follows: from battery, through the secondary winding of the ringing transformer 943, winding of relay 711, inner left back 30 contact of relay 710, outer left front contact of relay 712, thence through the switch over the ring side of the called line 217 through the substation thereof and returning over the other side of the line through contacts 35 of relays 712 and 710 through the other pole of battery. The relay 711, being of a marginal character, does not operate so long as the subscriber's receiver is on the switchhook.

Relay 940, in operating, closes a circuit 40 for operating relay 941 which locks through its inner right contact. Relay 941 closes a circuit for the operation of relay 942. Relay 942 opens the operating circuit of relay 941, locks and also short-circuits and releases the 45 relay 941. Relay 941 in releasing opens the operating circuit of relay 942 and short-circuits and releases said latter relay. The release of relay 942 causes relay 941 to operate again and this cycle of operation continues as long as the relay 940 remains energized. 50 Ground is connected first to one and then to another of the primary windings of the ringing transformer 943 by the contacts of relay 941 so that an alternating current is induced in the secondary winding of the 55 transformer 943 as long as the common point of the primaries is connected to battery through the front contacts of relays 944 and 945. The relay 940 also closes a circuit for 60 slow release relay 902 which operates and closes a circuit for slow release relay 901. Relay 901 operates and opens the circuit of relay 902 which releases after an interval. Relay 902 opens the circuit of relay 901 65 which also releases after a further interval.

Relay 901 again completes the operating circuit of relay 902. These two relays continue to operate in measured cycles applying ground potential at intervals to the conductor 946. When ground is first applied 70 to conductor 946 a circuit is closed through the winding of relay 944, left back contact of relay 945 to battery. Relay 944 operates and closes a circuit from battery, through the left winding of relay 945, winding and 75 left contact of relay 944, right-hand winding of relay 945 to ground. Relay 945, however, is shunted and does not operate at this time. When ground is removed from conductor 946, relay 945 operates in series 80 with relay 944. With the next application of ground to conductor 946, relay 944 is shunted by a circuit from battery, through the left-hand winding and right front contact of relay 945 to the grounded conductor 85 946. Relay 944 releases and when ground is again removed from conductor 946, relay 945 releases. This cycle of operation continues as long as the relays 901 and 902 continue to operate. 90

Battery potential is applied through the left front contact of relay 945 and the right contact of relay 944 to the middle point of the primary of the ringing transformer 943 95 whenever relays 944 and 945 are both operated. The period of operation of the relays 944 and 945 is such that battery potential is applied to the primary of the transformer for a period equal to the usual ringing interval and then withheld for a silent interval. 100 During these periods, relays 941 and 942 which are more rapid in their operation, apply ground potential to the opposite ends of the primary of the transformer at a rapid interval to reverse the direction of 105 the current in the primaries. This produces an alternating current in the secondary of the transformer 943 of the requisite frequency to operate the call bells at the subscribers' stations. 110

As soon as the called subscriber answers, the relay 711 operates and causes the release of relays 940 and 712. The relay 940 removes the operating ground and disables the ringing equipment from further operation. 115 Relay 712 at its left contacts completes the tip and ring conductors of the link circuit and the relay 709 is connected in series with the called subscriber's line. Relay 709 applies ground potential to the 120 conductor 714 for holding purposes. Talking current is supplied to the calling line from the windings of the relay 701 and to the called line from the windings of the relay 709. 125

When the calling subscriber hangs up his receiver, relay 701 releases and releases the relay 704. Relay 704 removes ground from conductors 316 and 715 whereby the cut-off relay 115 of the calling line 100 and the 130

relay 229 and horizontal magnet 227 are released. Magnet 227 restores the horizontal bar 224 and the calling line 100 is disconnected from the horizontal link 213 and the horizontal link 213 is also disconnected from the link circuit 300. When the called subscriber hangs up, his receiver, relay 709 releases and removes ground from the conductor 714 and opens the holding circuit of relay 232 and the horizontal magnet 225. Magnet 225 restores the bar 221 and the called line 217 is thereby disconnected from the horizontal link 210 and said link is also disconnected from the other end of the link circuit 300. Thus, the connection has been fully released and the subscribers are free to make further calls.

In case the called subscriber's line is busy at the time the test is made, relay 710 remains operated in a circuit as follows: battery, through the left-hand winding and outer left front contact of said relay, conductor 719 and thence as traced to the grounded sleeve conductor of the busy called line 217. Since the relay 710 remains operated, the ringing equipment is not brought into play as previously described. Instead, the busy tone relay 708 is operated in a circuit traceable over the grounded conductor 719, outer left front contact of relay 710, contact and winding of relay 708, winding of the relay 900 to battery. Relay 708 in operating opens the horizontal magnet circuit and immediately frees the called line from the switch. Relay 900 operates relay 923 in a circuit from battery, through the winding of relay 923, contact of said relay to the grounded contact of relay 900. Relay 708, in operating, also completes a circuit from battery, through the winding of relay 923, resistance 903, inner left front contact of relay 708, condenser 720 to the ring side of the calling subscriber's line. Relay 923 operates and opens the shunt around resistance 903. Immediately that the contact of relay 923 is opened, relay 923 again releases and completes the shunt. This operation continues as long as relay 900 is operated thereby inducing a tone in the calling subscriber's line indicating that the called line is busy.

In response to the busy tone, the calling subscriber replaces his receiver and the equipment is released as previously described.

*P. B. X. subscriber calls the central office.*

It will next be assumed that the subscriber of line 100 desires to extend a call to the central office for which purpose he dials the number 11. In response to the initiation of the call the apparatus functions in the manner hereinbefore described and the calling subscriber's line is connected over an idle horizontal link in the group 307 to an idle

local or vertical link circuit 300. Moreover, an idle sender is attached to the link circuit 300 over an idle horizontal link 215 ready to receive the impulses from the calling subscriber's line.

Since the first digit consists of a single impulse, the counting relays 622 and 623 are operated and locked as above described. After an interval, relay 606 releases and closes an operating circuit for relay 609. With relay 609 operated, the register relay 628 operates in a circuit from battery, through the winding of said latter relay, outer left contact of relay 609 left contact of relay 622, left back contact of relay 620 to ground, over conductor 624. Relay 628 operates the relay 634 in a circuit from battery, through the winding of relay 634, outer left back contact of relay 635, right front contact of relay 628, to ground at the contact of relay 600. Relay 634 locks directly to ground. Relay 634 causes the operation of relay 601 in a circuit from battery, through the winding of the latter relay, outer right back contact of relay 635, outer right front contact of relay 634, inner left contact of relay 628 and thence to ground as previously traced over conductor 624. Relay 601 removes the shunt as above described and permits relay 608 to operate in the circuit of relay 609 releasing the counting relays 622 and 623. The counting relays on releasing also causes the deenergization of relay 628. Furthermore, relay 601 releases upon the deenergization of relay 628. Relay 628, in releasing, operates relay 635 in a circuit from battery, through the winding of the latter relay, left front contact of relay 634, right back contact of relay 628 to ground at the contact of relay 600.

Since the second digit of the wanted number is also 1, the counting relays 622 and 623 are again operated and relay 628 is again energized. Relay 628, in operating, closes a shunt circuit which causes the deenergization of relay 634. Relay 601 is again operated, causing the operation of relay 608 and thereafter relays 628, 609 and the counting relays become deenergized. Relay 628, in releasing at this time, causes the operation of relay 632. The circuit may be traced from battery, through the winding of relay 632, inner right contact of relay 635, left back contact of relay 634, right back contact of relay 628 to ground at the contact of relay 600. Relay 632 operates relay 607 in a circuit from battery, through the winding of relay 607, outer left contact of relay 632 to ground at the contact of relay 600. In the manner hereinbefore described, relay 607 causes the association of the sender with the marker.

Upon the association of the marker with the sender, the relay 508 in the marker is

operated by means of a circuit from ground, through the left contact of relay 632, outer right contact of relay 611, winding of relay 508 to battery.

5 Since the register relay 508 is operated in the marker, a circuit is closed for operating relay 501. This circuit may be traced from battery, through the winding of said relay, inner left front contact of relay 508, 10 normal contacts of relays 509, 512 and 513, conductor 511, and thence to ground as previously traced at the left front contact of a start relay 503. The relay 501 opens up the operating windings of the line relays. Relay 15 501 also closes a circuit for the vertical magnet 411 traceable from ground, through the inner left contact of said relay, through the inner left back contact of relay 1008, winding of the vertical magnet 411 to battery. Magnet 411 rotates the bar 409 and 20 prepares the contacts in the row 406 in which appears the idle outgoing trunk 402 leading to the central office. Magnet 411 also closes a circuit for relay 703 which may be traced from ground, through the contact of 25 said magnet, conductor 414, middle right contact of relay 610, right front contact of relay 632, through the horizontal link 215 and contacts of the switch, winding of relay 703 to battery. Magnet 411 also closes a circuit 30 for operating the relay 1001. Relay 1001 at its left contact closes the circuit for operating relay 1002. Relay 703, in operating, releases the cut-off relay 115 of the calling line. 35 At the time the cut-off relay 115 operates, it causes the release of the group relay 104 and control relay 500 in the manner hereinbefore explained, resulting in the release of the vertical operating magnets 200 and 321. 40 With the relay 501 energized on a central office call and with the cut-off relay 115 de-energized, the line relay 102 of the calling line is again operated for the purpose of controlling the switching apparatus to extend 45 the calling line through to the selected outgoing trunk. The circuit for the line relay 102 may be traced from battery, through the outer right front contact of relay 501, right-hand winding of relay 102, contact of the cut-off relay 115, tip conductor of the line 50 100, through contacts of the switch and the horizontal link 213, through the outer right front contact of relay 703, left-hand winding of relay 709 to ground. Relay 102 operates and causes the operation of relay 104 55 which in turn causes the re-operation of vertical operating magnet 200. The relay 104, in operating, closes an operating circuit for relay 500 as follows: ground, over conductor 60 116, through contacts of relay 102, thence through the right-hand winding and contact of relay 104, winding of relay 500, inner right contact of relay 501 to battery.

65 In the manner already explained, the horizontal group relay 114 is energized and

locks in series with relay 106. With relay 114 operated, a circuit is closed for operating the first idle horizontal magnet in the group controlling the links 307. This circuit may be traced from ground, through 70 the right contact of magnet 200, left front contact of relay 501, inner contact of relay 106, left contact of relay 114, right front contact of relay 229 (since the horizontal link 213 is already engaged in associating the 75 calling line with the link circuit 300), right back contact of relay 233, right-hand winding of horizontal magnet 226 to battery. Magnet 226 operates the bar 223 and since 80 both magnets 200 and 411 are operated, the calling line 100 is thereby connected over the horizontal link 212 to the trunk 402 outgoing to the central office. Upon the extension of the connection, a holding circuit is completed from battery, through both windings 85 of magnet 226, winding of relay 233, contacts of the switch, conductor 415 to ground at the left contact of relay 1002. Relay 233, however, does not operate in this circuit since its winding is shunted by the original 90 operating circuit of magnet 226.

Each time relay 703 operates, it opens the circuit of the impulse relay 602 in the sender. Before relay 602 can release the relay 600 to 95 remove the holding ground from conductor 605, relay 709 operates, as above mentioned, to supply a substitute ground. This substitute ground potential is applied over a circuit through the contact of relay 709, conductor 100 714, left contact of relay 702, conductor 317 through contacts of the switch to the conductor 605. Therefore, the sender is held from releasing so long as relay 709 remains operated.

With the connection extended through to 105 the outgoing trunk, the grounded conductor 415 is connected to the cut-off relay 115 in the calling line and this relay operates. Relay 115 causes the release of the line relay 102 and relays 104, 106, 114 and 500. Relay 115 also releases the relay 709 in the link circuit. Relay 709 removes ground from 110 conductor 605 and permits the sender and marker to restore to their normal condition. Upon the restoration of these devices the shunt is removed to permit the operation of relay 233 in series with the horizontal magnet 226. Moreover, the horizontal magnet 227 and relay 229 are released thereby disconnecting the calling line 100 from the 115 horizontal link circuit 213. Furthermore, the horizontal magnet 201 is released to disconnect the sender from the vertical link circuit 300. Thus, all previous connections 120 have been restored and there remains only the connection from the calling line 100 through the horizontal link 212 to the idle trunk 402 outgoing to the central office.

When relay 104 releases it opens the circuit of the vertical operating magnet 200 125 130

and with relay 501 released, it opens the circuit of the vertical operating magnet 411. With these vertical magnets deenergized and the corresponding bars restored, the connection through the switch is held by the continued energization alone of the horizontal magnet 226. With the marker released, a shunt which has up to this time existed around the winding of relay 1008 is removed and this relay operates. The operating circuit for the relay may be traced from battery, through the left-hand winding thereof, to ground at the contact of relay 1002. Relay 1008 operates and locks through its right winding and being individual to the outgoing trunk 402 identifies that trunk as busy.

With the calling line extended through the outgoing trunk, the bridge relay 1000 connected across the tip and ring thereof is energized. Relay 1000 closes a substitute holding circuit for the relay 1002, relay 1001 having released upon the release of the vertical magnet 411. Relay 1000 extends ground from its inner contact over the tip conductor of the trunk 402 leading to the central office. This may cause the operation of the line relay at the central office and the consequent lighting of the lamp to notify the operator that a call is waiting on the incoming trunk. When connection at the central office is made with trunk 402, relay 1005 operates and closes an operating circuit for relay 1006. Relay 1006 closes an operating circuit for relay 1001 which connects the tip and ring conductors of the trunk circuit leading from the calling line to the tip and ring conductors of the circuit outgoing to the central office and discharging the bridge relay 1000. Relay 1003 now operates and operates the relay 1004. Relay 1004 disconnects the relay 1005 and the circuit is thereby placed in condition for conversation.

When the calling subscriber hangs up his receiver, relay 1003 releases, releasing relay 1004. If the connection is taken down at the central office, relay 1005 remains deenergized whereupon relay 1006 becomes released, in turn releasing the relays 1001 and 1002. The removal of ground potential from the ground conductor 415 releases the horizontal magnet 226, relay 233 and the calling line cut-off relay 115. Thus, the connection through the switch is released and the calling line is free to be called by other lines.

*P. B. X. subscriber calls the attendant.*

Assuming that the local subscriber of the line 100 wishes to call the attendant at the P. B. X., he does so by dialing the single digit 0. The initiation of the call results in the operation of the switch to extend the calling line to the first idle link cir-

cuit 300, and to associate an idle sender through the horizontal link 215 with the link circuit. The digit being zero, the subscriber transmits a series of ten impulses which are received on the counting relays in the associated sender. From an inspection it will be found that a series of ten impulses results in the energization of counting relays 612, 613, 614, 615, 616 and 617. Following the last impulse, relay 606 releases and a circuit is closed for relay 609. Relay 609 instead of operating one of the register relays 627, 628, etc., causes the operation of relay 607 to immediately associate the sender with the marker without waiting for a second series of impulses. A circuit for relay 607 may be traced from battery, through the winding of said relay, left contact of relay 601, outer right contact of relay 609, inner left front contact of relay 614, left front contact of relay 616, right contact of relay 608, to the grounded conductor 626. In the manner hereinbefore described, relay 607 causes the association of the marker with the sender.

When the relay 505 releases subsequently, a circuit is closed for operating relay 519. This circuit may be traced from battery, through the winding of said relay, left back contacts of relay 508, 509, 512 and 513, conductor 511, to ground through contacts of relays 504, 505 and 503. Relay 519 operates the vertical operating magnet 310 controlling the other end of the link circuit 300 in a circuit from ground, through the left contact of relay 519, and thence over the conductor 516, as previously traced. Magnet 310 in operating closes a circuit from ground over conductor 717, conductor 718, thence through the back contacts of relays 517, 507 and 506 to the conductor 520. Conductor 520 similar to conductor 518 leads to a horizontal magnet relating to the horizontal link 216 which has access to the attendant's equipment shown in Fig. 9. For simplicity, the horizontal magnet and associated relay relating to link 216 has been omitted from the disclosure. Upon the operation of this horizontal magnet the calling line 100 is connected over one of the links in the group 307 with one end of the link circuit 300, and the other end of said link circuit is connected over the horizontal link 216 to the attendant's equipment in Fig. 9. The vertical magnets and other parts of the system not required for the maintained connection are restored to normal as heretofore explained.

Upon the extension of the line to the attendant's position the calling lamp 908 is lighted to advise the attendant that one of the subscribers is calling. The circuit for this lamp may be traced from battery, through the lamp, outer right back contact

of relay 909, contacts of key 910, conductor 911, through contacts of the switch at the link 216, conductor 719 of the link 300, to ground at the contact of relay 710. The attendant to answer the call throws the key 910, thus opening the lamp circuit and connecting her telephone set 912 across the line. Release of the equipment and the connection takes place in the manner heretofore explained.

*Attendant initiates a call.*

If the attendant desires to initiate a call she throws the listening key 913, operating relay 914 and closes a bridge across the tip and ring conductors of attendant's line 101, resulting in the initiation of a call in precisely the same manner as that described in connection with the origination of a call on a subscriber's line.

If the attendant desires to call the central office directly, she may do so by throwing the listening key 800 and the central office key 801. This results in removing all bridges from the line and connecting the attendant's telephone set directly across the tip and ring conductors of the trunk 400 outgoing to the central office. The circuit for the attendant's telephone set may be traced over the tip of the trunk 400, through contacts of key 802, contacts of relay 803, contacts of key 800, conductor 804, through the attendant's telephone set 912 and returning over conductor 805, winding of relay 806, contacts of key 800, contacts of relay 803, winding of relay 807, contacts of key 802, over the other side of the trunk 400.

*Incoming call from central office.*

When a call is incoming from the central office over one of the incoming trunks 400, the line relay 808 is operated in a circuit traceable over the tip of the trunk 400, contacts of key 802, contacts of key 801, both windings of relay 808, contacts of key 802, thence over the ring side of the trunk 400. Relay 808 operates the relay 809 which in turn closes an obvious circuit for line lamp 916, at the attendant's position. When ringing current is applied to the incoming trunk at the central office, the ringing current responsive relay 810 operates in a circuit closed over the tip and ring conductors of the trunk 400, through right-hand winding of said relay. Relay 810 locks in a circuit through its left winding and contact, left contact of relay 811, conductor 812, to ground at the contact of relay 809. Relay 810 at its outer left contact closes an obvious circuit for the lamp 917 at the attendant's position. It will be noted that relay 918 operates in series with the lamp 917 and closes an operating circuit for the buzzer 919 to attract the attendant's attention.

The attendant answers the call by operat-

ing the listening key 800 and bridges her telephone set across the trunk and also closes an obvious circuit for relay 811. Relay 811 releases relay 810 which extinguishes the lamp 917 and disables the buzzer 919. The relay 811 also closes a circuit for bridging the retardation coil 836 across the left hand winding of the line relay 808.

The relay 807 operates in series with the attendant's telephone set and operates relay 813 in a series circuit including relay 809. Relay 813 also opens a shunt around the right-hand high resistance winding of the coil 836.

It will be noted that the lamp 920 is lighted in parallel with the relay 811 and serves the purpose of a guard signal.

The attendant after answering the call and learning what station is desired operates her dial key 814. This causes the operation of relay 803 which disconnects the attendant's telephone set from the outgoing trunk and connects it to the windings of relay 815. Relay 807 now releases and causes the release of relay 813. The circuit for operating relay 815 may be traced from battery, through the left hand winding of said relay, normal contacts of relay 816, conductor 817, back contact of relay 819, conductor 818, front contact of relay 803, contact of key 800, conductor 804, through the attendant's telephone set 912 and returning over conductor 805 through the relay 806 and key 800, front contact of relay 803, normal contact of relay 816, right hand winding of relay 815, to ground. Relay 815 closes an obvious circuit for relay 820.

Relay 803 in operating causes the operation of the vertical magnet 410 relating to the incoming trunk 400, provided the marker, shown in Fig. 5, is idle. The circuit for this magnet may be traced from battery, through the winding thereof, conductor 821, contact of relay 822, contact of relay 819, contact of relay 803, conductor 823, windings of relay 522, contacts of relays 500 and 503, to ground. The magnet 410 does not operate due to the high resistance of the left winding of relay 522. Relay 522 operates relay 502 which shunts the left winding of relay 522 permitting magnet 410 to energize. Relay 502 also blocks the marker circuit from other calling lines. The magnet 410 closes a circuit for operating one of the horizontal links in the group 311, to associate an idle sender with the incoming trunk over the connecting circuit 412. The circuit may be traced from ground, through the contact of magnet 410, conductor 824, contact of relay 825, conductor 722, thence through the right contact of relay 206, and the winding of relay 201, provided the link 215 is idle at this time. The sender upon being attached extends ground over the conductor 826 through the winding of relay 819, operating

this relay. Relay 819 opens the circuit of magnet 410 permitting the same to release. Relay 819 also prepares a circuit for the impulse relay 602 in the sender connecting the same in series with the attendant's telephone set 912. This circuit may be traced from battery, through the winding of relay 602, thence through the horizontal link 215, conductor 417, outer right front contact of relay 419, conductor 818, thence as previously traced through the attendant's telephone set 912 and returning over conductor 805, through contact of key 800, contact of relay 803, contact of relay 816, right-hand winding of relay 815 to ground.

The attendant now proceeds to operate a calling dial, not shown, associated with her telephone equipment to send impulses into the sender corresponding to the number of the wanted station, which she has orally received over the trunk from the central office operator or subscriber.

After the line marker has been associated with the sender as hereinbefore described, and the line relay for a magnet corresponding to the called line has been operated, conductor 516 is grounded thereby completing a circuit which may be traced over the horizontal link 215, through contacts of the switch, conductor 418, winding of relay 825, to battery. Relay 825 closes an obvious circuit for reoperating the vertical magnet 410 and also a circuit for operating relay 827. The magnet 410 again grounds the conductor 824; thereby a circuit is completed through the register magnets of the sender for selecting an idle horizontal magnet in the proper group representing the called subscriber's line. With the horizontal magnet operated the called line, for instance the line 100, is extended over a horizontal link in the group 307 to the outgoing trunk circuit 400.

Magnet 410 closes a circuit over conductor 824 through the outer left front contact of relay 825, outer right front contact of said relay, winding of relay 822, to battery. Relay 822 releases relay 819 which releases relay 602 and causes the restoration of the sender.

Relay 827 in operating closes an operating circuit for relay 828 traceable through the right-hand winding of said latter relay, left contact of relay 827, left contact of relay 829, to the grounded conductor 812.

A test is now made to determine the condition of the called line. The test circuit may be traced from battery through the winding of relay 830, normal contact of relay 831, normal contact of relay 830, front contact of relay 827, conductor 832, through contacts of the switch to the test conductor of the called line 100. In parallel with this circuit the right-hand winding of relay 827 is also connected. If the line is idle relay 830 does not operate and relay 827 releases

as soon as relay 825 becomes deenergized, following the disconnection of the sender. With relay 827 released and relay 828 operated the ringing equipment shown in Fig. 9 is rendered effective and ringing current is applied to the tip and ring conductor of the called subscriber's line. It will be noted that relay 828 remains energized after relay 827 releases in a circuit traceable from battery, through the winding of start relay 940, thence through the left hand winding and contact of relay 828, contact of relay 833, back contact of relay 830, contact of relay 829, to the grounded conductor 812. After the called subscriber has answered relay 833 operates in series with the ringing source and relay 828 releases to disconnect the ringing current from the called line.

The connection is held through the switch by the maintained operation of the horizontal operating magnet which is locked to the grounded conductor 812.

Relay 828 on releasing reconnects the subscriber's line to the windings of relay 815, which in turn operates the relay 820 and relay 820 causes the operation of relay 816 in a circuit, traceable from battery, through the winding of relay 816, contacts of keys 814 and 801, left contact of relay 809, outer right back contact of relay 834, left contact of relay 820, outer left contact of relay 828, outer right back contact of relay 825, front contact of relay 822, right contact of relay 829, to the grounded conductor 812. Relay 816 at its outer left contact closes a locking circuit for itself. Relay 816 releases relay 815 which in turn releases relay 820.

Relay 807 operates in series with the subscriber's telephone thereby operating relay 813. Relay 813 closes an operating circuit for relay 834, from battery, through the winding of said relay, contact of relay 813, normal contact of relay 820, thence to ground over conductor 812. Relay 834 at its outer right front contact closes a new operating circuit for relay 816. Relay 834 also closes an operating circuit for the relay 820. Relay 820 again locks relay 816 and operates relay 835 in a circuit from battery through the winding of relay 835, inner left contact of relay 834, left contact of relay 820, and thence to ground as previously traced over the conductor 812. Relay 835 opens the guard lamp 920 thereby advising the attendant that the subscriber has answered.

When the subscriber hangs up when the conversation is completed relay 807 releases, releasing relay 813 and relay 811. After a short interval relay 820 releases releasing relay 835. The release of relays 811 and 835 opens the circuit through the retardation coil 836 leaving the high resistance relay 808 bridged across the line to give a supervisory signal at the central

office. When the connection is broken down at the central office relay 808 releases, releasing relay 809 whereby the remaining relays which are energized are restored to normal. The removal of holding ground from conductor 812 causes the release of the horizontal operating magnet and the connection through the switch is restored to normal.

As has been explained hereinbefore, the system is specially designed to guard against interference. When one line is calling, the group circuit in the marker, which is available to all calling lines, is rendered non-accessible to a subsequently calling line. This is accomplished by energizing the relay 500, thus preventing the operation of a second one of the vertical group relays 104.

During the time the marker group circuit is associated with a calling line in response to the initiation of a call on said line, the marker cannot be associated with a sender for the purpose of selectively controlling the switch. Inasmuch as the marker has been associated with the calling line, the relay 500 is operated whereby the operating circuit hereinbefore traced for the relay 610, which associates the marker with the sender, is opened.

If, on the other hand, the marker is associated with the sender for the purpose of selectively controlling the switch during this time no subscriber's line, by initiating a call, can be associated with the marker. This is due to the fact that the relay 503 is operated in series with the connecting relay 610 whereby the potential is disconnected to prevent the operation of a group relay 104.

In case the marker is taken in use, in connection with an incoming call, it is also impossible for a calling subscriber's line to obtain access to the marker. This result is accomplished by operating the relay 502 at the time the marker is appropriated for controlling the extension of the incoming call. Relay 502 in operating disconnects battery and prevents a calling line from taking the marker into use.

What is claimed is:

1. In a telephone system, a plurality of local subscribers' lines arranged for connection with each other, outgoing trunks for extending connections from any of said lines, incoming trunks for extending connections to any of said lines, and a single unitary cross-bar switching device for effecting all of said connections.

2. In a telephone system, a plurality of local subscribers' lines arranged for connection with each other, outgoing trunks for extending connections from any of said lines, incoming trunks for extending connections to any of said lines, and a single switch for effecting all of said connections

consisting of coordinate rows of separately operable contacts and intersecting bars for operating said contacts.

3. In a telephone system, a plurality of local subscribers' lines arranged to be interconnected, outgoing trunks for extending connections from any of said lines, incoming trunks for extending connections to any of said lines, and a single cross-bar switch for effecting all of said connections said switch having a plurality of bars temporarily operable to prepare a connection and other bars operable to maintain the connection after the release of the first mentioned bars.

4. In a telephone system, a plurality of local subscribers' lines arranged to be interconnected, outgoing trunks for extending connections from any of said lines, incoming trunks for extending connections to any of said lines, a single cross-bar switch comprising a plurality of link circuits, and means for operating the switch to establish any of said connections through said link circuits.

5. In a telephone system, a number of subscribers' lines arranged to be interconnected, outgoing trunks for connections from said lines, incoming trunks for connections to said lines, a single coordinate switch for establishing any of said connections comprising a number of links, a plurality of said links being employed on certain of said connections, and means for operating the switch.

6. In a telephone system, subscribers' lines, incoming trunks, outgoing trunks, a switch comprising links and operating bars, means for operating the switch to establish connection between any two of said lines involving a number of said links, means for operating the switch to establish connections between one of said lines and an incoming trunk involving a single link, and means for operating said switch to establish connections between said lines and the outgoing trunks involving a single link.

7. In a telephone system, subscribers' lines, arranged for interconnection with each other, outgoing trunks for extending connections from the lines, incoming trunks for extending connections to any of said lines, a single unitary cross-bar switching device for effecting any of said connections, and a controlling device common to all of said lines for controlling said switch.

8. In a telephone system, subscribers' lines arranged for interconnection with each other, outgoing trunks for extending connections from the lines, incoming trunks for extending connections to any of said lines, a coordinate switching device comprising intersecting bars for effecting all of said connections, a controlling mechanism, means for operating said switch to appropriate said

controlling mechanism; and means under the control of said mechanism for operating said switch.

9. In a telephone system, a plurality of subscribers' lines arranged for interconnection, trunk lines for interconnection with said subscribers' lines, a single switch structure having link circuits and operating bars, a plurality of senders common to said lines, means for selecting any one of said senders through one of said link circuits, and means under the control of the selected sender for operating said switch to establish any of said connections involving other of said link circuits.

10. In a telephone system, a plurality of local subscribers' lines arranged for connection with each other, outgoing trunks for extending connections from any of said lines, incoming trunks for extending connections to any of said lines, a single unitary switching device for effecting all of said connections, a plurality of senders, and a common marker associable with any one of said senders for controlling the operation of said switching device.

11. In a telephone system, subscribers' lines arranged for connection with each other, trunk lines for extending connections to said subscribers' lines, trunk lines for extending connections from said subscribers' lines, a single unitary switch for effecting all of said connections, a marker associable with any subscriber's line upon the initiation of a call and also serving to control the selective operation of said switch, and means for rendering said marker inaccessible to calling lines when it is in the act of controlling the selective switch.

12. In a telephone system, subscribers' lines arranged for interconnection, incoming trunks for extending connections to the sub-

scribers' lines, outgoing trunks for extending connections from the subscribers' lines, a single unitary switch for effecting all of said connections, a marker for controlling the selective operation of said switch and associable with any subscriber's line, a sender, means for associating said sender with the marker to selectively operate said switch, and means for rendering said marker inaccessible to the sender when such marker is associated with a calling line.

13. In a telephone system, subscribers' lines arranged for interconnection with each other, trunk lines arranged for connection with the subscribers' lines, a single unitary switch for effecting all of said connections, a marker mechanism for controlling the operation of said switch, means for associating said marker with a calling line upon the initiation of a call thereon, and means for rendering said marker busy to the calling line when the marker is taken into use for controlling the selective switch to effect a connection between a subscriber's line and one of said trunk lines.

14. In a telephone system, telephone lines, trunk lines, a switch having link circuits for connecting the telephone lines to said trunk lines, controlling mechanism for selectively controlling said switch, a relay for each telephone line, means for operating one of said relays to cause the line to be associated with the controlling mechanism, means for causing the relay to release, and means for again operating said relay to effect connection between the said telephone line and a trunk through one of said link circuits.

In witness whereof, I hereunto subscribe my name this 30th day of November A. D., 1923.

EDWARD E. HINRICHSSEN.