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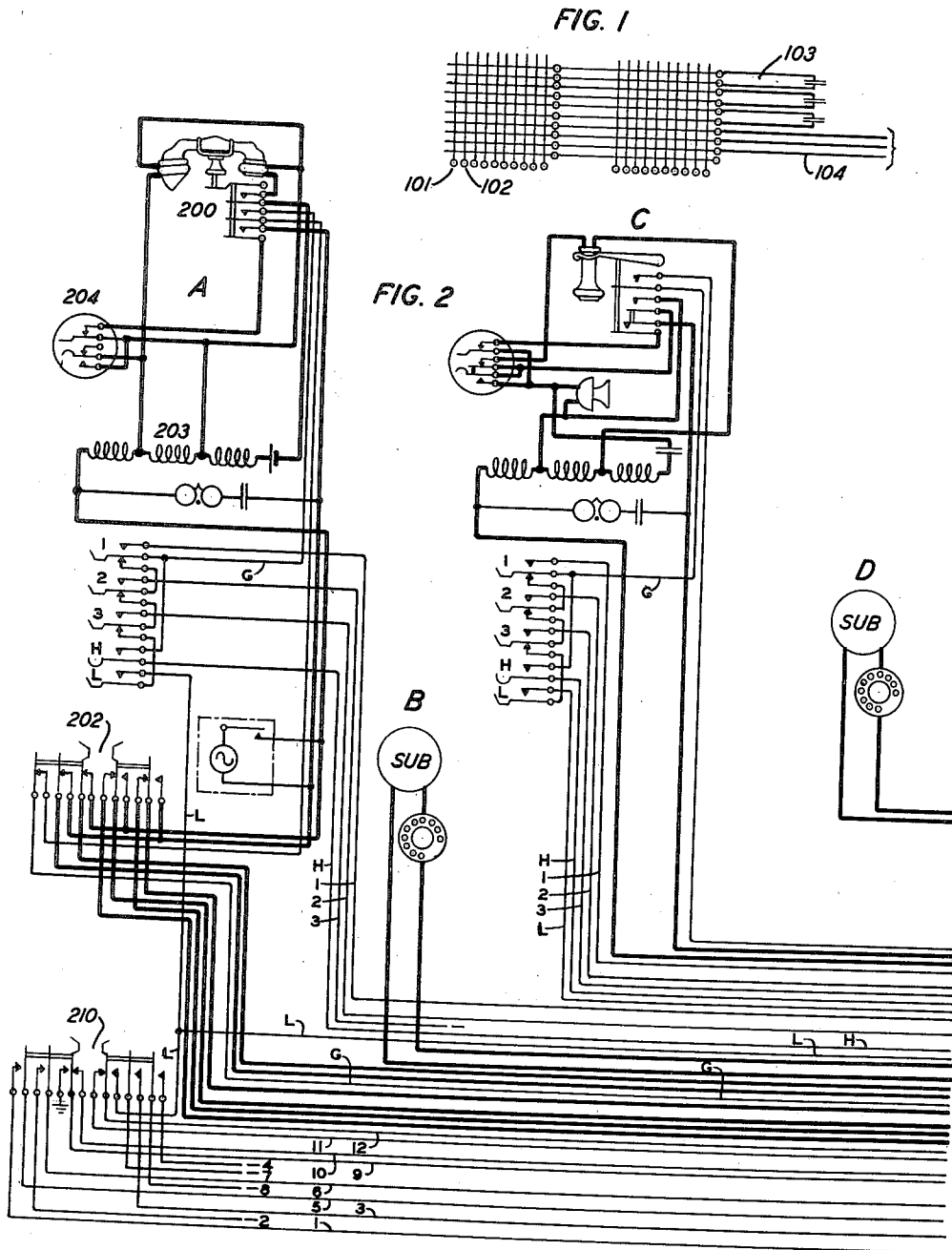
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2,185,287

TELEPHONE SYSTEM

Filed June 16, 1936

5 Sheets-Sheet 1



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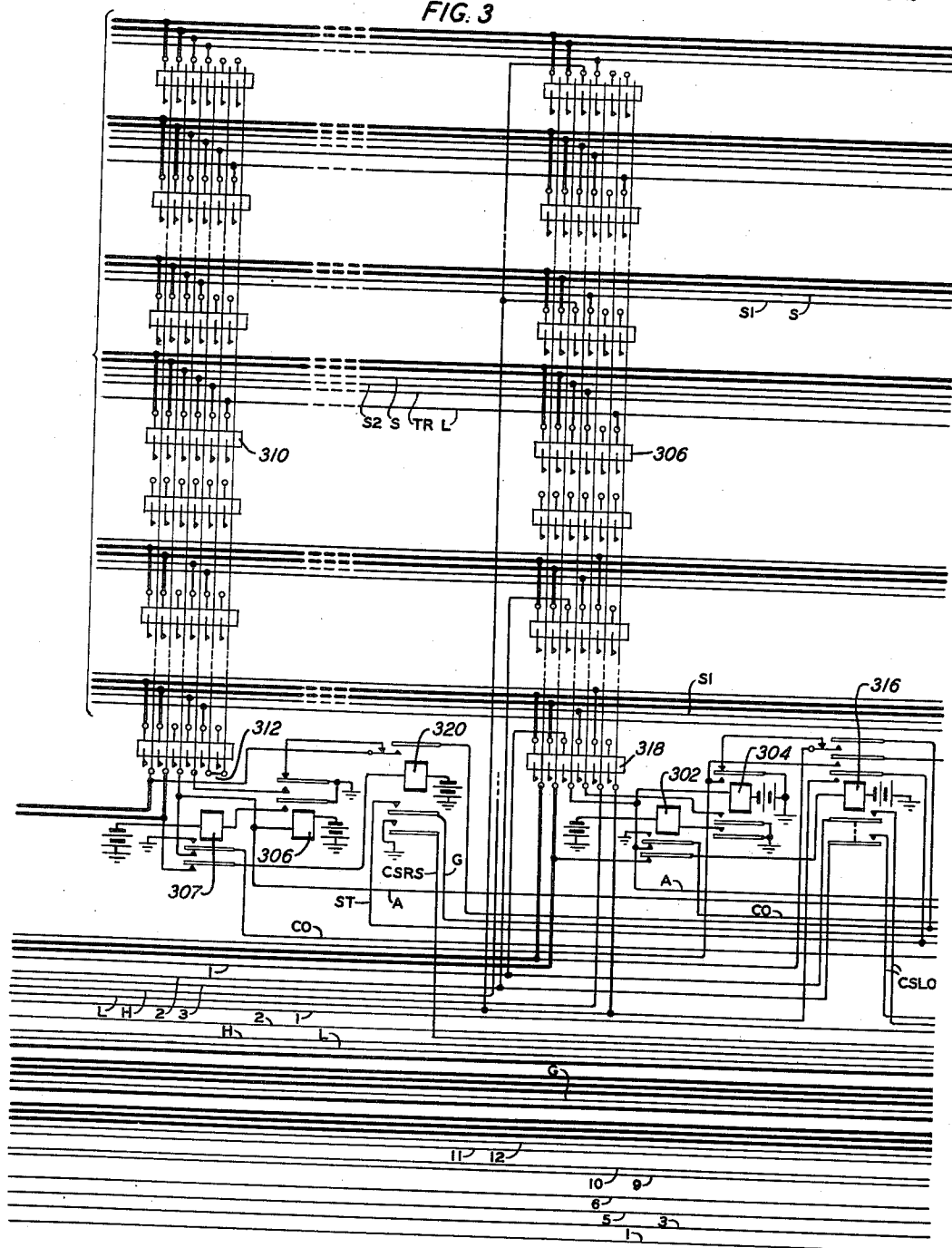
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TELEPHONE SYSTEM

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5 Sheets-Sheet 2

FIG. 3



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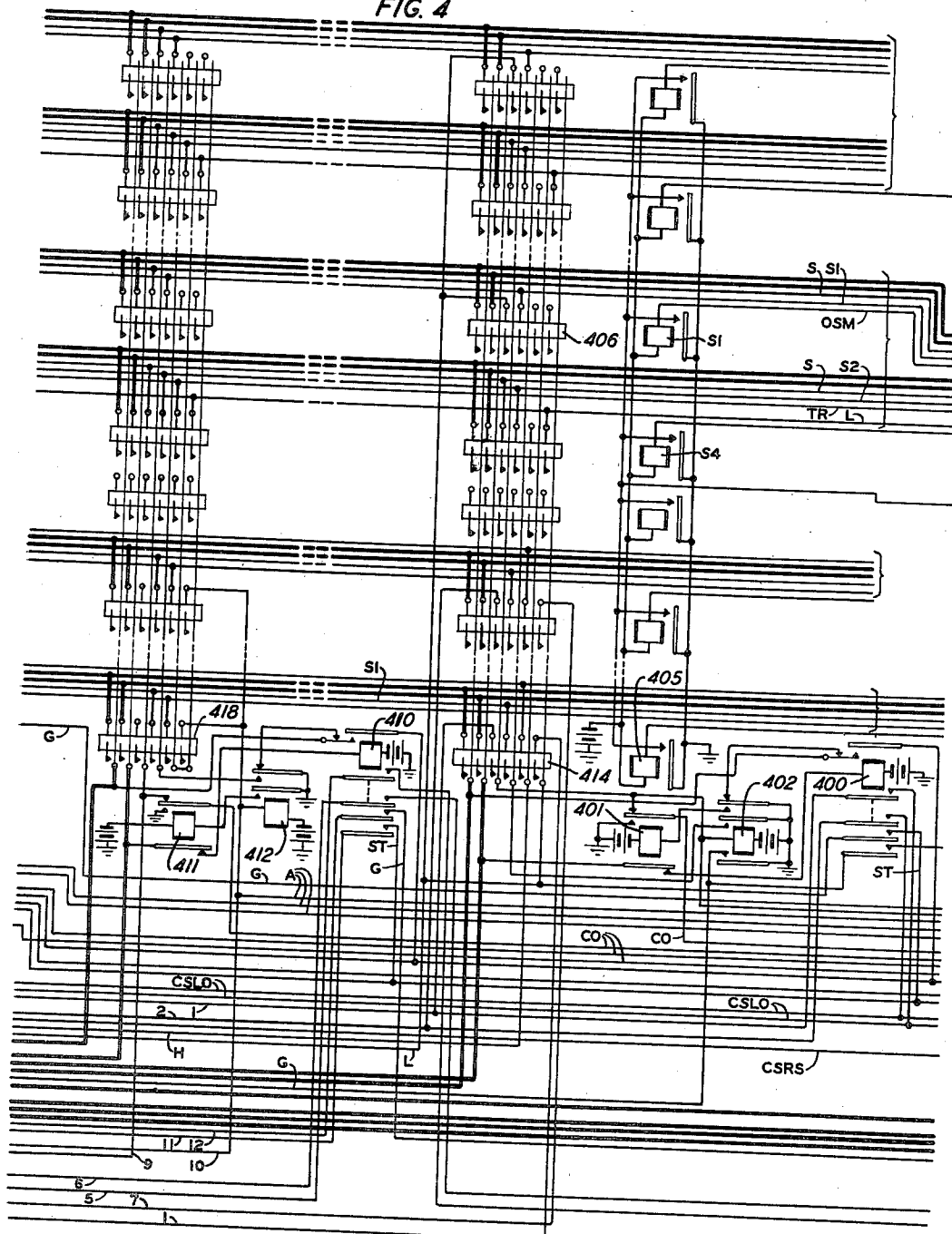
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TELEPHONE SYSTEM

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5 Sheets-Sheet 3

**FIG. 4**



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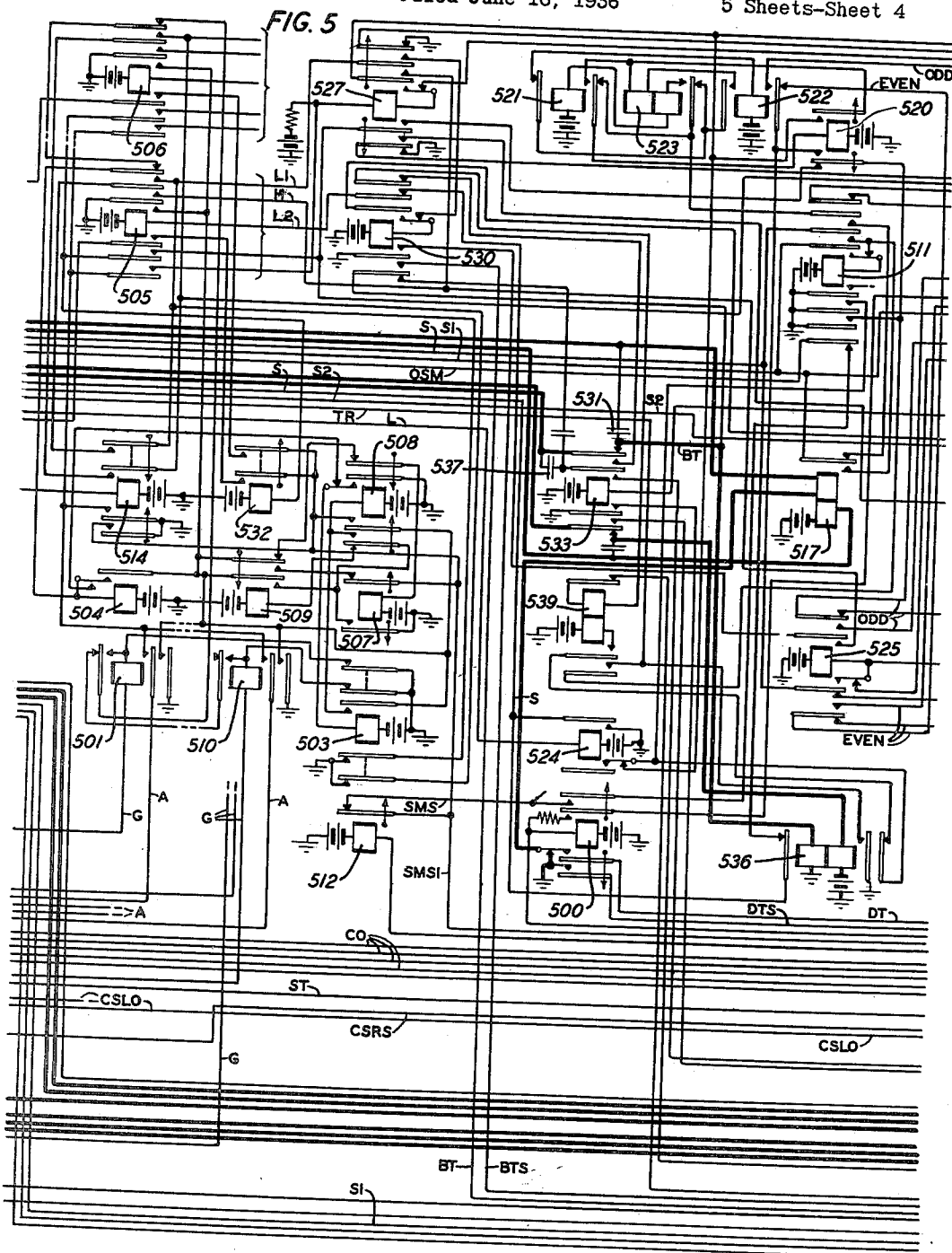
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TELEPHONE SYSTEM

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5 Sheets-Sheet 4



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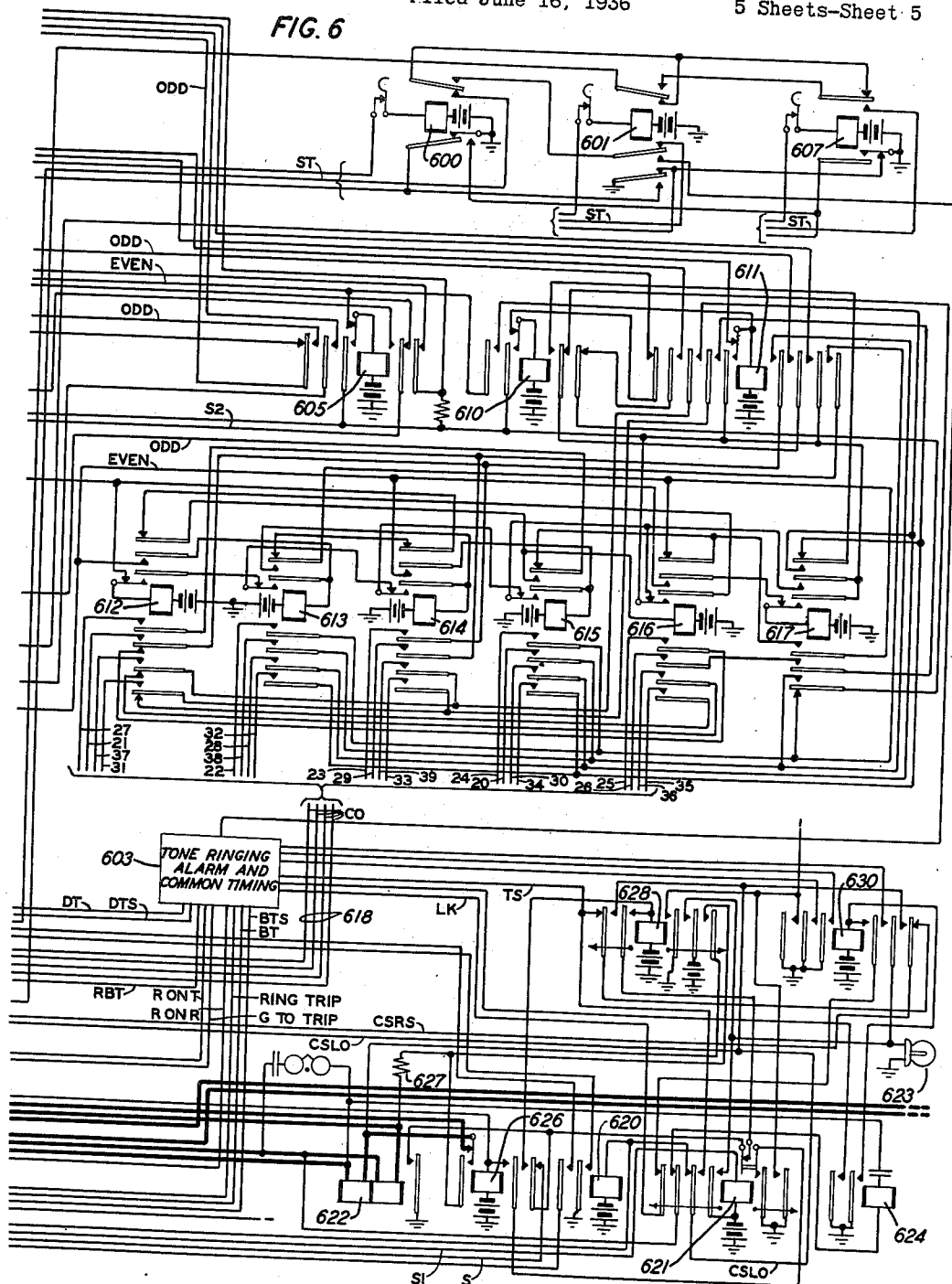
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TELEPHONE SYSTEM

Filed June 16, 1936

5 Sheets-Sheet 5



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## UNITED STATES PATENT OFFICE

2,185,287

## TELEPHONE SYSTEM

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Application June 16, 1936, Serial No. 85,459

17 Claims. (Cl. 179—18)

This invention relates to telephone systems and particularly to small capacity automatic telephone systems in which cross-bar switches are employed.

5 An object of the invention is to provide improved and economically arranged systems for automatically establishing connections between telephone lines and between lines and trunks.

10 Heretofore systems have been provided for establishing connections between two subscribers' lines in a single switch by means of links at two cross-connecting points only and between a subscriber's line and a trunk at one cross-connecting point only. The features of the present invention have been applied in a  
15 system of this type as disclosed in the Patent 2,071,075 of Feb. 16, 1937, to C. D. Koechling.

One feature of the present invention provides for call conference connections in systems of the  
20 above-mentioned kind. After a connection has been established between a calling subscriber and a called subscriber over a link, the called subscriber may replace his receiver on the switchhook and the calling subscriber may then dial  
25 the number of another called subscriber's line and thereby cause said second called subscriber's line to be connected to the same link. Other subscribers' lines may be added in the same manner to the conference connection.

30 The arrangement is such that when the calling subscriber starts dialing the number of another subscriber, the first called subscriber's bell is rung and when the second called subscriber answers the call the first called subscriber's bell  
35 will cease to ring as an indication to this first called subscriber to again remove his receiver from the switchhook and thereby cause his line to be connected in the conference connection. In case the second called subscriber's line is busy,  
40 the first called subscriber's bell will cease to ring when the second called subscriber's line is seized and the calling subscriber will receive a busy signal. The first called subscriber will answer the  
45 call as usual and be informed by the calling subscriber that the second called subscriber's line is busy.

50 In the system disclosed in the above-mentioned patent there is provided an allotter circuit arranged for allotting succeeding links to be used for establishing connections. A starter wire is extended to an idle link when a subscriber calls and when the link is taken for use  
55 this starter wire is extended to a succeeding idle link. It is a feature of the present invention to provide an improved allotter circuit arrange-

ment of this kind in which a single relay is provided for each link for this purpose and in which the relays of two links in the allotter circuit are always operated. The starter wire is extended  
5 by the relay of one of said links for the assignment of said link to be used in the next connection, and when this link is taken for use, this relay is released and the starter wire is extended to the succeeding idle link and the relay of the  
10 next succeeding idle link is then operated.

Another feature is the arrangement for releasing a connection between subscribers' lines solely in response to the calling subscriber replacing  
his receiver on the switchhook and an arrangement whereby the release of the called subscriber  
15 from a connection may take place by the called subscriber removing his receiver from the switchhook and operating any one of the keys normally used for establishing trunk connections as arranged in the above mentioned patent. When  
20 the called subscriber replaces his receiver on the switchhook two relays are released to complete a holding circuit in the link to prevent the link from releasing except by the calling subscriber  
25 replacing his receiver on the switchhook. If the called subscriber then decides to free his line from the connection he may, by the operation of one of the trunk keys cause the reoperation of one of these relays and thereby cause his line  
30 to be free to establish another call.

Another feature is an arrangement in a system of this kind where a trunk call for a subscriber of a so-called keyless station is first received by a master subscriber of a so-called key station  
35 and then transferred to the subscriber of the keyless station, whereby the subscriber at the key station may by operating a key cause his line to be freed from the connection established to the keyless station. This arrangement is also  
40 operative when a trunk connection is desired by a keyless station in which case the key station subscriber establishes a connection from his station to a trunk and then transfers the trunk connection to the keyless station.

45 This invention has been illustrated in the accompanying drawings in which:

Fig. 1 shows diagrammatically how lines, links and trunks are arranged on a cross-bar switch in a small capacity automatic telephone system; and

50 Figs. 2 to 6 show the various features of the invention in detail in a small capacity automatic telephone system of the general type disclosed in the patent to C. D. Koechling above mentioned. Fig. 2 shows four different types of sub-  
55

scribers' lines. Figs. 3 and 4 show four vertical units and six horizontal units or levels of a cross-bar switch together with the line equipment associated with the lines to which the vertical units are connected, and Figs. 5 and 6 show one link circuit in detail for recording dial pulses and extending connections to lines and trunks, an allotter circuit for allotting links in rotation and one trunk circuit in detail for extending calls to a central office.

In Fig. 1 the subscribers have been shown in the vertical units and the connecting links and trunks in the horizontal units. For example, if a connection is to be established between two subscribers' lines such as 101 and 102, a connection is established from line 101 over the associate vertical unit through the switch to one branch of a link such as 103 and through this link over another branch through the switch and the vertical unit associated with line 102. If a connection is to be established from the subscriber's line 101 to a trunk a connection is made through the switch to the trunk such as 104. The cross-bar switch structures may be of any well known type in which a selecting magnet for a horizontal unit and a holding magnet for a vertical unit may be operated to establish a connection through contacts at the intersecting points of these units.

In the present system using this type of cross-bar switch and embodying the features of the invention, four different types of subscribers' lines have been shown. The subscriber's line indicated at A is called a master key station and provided with means for receiving and extending connections to any other station and to extend and receive connections from any trunk, three of which have been arranged in this system. The connections to these trunks may be established by operating corresponding keys 1, 2 or 3 of said trunks. The subscriber's station B is called a keyless extension station and may establish connections to any other subscriber's line in the system, but only receives and extends calls over a trunk through the aid of the master station A, that is, trunk calls intended for or that are to be made from station B must first be received or set up by the station A which then transfers the trunk connection to station B and retires from the connection. Station C is also equipped with a key for establishing connections to and from trunks and may establish connections to and from any other subscribers but is provided with means for aiding in establishing connections for extension stations. Station D is a keyless station arranged for receiving and establishing connections to other subscribers in the system, but not trunk connections. To fully understand the features of this invention a detailed description will now be made of the various calls possible over the system disclosed. Calls will be described as follows: A line-to-line call from the master station A to station B, to the key station C and to the keyless station D; a call from line A to a trunk; a call from the keyless station B to a trunk which is accomplished by the aid of station A; a conference connection, that is, a call, for example, from station A to station C and then to station D to bring these two stations into a conference connection with station A; calls incoming from a trunk; transferring calls from a trunk from one station to another and calls from a trunk to keyless stations and for emergency calls from master station A.

If the call is made from station A the sub-

scriber at this station will remove his handset 200 from the switchhook and operate the key L. This closes a circuit for the operation of relay 400 from battery through the winding of this relay, contacts of the holding magnet 401, of the vertical unit over which a connection may be established from station A to one bank of the link shown in Figs. 5 and 6, over the R lead, contacts of the emergency key 202, the left-hand and middle winding of the repeating coil 203, off-normal contacts of dial 204, switchhook contacts, contacts of emergency key 202 over the T lead, make-before-break contacts of relay 400, contacts of relay 402 to ground. The operation of this relay closes a circuit for the start relay 500 and the relay 501 which is individual to this particular line over a circuit from battery, winding of relay 500, contacts of relay 500, which is operated and is the first relay in the allotter circuit that allots the first link to be used for the next call, contacts of the second allotter relay 601 which is also operated back over the start lead ST, contacts of relay 400 over the L lead to contacts of key L, contacts of keys 3, 3 and 1, over the G lead, through the switchhook contacts and contacts of key 202, contacts of relay 400, winding of relay 501 to ground at contacts of relay 503. The operation of the relay 501 closes circuits for the operation of relay 504 from battery, winding of this relay, contacts of relays 505 and 506 and other intermediate relays, not shown, but of which one is provided for each link as will hereinafter be apparent, left-hand armature and front contact of relay 501 to ground at contacts of relay 503. Relay 507 is now operated from battery through the winding of this relay, contacts of relays 508, 509, and 501 to ground. This relay in turn operates relay 509 which is slow in operating. Relay 504 closes a holding circuit for itself to ground at contacts of relay 501 and closes a circuit for relay 503 from battery, winding of this relay, contacts of relay 502, contacts of relay 504 to the ground at relay 501. When relay 503 operates the operating circuits from all the other relays individual to the different lines such as 510 serving the same purpose as relay 501, are opened to prevent any other call from proceeding at this time. The operation of relay 503 operates the relay 508 which is slow in operating over a circuit from battery through the winding of this relay, contacts of relay 503 to ground at contacts of relay 501 and this relay in turn closes a locking circuit for relay 503 while relay 507 releases slowly. Relay 508 releases relay 509 and connects ground to the SMS lead for the operation of the select magnet of the allotted link over the OSM lead. In this case this select magnet is marked S1 and the circuit may be traced from battery through the winding of this magnet S1, the OSM lead, contacts of relays 511, 500, 512, 508, to ground at relay 501. This insures holding operated the relays 508 and 503 until all other relays are released which will prevent a double connection. That is, in case the circuit from the operating ground of the operated relay 501 to the relay 504 is opened, relay 504 will fail to operate which will also fail to operate relays 503 and 508. As previously mentioned relay 501 operates relay 507 which operates relay 509. The operation of relay 509 releases relay 507. With relay 507 released and with relay 509 operated a ground is connected to the SNS lead to operate the select magnet. This insures service in case relay 504 does not operate due to its operating circuit being

opened at one of the contacts of the relay 501 or relay 505 or 506 of that group.

The operation of the select magnet S1 moves the usual fingers of the select bar in this level. It also operates relay 514 over a circuit from battery through the winding of this relay, contacts of select magnet S1 to ground. Relay 514 closes a locking circuit for relays 508, 503 and 504. Relay 514 also connects a ground through the A lead to close a circuit for the cut-off relay 402 from battery through the winding of this relay, the A lead, contacts of relay 501, contacts of relay 514 to ground. The cut-off relay 402 closes a connection to ground for relay 501 to shunt this relay and cause it to release and closes an obvious circuit for the holding magnet 401 of the vertical unit in the switch to connect the calling line to the originating branch of the link shown in Figs. 5 and 6 at the cross-connecting point 406. When this connection is established relay 402 locks from battery through the winding of this relay over contacts at the connection made at the point 406, L lead, the L key and the trunk keys 3, 2 and 1 at the subscriber's set, the G lead, through the switchhook contacts, contacts of key 202 back to ground at the lower armature and front contact of relay 402. The operation of the holding magnet 401 releases relay 400 and connects ground to the CO lead which extends to contacts of the counting relays shown in Fig. 6 as will hereinafter be described for busyng the calling line to incoming local calls. The connections for the T and R leads extending over the cross-connecting point 406 to the allotted link now causes the operation of relay 517 through the calling subscriber's loop, contacts at the cross-connecting point 406, the tip conductor, upper winding of relay 517, contacts of relay 500 to ground over the DT lead to the tone ringing alarm and common timing circuit indicated by the box 603 and the ring conductor to battery through the lower winding of relay 517. Relay 517 closes a circuit for the operation of relay 511 from battery through the winding of this relay and its make-before-break contacts, contacts of relay 517, over lead S1 to contacts at the cross-connecting point 406 to ground at contacts of relay 402. Relay 511 in operating opens the circuit for the select magnet S1 and this relay in turn opens the circuit for relay 514 which causes the release of relays 504, 508 and 503. Relay 511 locks from battery through the winding of this relay and its upper inner armature and front contact directly to the S1 lead. It will be noted that on the operation of relay 500 a connection was made through its lower outer armature and front contact to ground over the lead DTS to the tone circuit 603 to start the dial tone. Dial tone is now transmitted over the DT lead, contacts of relay 500, the upper winding of relay 517, over the tip conductor to the calling subscriber's circuit back through the lower winding of relay 517 and battery.

The operation of relay 511 also transfers the start lead for the allotting of the next idle link for the next call. It should be noted that the circuit for relay 600 is opened at the upper outer armature and back contact of relay 511. This releases relay 600 and a circuit is now closed for the operation of the next succeeding allotter relay 607 from battery through the winding of this relay, contacts of the relay in the third link corresponding to relay 511 to ground at the make-before-break contacts of relay 600. The operation of the relay 607 connects the second link by extending the start wire ST over the upper outer arma-

ture and front contact of relay 601, upper armature and back contact of relay 600, lower inner armature and front contact of relay 601 to the start relay in the second link corresponding to start relay 500 of the first link. Should the second link be taken for use, relay 601 will release and relay 600 reoperates. The circuit for relay 600 in this case would extend from battery, winding of relay 600, contacts of relays 511 and 601 to ground and the start wire will then be extended over the upper outer armature and back contact of relay 601, upper outer armature and front contact of relay 607 for the allotting of the third link. Thus it will be seen that only a single relay will be required for each link in this allotter circuit with relays of two succeeding links maintained normally operated. If all three links are in use the start lead will not be extended until one of the links becomes idle when the start relay of this idle link will be operated by the circuit closed by the next preceding start relay being operated to extend the start wire to this link.

The subscriber upon receiving the dial tone now operates the dial which will release and operate the relay 517 in unison with the make and break of the dial contacts. The relay 520 operates when the relay 517 releases on the first impulse of each digit and remains operated until the end of the last pulse of each digit. The circuit for relay 520 may be traced from battery through the winding of this relay, contacts of relays 521, 511 and 517, over the S1 lead, contacts at the cross-connecting point 406, contacts of relay 402 to ground. On the first pulse and subsequent odd impulses the relay 522 operates when the relay 517 releases over a circuit from battery through the winding of this relay, contacts of relays 521, 523, 511 and 517 to ground on the S1 lead. For the second pulse and subsequent even impulses the relay 521 will operate and the relay 522 will release. The relay 522 when operated connects ground to the odd lead to operate the odd number register relays, and when relay 522 is released it connects ground to the even lead to operate the even register relays. These registers can only operate while the relay 520 is operated. The numbering system used in the present invention which provides for twenty subscribers' lines as indicated in Fig. 1, may be numbered from 20 to 39. Relays 521, 522 and 523 operate and release in the following manner. When relay 517 releases on the first pulse the relay 522 operates from battery through the winding of this relay, contacts of relays 521, 511 and 523 to the S1 lead. When relay 517 reoperates relay 523 operates over a circuit from battery, winding of relay 523, contacts of relays 521 and 522, left-hand winding of relay 523, contacts of relay 520, make-before-break contacts of relay 524 to ground at contacts of relay 511. It should be noted that on the operation of relay 522 a circuit was also closed for relay 525 from battery through the winding of this relay and its make-before-break contacts, contacts of relays 605, 523 and 520 to ground at relay 511. When relay 517 releases on the second impulse, relay 521 will operate over a circuit from battery through the winding of this relay, right-hand winding of relay 523, contacts of this relay and contacts of relays 511 and 517 to ground on the S1 lead. The operation of relay 521 releases the relay 522 and transfers the operating circuit of relay 520 to a holding circuit from battery through the winding of relay 520, contacts of relays 521, 520, 524 to ground at contacts of relay 511. The purpose of this is to remove any shunt



from around relay 523 when relay 517 reoperates so as not to interfere with the release requirements of relay 523. Thus it will be seen that on the odd impulses relay 522 will operate when relay 517 releases and on the even impulses relay 522 will operate and 523 release, with relay 523 operated on the odd impulses and released on the even impulses. It should be noted at this point that in the case of a momentary opening of the line before a digit has been dialed the relay 517 will release and relays 520 and 522 operate. When relay 522 operates, and causes relay 525 to operate, relay 525 will be held operated under control of relay 520, then when relay 517 reoperates relay 520 will release, releasing these relays 522 and 525 to again prepare the circuit for the reception of the first digit.

The effect on the register relays of these pulses of the first digit will now be described. As stated when a first impulse is received relays 522 and 525 operate and when relay 522 releases on the second impulse of the first digit relay 605 operates over a circuit from battery, winding of this relay and its make-before-break contacts, contacts of relays 525, 522, 520 to ground at relay 511. This relay in operating locks over its inner left-hand armature and front contact to the common ground at contacts of relay 511 over make-before-break contacts of relay 524. Relay 605 releases the start relay 509 by opening the connection at its outer right-hand armature and back contact and closes the odd lead from contacts of relay 521 for the subsequent operation of relay 610. Therefore, when the first impulse is received this relay will operate from battery through the winding of this relay 610 and its make-before-break contacts, contacts of relays 611, 525, 605, 522, 520 to ground at relay 511. Relay 610 locks over a circuit from battery through its winding and inner left-hand armature and front contact to ground on the common lead. Relay 610 closes the even lead from relay 522 to relay 611 so that when the fourth impulse is received relay 611 will operate from battery through its winding, contacts of relays 610, 525, 522, 520 to ground on relay 511. The operation of relay 611 prevents this fourth impulse and subsequent impulses if dialed on the first digit from establishing any connection to any station as in this system there are only two groups of ten subscribers each to choose from so that the third impulse in this case when received will choose the second group of ten subscribers' lines 30 to 39. In case only two impulses have been received the first group of subscribers' lines 20 to 29 would have been chosen. Assuming that three impulses are received on the first digit the relay 520 will release at the end of this digit and relay 525 which is locked through the lower armature and front contact of relay 522 will also release at this time. Relays 605 and 610 are therefore the tens digit or first digit register relays. The odd and even relays are now transferred to the unit or second digit register relays 612 to 617. On the first impulse of the second digit relays 522 and 520 are operated and relay 520 in this case causes the operation of relay 527 over a circuit from battery, winding of this relay and its make-before-break contacts, contacts of relays 605, 525, 520 to ground at 511. Relay 522 in operating connects ground to the odd lead and in releasing to the even lead to operate relays 612, 614 and 616 over the odd lead and relays 613, 615 and 617 over the even lead. In operating these registering relays

relay 612 will release on the operation of relay 613, relay 613 will release on the operation of relay 614, relays 614 will release on the operation of relay 615, and relays 615 will release on the operation of relay 616, but when relay 617 operates relay 616 will remain operated and when more than six impulses are dialed relays 612, 613, 614 and 615 will operate and release in the order named. When relay 612 operates on the seventh impulse relay 616 will release. As an example of the operation of this relay on a first impulse relay 612 will operate over a circuit from battery through the winding of this relay and its make-before-break contact, contacts of relays 614, 613, 616, 615 over the odd lead, contacts of relays 525, 605 and 520, to ground at relay 511. On the second digit relay 522 releases and relay 613 is operated over a circuit from battery, winding of this relay, contacts of relay 525 over the even lead through contacts of relays 522 and 520 to ground at relay 511. When relay 613 operates, the holding circuit established through the make-before-break contacts of this relay for holding of relay 612, is opened so that this relay will now release. The holding circuit for relay 613 is established over the operated armature and front contact, make-before-break contacts of relay 614. At the end of the last impulse of the second digit relay 520 will release and as relay 527 is operated relay 611 will operate if not already operated by a fourth impulse. The circuit extends from battery through the winding of this relay, its make-before-break contacts, contacts of relays 527 and 520 to ground at relay 511. Relay 611 locks over its inner left-hand armature and front contact to the common ground lead. Relay 611 closes a circuit for the operation of relay 525 from battery, winding of this relay, contacts of relay 611 to the common ground. This relay also connects the busy test relay 530 to the CO lead of the line selected as will hereinafter be described, and opens the operating path for relay 610 to prevent it operating in case a third digit is dialed when this relay is not operated and connects the common leads together which connect to the CO leads through the contacts of the register relays. These leads are shown at 618 for lines shown in the cross-bar switch and it is to be understood that others are connected to contacts of the register relay. Connections to these leads are open until dialing is completed to prevent two CO leads from being tied together, as the ground on one CO lead from a line, line switch, or call allotter circuit, would cause interference to another line by connecting this ground to another CO lead while the register relays are operating and releasing. If it is assumed that the line 28 was dialed, that is the first digit was 2 and the second 8, the relays 610, 617 and 613 will be operated. The circuit will now therefore be closed at the end of the second digit due to the operation of relay 527 for relay 530 as follows: battery, winding of this relay and its make-before-break contacts, contacts of relays 527, 611, 610, 617, 613, over lead 28 to the CO lead of the called line which may be line C. If this line is busy there will be a ground on the corresponding CO lead applied by the holding magnet 302 thus causing the operation of busy-test relay 530. This relay will lock over its upper inner armature and front contact to the common ground lead. As relay 530 operates the original energizing circuit will, of course, be opened at the make-before-break contacts and consequently no interfering ground or battery

will be left on the CO lead of the line C. The operation of relay 530 also opens the L2 lead to the line to prevent the seizing of the line by the operation of the corresponding relay 505. A busy-tone circuit is also closed and a busy tone transmitted to the calling subscriber. A connection is made to ground for the BTS lead for starting the busy tone equipment 603 and the busy tone is then transmitted from this source over the BT lead through contacts of relay 530 over the tip lead of the calling line through condenser 531.

If the line is not busy the relay 525 in operating after the completion of the second digit closes L1 and L2 leads for the operation of relay 505 individual to this link, from battery over the winding of this relay, contacts of relays 530, 525, 527, 503 to ground. This relay in operating closes a circuit for the operation of relay 532 from battery, winding of this relay, contacts of relays 505, 527, 520 and ground at relay 511. Relay 505 in operating also closes a circuit for relay 504 from battery, winding of this relay, contacts of relay 505 to ground at relay 503. Relay 504 operates relay 503 from battery, winding of relay 503, contacts of relays 508 and 504 to ground at relay 505. Relay 503 closes a circuit for relay 503 from battery, winding of this relay, contacts of relay 503, to ground at relay 505. The select magnet S4 of the terminating or called branch of the link is now operated to connect this branch to the called line. The circuit may be traced from battery through the winding of this magnet S4, contacts of relays 535, 532, 508 to ground at relay 505. After magnet S4 operates it closes an obvious circuit for the operation of relay 514 and this causes the release of relay 527, as the battery for the circuit of relay 527 is shunted through contacts of relays 505 and 514 to ground. Relay 532 is released by relay 527. The cut-off relay 304 of the called line C will now be operated over a circuit from battery through the winding of this relay over the corresponding CO lead to a circuit hereinbefore traced over contacts of relays operated in the register, namely, 613, 617 and 610 to ground at the upper armature and back contact of relay 527. Relay 304 operates the holding magnet 302 which therefore establishes a connection at the cross-connecting point 306 in the switch for the terminating branch of the link used. When this connection is made relay 533 is operated to connect ringing current to the called line. This circuit may be traced from battery, winding of relay 533, contacts of relay 605 over the S2 lead through the cross-connecting point at 306 to ground at contacts of relay 304. As magnet 302 operates relay 304 is removed from the connection over the CO lead to ground but after the connection is established through the cross-connecting point at 306 this relay will be held through contacts of relays 511, 517, over the S1 lead through the cross-connecting point at 403 to ground at relay 402. The ringing current is now transmitted from the source at 603 over the ring conductor, the upper inner armature and front contact of relay 533, condenser 537 to the ring conductor of the called line through the cross-connecting point 306, ring conductor to the calling subscriber's ringer and back over the tip conductor, the cross-connecting point at 306, the lower outer armature and front contact of relay 533, back to the source 603, while a direct current path extends from the conductor at 603, through the subscriber's set when he answers over the ring conductor tip through the upper armature

and back contact and upper winding of the ringing tip relay 539, contacts of relay 530, the upper outer armature and back contact of relay 533 to the ring conductor at 603. The subscriber on the line C will now in answering this call remove his receiver from the switchhook thus causing ringing tip relay 539 to operate on the next silent interval. This subscriber will also operate the key L and this causes the operation of relay 524 from battery, winding of this relay through the cross-connecting point at 307 over the L lead to the key L, the trunk keys 3, 2 and 1, switchhook contacts over the G lead to ground at relay 304. Relay 524 opens the common ground lead which holds the relays 525, 605, 611 and the register relays operated thus causing the release of these relays. The release of these relays removes the ground from the CO lead to the called line and the release of relay 605 causes the release of relay 533, thus stopping the transmission of ringing current to the called line. A circuit is now closed for the operation of relay 536, over the tip and ring conductors from battery and ground through the two windings of relay 536 and contacts of relay 533 over the called subscriber's loop. Relay 536 in operating releases relay 539 which was locked through its lower winding and lower armature and front contact through contacts of relay 536 to the common ground. Relay 536 opens a connection to ground for the S lead and a substitute ground is connected to this lead at the upper armature and front contact of relay 534. The connection between the calling and called subscribers is now established with relays 511, 517 and 536 operated. Conversation between the calling and called subscribers may now take place with talking battery for the calling subscriber supplied through the windings of relay 517 and for the called subscriber through the windings of relay 536.

In case this call had been for a keyless station, such as D, the operation of relay 306 and the holding magnet 307 take place in the same manner as the operation of the corresponding relays and magnet of station B. In this case when the called subscriber answers relay 539 is operated. The connection for the leads TR and L are tied together as shown at the point 312 and in this case therefore the relay 524 will be operated from battery, winding of this relay over the L lead back over the TR lead through contacts of the operated relay 539 to ground at contacts of relay 511. Relay 527 opens the common ground lead which holds the relays 525, 505 and 611 and the register relays which are now released. The release of relay 605 releases relay 533 and stops the ringing and when relay 536 operates it is connected to the line by the release of these relays and will release relay 539 and open the circuit for ground to this lead. Relay 536 also connects ground to this TR lead which holds the relay 524 operated.

In releasing the connections in case the calling party disconnects first, the called party will be held to the link until the receiver is replaced on the switchhook. This prevents the called party being disconnected from a link and then connected to the originating end of another link and receive dial tone. When the called party releases relays 524 and 536 are released thus permitting the release of the called party. If the calling party disconnects first relays 517 and 511 will be released but relay 304 and holding magnet 302 will not be released as relay 304 is held operated over the S lead by relay 524 as

stated while the calling party will be released by the opening of the circuit for relay 402 and consequent release of the magnet 401, relay 402 releasing by the opening of the L key by the calling party.

In the case of a call from a subscriber's line to a trunk, for example, from the key station C to the first trunk shown in Fig. 6 the subscriber at the key station C will remove his receiver from the switch-hook and operate a trunk key 1. Relay 316 is then operated from battery, winding of this relay, contacts of relay 302 through the subscriber's loop, make-before-break contacts of relay 316 to ground at contacts of relay 304. The holding ground for this relay is now transferred to a ground in the tone ringing alarm circuit specified at 603. The purpose of this transfer is to provide a means to transmit a busy tone to the station in case the trunk selected is busy. If the trunk is busy a relay in the tone circuit at 603 will operate, which will transfer the holding ground from the relay 316 in this case to ground through the winding of a repeating coil and with the operation of other relays a tone will be transmitted to the station through the windings of this coil. The operation of relay 316 closes the leads 1, 2 and 3 from the trunk key at the station C to the CS leads of all the trunks, the L lead to the ST lead of the link and link allotter circuit at the station lead G to the G lead in the link circuit. These leads are, of course, kept open until the relay 316 is operated for the purpose of preventing service interference in case one of these leads has become grounded. The G lead is the common lead to the station and when the switch-hook is released by the removal of the receiver this G lead is closed through switch-hook contacts to the various keys in the station. As key 1 is provided for trunk 1 and is operated, a circuit is now completed over the G lead for the corresponding relay such as the relay 501 or 510 in the link. The particular relay for this station has not been shown but it operates in series with relay 620 in the first trunk, also a circuit from battery, winding of relay 620, contacts of relay 621, lead CSLO, contacts of relay 316 over the G lead for the first trunk, contacts of the first trunk key over the G lead and contacts of the switchhook contacts, of relay 316 to the relay corresponding to relay 501 or relay 510, not shown, to ground at contacts of relay 503. Relay 620 closes a circuit for relay 512 from battery, winding of this relay, contacts of relay 620 to ground. This opens the connection for the SMS lead that ordinarily provides ground for the operation of the select magnet of the corresponding allotted link ordinarily seized when the line-to-line call is made. In this case the link will not be required. In this case the relays 504, 509, 507, 503 and 508 will operate as hereinbefore described and provide a ground connection for the operation of the select magnet 405 for the first trunk over a circuit as follows: battery, winding of magnet 405, contacts of relay 620, SMS lead, contacts of relay 503 and the relay corresponding to relay 501 or 510 to ground. Magnet 405 closes the usual circuit for relay 514 and this relay in turn closes a connection at its lower inner armature and front contact to ground for the A lead through a relay corresponding to relay 501 or 510 over the A lead through the winding of relay 304 to battery causing the operation of this cut-off relay. Relay 304 closes a circuit for holding magnet 302 to connect the line C at the cross-connecting point 318 to the conductors of the first

trunk. Relay 304 in operating closes a connection at its upper armature and front contact to ground for the G lead and this ground is extended over a subscriber's loop through key 1 through the contacts at the cross-connecting point 318 through the winding of relay 304 to battery. This placing of a ground on the G lead releases the relay corresponding to relay 501 or 510. The operation of the holding magnet 302 opens the circuit for relay 316 which now releases to open the CS leads between the station C and the trunks. Consequently, relay 620 is released and this causes the release of relay 512 and the select magnet 405. Magnet 405 in turn releases relay 514 which causes the release of the operated relays 504, 509 and 503. The release of these relays prepares the circuit for the establishing of another call. A connection from the station C to the central office over the first trunk is now established from the tip and ring conductors over the cross-connecting point 318, through the windings of relay 622, contacts of the emergency key 202 at the key station A out over a trunk to the distant office. It should be noted that on the operation of relay 304 a connection is established to ground on its lower inner armature and front contact through the connections at the cross-connecting point 318 over the S1 lead, through the winding of relay 621 to battery for the operation of this relay. This relay in operating opens the circuit for relay 620 over the CSLO lead, to prevent stations arranged for non-lock-out service from being connected to the trunk when the line is busy and to close a circuit for the signal lamp 623 which may be provided in this office as a busy signal. It also opens the circuit for a ringing bridge relay 624 and connects the CSLO lead to a tone circuit lead TS at 603 to provide a busy tone to a calling subscriber having a lock-out service. When this connection is released by the subscriber at station C replacing his receiver on the switchhook and releasing the trunk key 1 the relay 304 is released causing the release of the holding magnet 302 and the ground removed from the S1 lead which releases relay 621 in the trunk. Relay 622 is also released.

Description will now be made of a connection to a trunk from the keyless station B which must be set up by the subscriber at the master station A. The subscriber at the keyless station B must make a manual request to the subscriber or operator at station A to establish this connection. The subscriber at station A will select a trunk and connect his station to the trunk as hereinbefore described. Then the subscriber at A will operate the control key and the operator of the keyless station B will remove his receiver from the switchhook. This will operate the relay 410 from battery, winding of this relay, contacts of the holding magnet 411 through the subscriber's loop at station B, make-before-break contacts of relay 410 to ground at contacts of relay 412. In this case there will be a connection for the associated relays 501 to 510 over a G lead through the control key at station A due to the operation of relay 410. This connection may be traced from ground at relay 503 winding of the corresponding relay over a G lead, contacts of relay 410, lead 12 contacts of the control key, lead L over the connection at the cross-connecting point 414, which was established when the subscriber's line at A was connected to the first trunk, lead 1, over contacts of the control key, lead 5 contacts of relay 410, lead CSNL winding of relay 620 to

battery in the first trunk connected to station A. The operation of relay 620 and the relay corresponding to relay 501 or 510 causes ground to be connected to the A lead to operate the relay 412 from battery, winding of this relay over the A lead contacts of the relay corresponding to 501 or 510 to ground at relay 514 as it will be remembered that when this corresponding relay operates it causes the operation of the relays 504, 503, 502, 501, 503 in the manner described and then causes the operation of the select magnet 405 a second time and the operation of relay 514 to establish this connection for the operation of relay 412 over the A lead. Relay 412 in operating operates the holding magnet 411 and thereby connects at the cross-connecting point 418 the calling subscriber's line at station B to the first trunk. The subscriber at station A hearing the subscriber of station B in on the trunk connection will release the control key. As the relay 412 is operated the usual connection is established for the S1 lead to hold relay 621 operated as it has already been operated by relay 402 so that the subscriber at B will now have complete control over the connection over the trunk. The subscriber at station A may therefore disconnect his line from the trunk by replacing his receiver on the switchhook and releasing the trunk and central keys. This releases relay 402 and hold magnet 401 in the usual manner to restore the switch to normal.

The subscriber at station A or C may after he has secured a trunk to the central office hold this trunk so that it may be seized by any of the restricted service stations or for that matter by any other station. This is done by operating the holding key H by the subscriber at station A. This closes a circuit for the operation of relay 626 in the trunk connected to this line. The circuit may be traced from battery winding of this relay over a connection at the cross-connecting point 414, the H lead, the H key, the G lead over the switchhook contacts, contacts of key 202, back over the G lead to ground at the lower armature and front contact of relay 402. Relay 626 locks under control of relay 621. Relay 626 opens at its make-before-break contact the trunk connection towards the station and connects resistance 627 across tip and ring conductors towards the central office to hold the connection at the central office and to hold relay 622 operated from the central office connection. Relay 626 also closes an obvious circuit for relay 628 and opens the S lead towards the line. This, however, performs no function at this time. Relay 628 closes another holding path for relay 622 at its outer right-hand armature and front contact to hold this relay operated when relay 626 releases as will hereinafter be described. Relay 628 also closes a circuit for keeping the lamp 623 lighted when relay 621 releases. This relay also connects the CS lead to the relay 620 after the relay 621 is released to permit the trunk to be picked up. Relay 628 closes a locking circuit for itself through contacts of relays 621 and 622 when 621 is released. When the holding key H at the station A was operated the operator's trunk key for trunk 1 releases automatically and this removes the ground from the S1 lead which releases the relay 621. Relay 621 releases relay 626 and connects relay 620 to the CS lead through contacts of relay 628 and closes a holding circuit for this relay 628. Relay 620 is slow in releasing to insure the holding of the relay 626 until the tip and ring leads are open at the cross-connect-

ing point 414 which is opened when the holding key operates and the subscriber at A replaces his receiver on the switchhook due to the release of relay 402 and the holding magnet 401.

This held trunk may now be seized by a key station, such as A or C, or by a keyless restricted service station, such as D. In case the station C takes the trunk, the connection to this trunk is established as hereinbefore described by the operation of the relay 620. Relay 620 again closes a circuit for operating the select magnet 405 associated with the first trunk which is held and the corresponding holding magnet 302 is operated as described to connect station C to the first trunk. The tip, ring and S1 leads will again be closed to the trunk and the ground on lead S1 causes the operation of relay 621. This relay releases relay 628 which removes the bridge through the resistance 627 across the trunk, otherwise relay 621 performs the same function as described in connection with the seizure of the trunk as hereinbefore described. The release of relay 628 transfers the CS leads from the relay 620, windings to the CS lead in the tone ringing alarm circuit at 603 to make the trunk busy. The release of the trunk is the same as hereinbefore described in connection with a regular trunk call. If the restricted service line at station D calls to connect with this held trunk it will be noted that, on the operation of relay 320 when the subscriber's station D removes his receiver from the switchhook, a circuit is completed from ground through the contacts of this relay over the CSRS leads, contacts of relays 630, 628, 621, winding of relay 620 to battery to operate this relay 620 in the usual manner and seize the trunk in the same manner as a key station.

If a trunk is held and it is released at the central office relays 622 and 628 will merely release and restore the trunk to normal.

A call incoming over this trunk to a subscriber at this exchange operates relay 624 by ringing current incoming over tip and ring conductors. This relay closes a circuit for the operation of relay 630 which closed a locking circuit for itself under control of relay 621 to ground in the tone ringing and alarm circuit over the LK lead. If the call is abandoned relay 624 will cease to operate and after a time interval the relay in the tone ringing alarm circuit 603 which holds the ground on the LK lead will release to release relay 630 and restore the circuit to normal. On the other hand, the operation of relay 630 closes a circuit for the trunk lamp 623 to the tone and ringing alarm circuit at 603 which causes this lamp to flash and connects the CSRS lead to the circuit for relay 620 so that a restricted service subscriber at station D can take up the call. When the trunk is seized by one of the subscribers and relay 621 operates, relay 630 is released disconnecting the lamp 623 from the alarm circuit 603 and restores the tone ringing and alarm circuit connections to normal.

In case it is desired to establish a conference connection between several subscribers' lines in the system, the procedure may be as follows. For example, if station A calls station C in the regular manner and then desire a conference connection with station D, the subscriber at station C replaces his receiver which causes the release of relays 524 and 536. The release of relay 536 closes a circuit for holding the line of station C connected at the cross-connecting point 396 by maintaining relay 304 operated over a circuit from battery through the winding of this relay,

lead S, contacts of relays 536 and 511, lead S1, contacts at the cross-connecting point 496, contacts of relay 402 to ground. The subscriber at station A then dials the number of the desired subscriber which is the line D in this case. When the first digit is dialed the relay 605 is operated which then operates relay 533 which causes the ringer at the first called station to operate, as hereinbefore described, that is, the station C is called by the operation of this relay. When the second called station line is connected to the link in the same manner as the first line was, the ringers of the two called stations will ring simultaneously and when the second called subscriber at station D answers the ringer at the first called subscriber's station C will cease to ring as well as the ringer at the second called subscriber's station D and this will indicate to the first called subscriber that the second called subscriber has answered. The first called subscriber now removes his receiver from the switchhook. In case the second line is busy the relay 539 will operate when the line is tested which will cause the bell at the first called station to cease ringing and the calling subscriber to receive a busy signal. The first called subscriber will then answer and operate relay 524 releasing relay 530 and all the register relays.

In case either an incoming or outgoing trunk call is to be transferred from one subscriber to another the station from which the call is to be transferred operates the holding key to hold the trunk as hereinbefore described and the station to which the call is to be transferred may be called locally by depressing the L key and dialing as usual. The station called must then be informed to which trunk the call is to be made. To connect to the trunk he must then operate the proper trunk key as usual.

At station A the key 202 is provided for so-called "emergency service" to a central office. With the key normal, incoming and outgoing central office calls are handled in the normal manner. When the emergency key 202 is operated, however, the trunk shown is split and the station is connected directly to the central office end of the trunk thereby enabling the station to function as a common battery subscriber's line for receiving a central office call. It is unnecessary to operate any of the trunk keys at this station in order to receive a central office call when this key is operated. It is seen that the incoming tip and ring conductors will in this case be connected directly to the line by the operation of this key and the connection through the trunk equipment will be opened. As stated a keyless restricted service station D may make outgoing calls over a trunk if a trunk is held. On the other hand it will be noted that ordinarily this station D cannot make any outside trunk calls. If one is attempted and relay 320 operates, the ground on the CSRS lead will be connected through contacts of relays 630 and 628 to the lead TS going to the tone alarm circuit 603 which causes a busy signal to be transmitted over the RBT lead through contacts of relay 329, a certain interval after the connection through the TS lead is made.

What is claimed is:

1. In a telephone system, a cross-bar switch, subscribers' lines terminating in said switch, links terminating in said switch, means responsive to the dialing of two series of impulses over a calling subscriber's line for connecting said calling line to a corresponding first called line

through an idle link, means responsive during the dialing of one series of impulses of a second called subscriber's number for signaling the first called subscriber and responsive to the dialing of the second series of impulses of the second called subscriber's number for connecting said second called subscriber's line to the calling subscriber's line over the same link used for connecting the first called subscriber's line to the calling subscriber's line and for signaling the second called subscriber, and means for discontinuing the signaling of the first called subscriber when said second called subscriber answers the call.

2. In a telephone system, a cross-bar switch, subscribers' lines terminating in said switch, links terminating in said switch, means for establishing a connection from a calling line to a called line through a link and signaling the called subscriber, means responsive to the called subscriber answering the signal by removing his receiver from the switchhook for causing said signaling to cease, means for thereafter establishing a connection from the calling line to another called line through the same link, signaling the second called subscriber and for again signaling the first called subscriber if he has in the meantime replaced his receiver on the switchhook, and means responsive to the second called subscriber answering the signaling by removing his receiver from the switchhook for causing the signaling of both the first and the second called subscriber to cease.

3. In a telephone system, a cross-bar switch, subscribers' lines terminating in said switch, links terminating in said switch, means for establishing a connection from a calling line to a called line through a link and signaling the called subscriber, means responsive to the called subscriber answering the signaling by removing his receiver from the switchhook for causing said signaling to cease, means for thereafter establishing a connection from the calling line to another called line through the same link, means operative during the establishing of said last-mentioned connection for signaling said first called subscriber if he has in the meantime replaced his receiver on the switchhook, means operative when the last-mentioned connection has been completed for signaling said second called subscriber, means responsive to the second called subscriber answering the signaling by removing his receiver from the switchhook for causing the signaling of both the first and the second called subscribers to cease.

4. In a telephone system, a cross-bar switch, subscribers' lines terminating in said switch, links terminating in said switch, means for establishing a connection between a calling line and a called line through a link and signaling the called subscriber, means responsive to the called subscriber answering the signal by removing his receiver from the switchhook for causing said signaling to cease, means for thereafter establishing a connection from the calling line to another called line through the same link, means operative while the second call connection is being made for signaling said first called subscriber if he has in the meantime replaced his receiver on the switchhook, means operative if the second called subscriber is found busy for causing said last-mentioned signaling of the first called subscriber to cease and a busy tone to be transmitted to the calling subscriber.

5. In a telephone system, a cross-bar switch, lines terminating in said switch, links terminat-



ing in said switch, means for establishing a connection from any calling line to any other line through an idle link, an allotter for said links, said allotter including a single relay for each link with a relay of a first idle link operated to effect the seizure of said link when a subscriber calls, and with the relay of the next idle link also maintained operated.

6. In a telephone system, a cross-bar switch, lines terminating in said switch, links terminating in said switch, means for establishing a connection from any calling line to any other line through an idle link, an allotter for said links for allotting succeeding idle links for use by calling subscribers in the establishing of connections, said allotter including a single relay for each link with two of said relays always operated if more than one link is idle.

7. In a telephone system, a cross-bar switch, lines terminating in said switch, links terminating in said switch, means for establishing a connection from one line to another line through an idle link, means for allotting said links for use in establishing connections between lines comprising a relay for each link, a common starter wire, and means for advancing said starter wire through operated contacts of said relays to a succeeding idle link when a preceding link is seized by a calling line through said starter wire.

8. In a telephone system, a cross-bar switch, lines terminating in said switch, links terminating in said switch, means for establishing a connection from any calling line to any other line through an idle link, an allotter for said links for allotting succeeding idle links for use by calling subscribers in the establishing of connections, said allotter comprising a common starter wire, a relay for each link, means for normally maintaining two of said relays operated for the advancing of said starter wire from one link to another, and circuit means controlled by said links for releasing a relay in the allotter when its associated link is taken for use and for operating the relay of the second next succeeding link if idle.

9. In a telephone system, a cross-bar switch, two types of subscribers' lines terminating in said switch, links terminating in said switch, trunks terminating in said switch, means for establishing a connection between a calling subscriber's line and a called subscriber's line of either or both types through a link, means for establishing a connection from a subscriber's line of a first type to a trunk, means for establishing a connection from a trunk to a subscriber's line of said first type, means for establishing a connection from a subscriber's line of a second type to a trunk under control of the subscriber of a line of the first type, means for establishing a connection from a trunk to a subscriber's line of the second type under control of a subscriber of a line of the first type.

10. In a telephone system, a cross-bar switch, two types of subscribers' lines terminating in said switch, links terminating in said switch, trunks terminating in said switch, means for establishing a connection between a calling subscriber's line and a called subscriber's line of either or both types through a link, means for establishing a connection from a subscriber's line of the first type to a trunk, means for establishing a connection from a trunk to a subscriber's line of said first type, means operative after a connection has been established between a subscriber's line of the first type and a subscriber's line of

the second type over a link for establishing a connection from said subscriber's line of the first type to a trunk, establishing a connection between said subscriber's line of the second type and said trunk, releasing said subscriber's line of the first type from said trunk and releasing said subscriber's line of the first type and of the second type from said link.

11. In a telephone system, a cross-bar switch, two types of subscribers' lines terminating in said switch, links terminating in said switch, trunks terminating in said switch, means for establishing a connection between a calling subscriber's line and a called subscriber's line of either or both types through a link, means for establishing a connection from a subscriber's line of the first type to a trunk, means for establishing a connection from a trunk to a subscriber's line of said first type, means operated after the connection has been established from a trunk to a subscriber's line of the first type for establishing a connection between a subscriber's line of the second type and said trunk and for releasing said subscriber's line of the first type from said trunk.

12. In a telephone system, a cross-bar switch, two types of subscribers' lines terminating in said switch, links terminating in said switch, trunks terminating in said switch, means for establishing a connection between a calling subscriber's line and a called subscriber's line of either or both types through a link, means for establishing a connection from a subscriber's line of the first type to a trunk, means for establishing a connection from a trunk to a subscriber's line of said first type, means operative under control of a subscriber of a line of the first type effective after a connection has been established between said subscriber's line of the first type and a subscriber's line of the second type over a link for establishing a connection from said subscriber's line of the first type to a trunk, establishing a connection between said subscriber's line of the second type and said trunk, releasing said subscriber's line of the first type from said trunk and releasing said subscriber's line of the first type and of the second type from said link.

13. In a telephone system, a cross-bar switch, two types of subscribers' lines terminating in said switch, links terminating in said switch, trunks terminating in said switch, means for establishing a connection between a calling subscriber's line and a called subscriber's line of either or both types through a link, means for establishing a connection from a subscriber's line of the first type to a trunk, means for establishing a connection from a trunk to a subscriber's line of said first type, means operative under control of a subscriber of a line of the first type effective after a connection has been established from a trunk to said subscriber's line of the first type for establishing a connection between a subscriber's line of the second type and said trunk and releasing said subscriber's line of the first type from said trunk.

14. In a telephone system, a cross-bar switch, subscribers' lines terminating in said switch, trunks terminating in said switch, links terminating in said switch, means for establishing a connection between a calling line and a called line through a link, a key for each trunk at each subscriber's station, means responsive to the operation of a trunk key of a subscriber's station for establishing a connection between said subscriber's line and a corresponding trunk through

said switch, means operative in response to a calling subscriber replacing his receiver on the switchhook and operating any trunk key for freeing his line from said connection, and means responsive to the calling subscriber hanging up his receiver for releasing said link.

15. In a telephone system, a cross-bar switch, subscribers' stations, a line from each station terminating in said switch, trunks terminating in said switch, links terminating in said switch, a key for each trunk at each subscriber's station, means for establishing a connection between a calling line and a called line through a link, means for releasing said connection control solely over the calling subscriber's line, means for freeing the called subscriber's line from said connection without releasing it operative by the called subscriber replacing his receiver on the switchhook and actuating any one of said trunk keys.

16. In a telephone system, a cross-bar switch, subscribers' lines terminating in said switch, trunks terminating in said switch, links terminating in said switch, means for establishing a

connection between two lines through a link, means for establishing a connection between lines and trunks without the aid of a link, means for releasing a connection between two lines under control of the call originating line only, means for freeing the called line from a connection to a calling line without releasing the calling line from the link used in the connection, said means including a part of the means used for establishing a connection from a line to a trunk.

17. In a telephone system, a cross-bar switch, lines terminating in said switch, links terminating in said switch, means for establishing a connection from one calling line to another line through a link, and means for establishing successively to a plurality of called lines a common conference connection from a calling line over a single link and for signaling over all previously connected called lines each time a succeeding called line is being connected to the conference connection.

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