

Jan. 4, 1938.

L. J. BOWNE ET AL
TELEPHONE SYSTEM

2,104,449

Filed Aug. 12, 1936

14 Sheets-Sheet 1

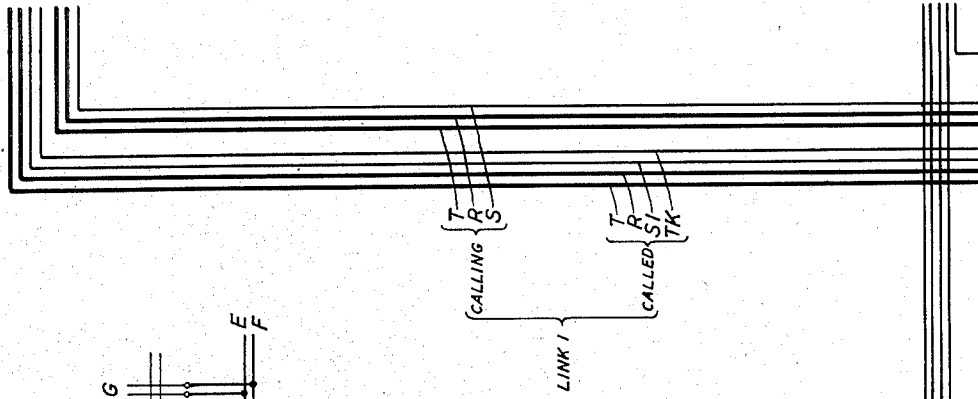


FIG. 1

FIGS. 1, 3 & 4	FIG. 8	FIG. 12	FIG. 16
FIG. 5	FIG. 9	FIG. 13	FIG. 17
FIG. 6	FIG. 10	FIG. 14	
FIG. 7	FIG. 11	FIG. 15	

FIG. 2

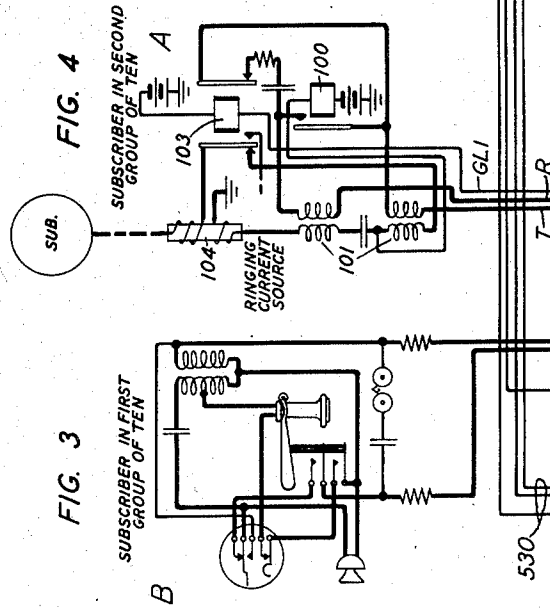


FIG. 4

FIG. 3

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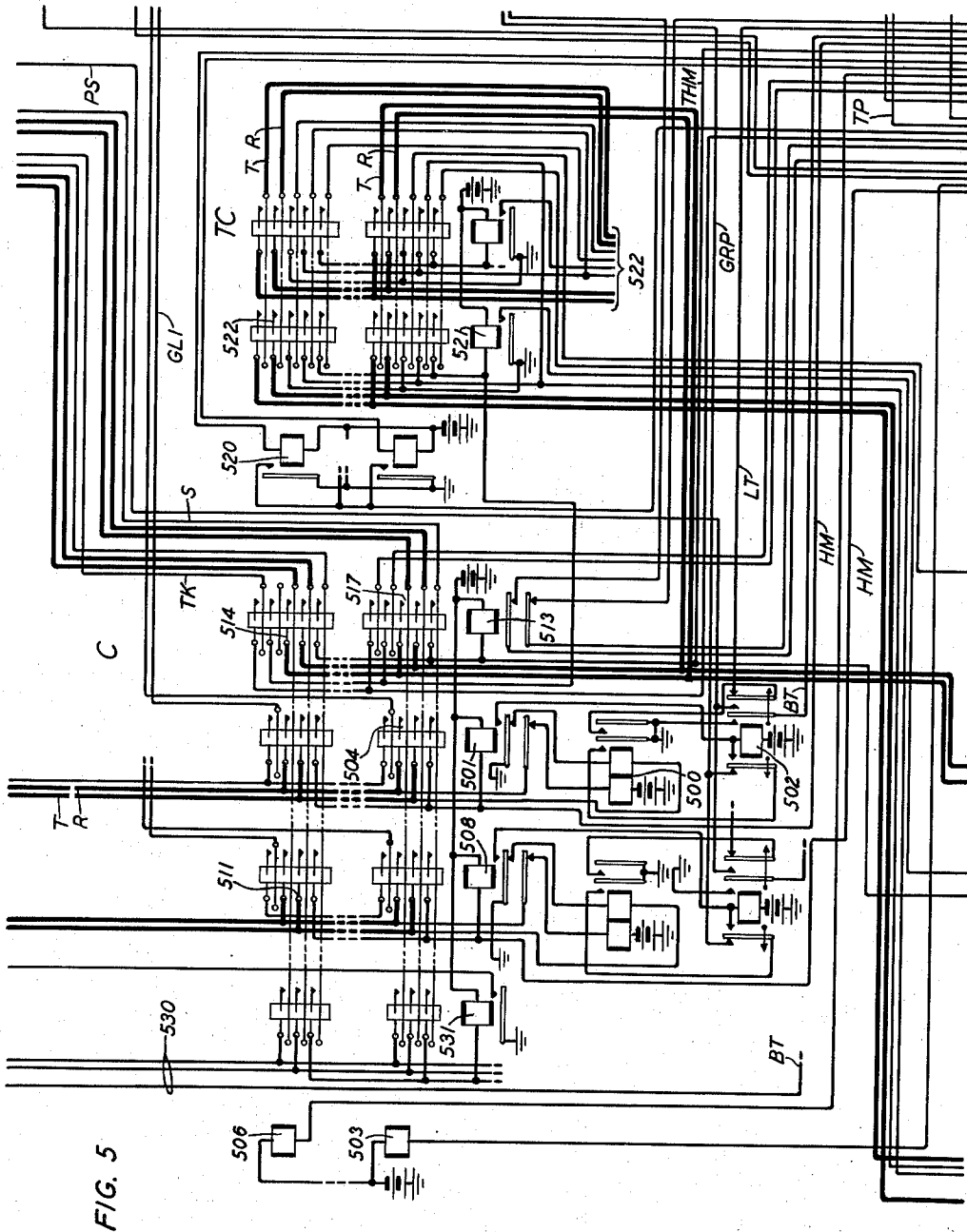
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14 Sheets-Sheet 2



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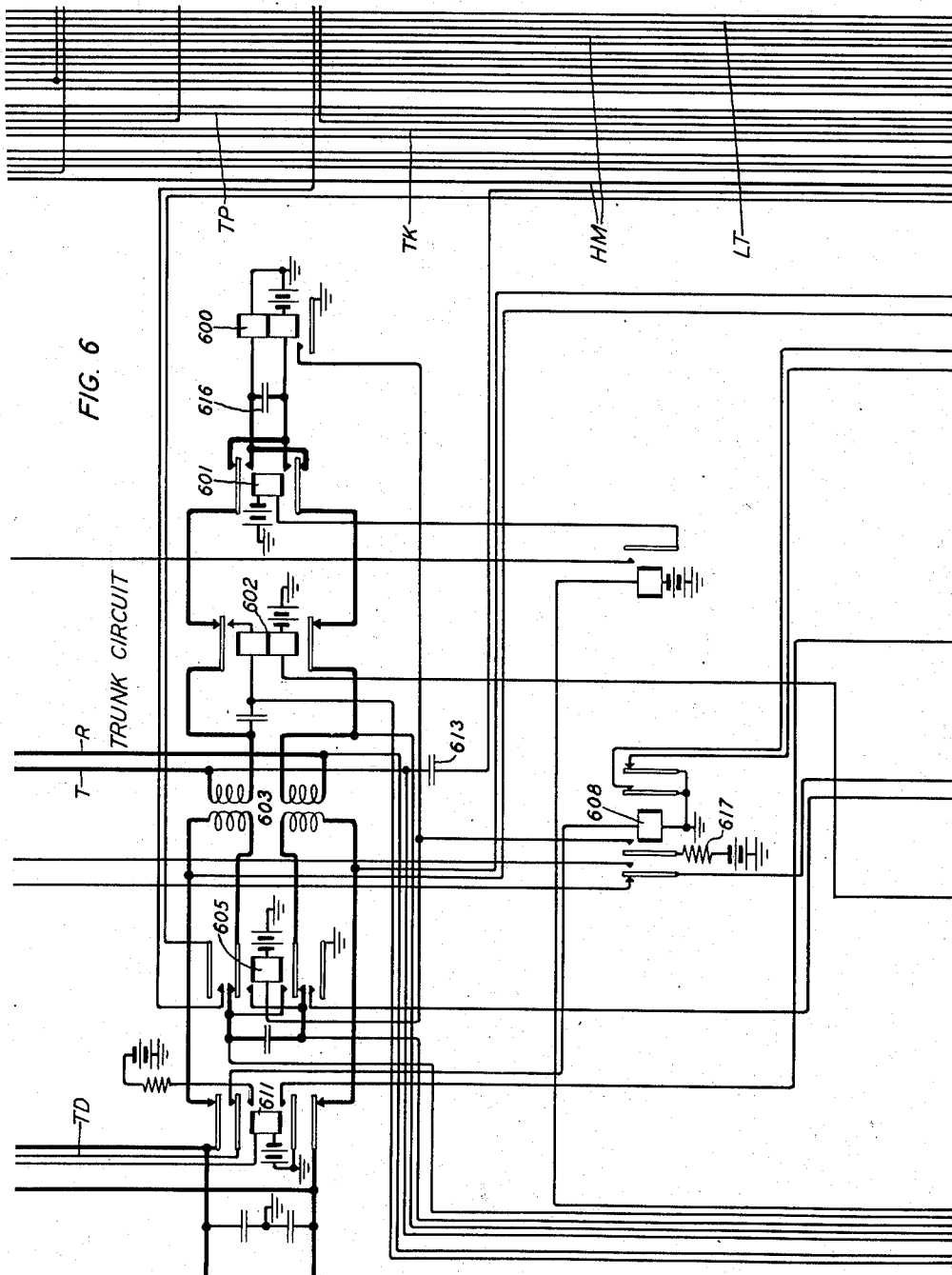
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TELEPHONE SYSTEM

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14 Sheets-Sheet 3



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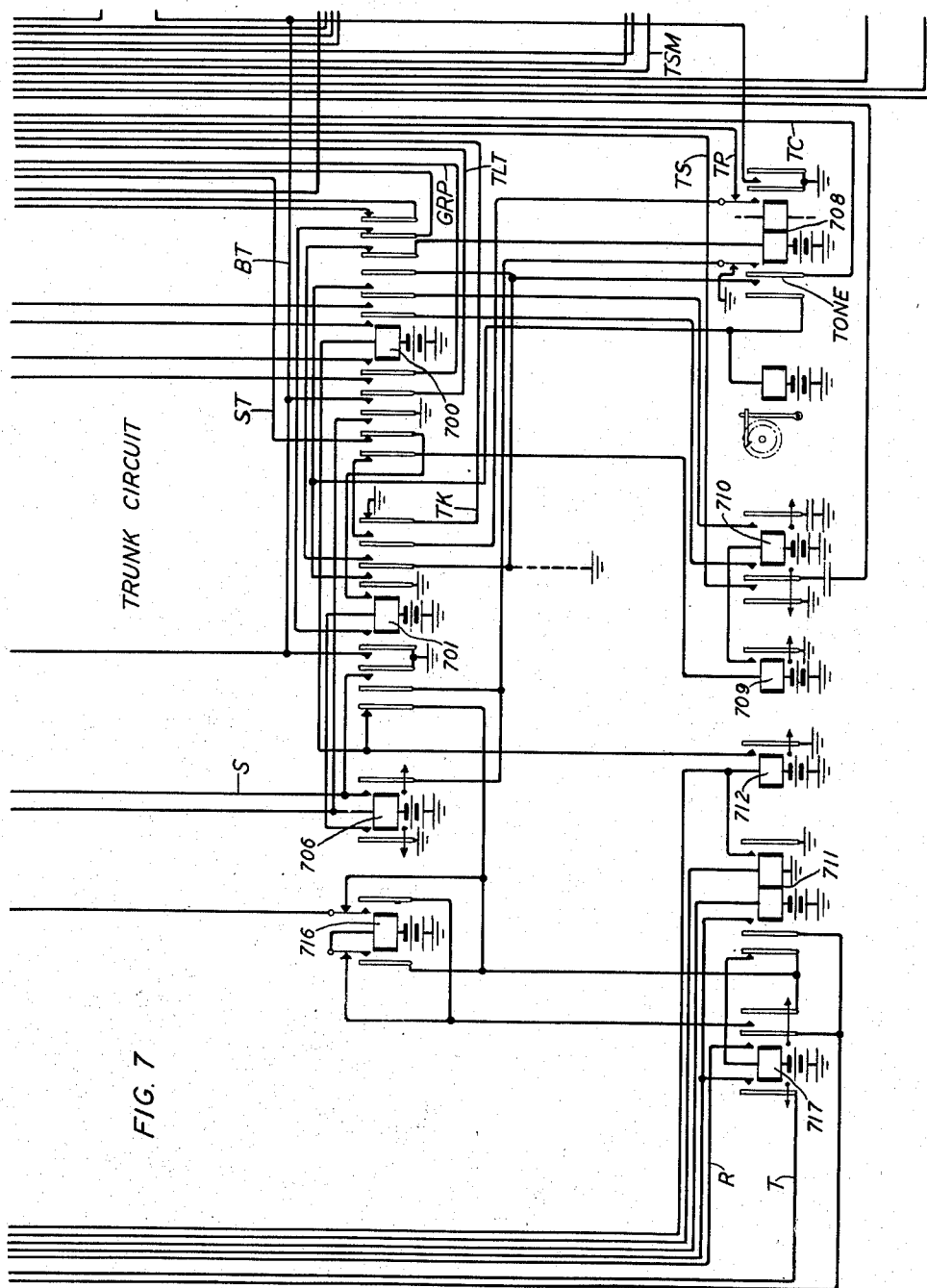
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14 Sheets-Sheet 4



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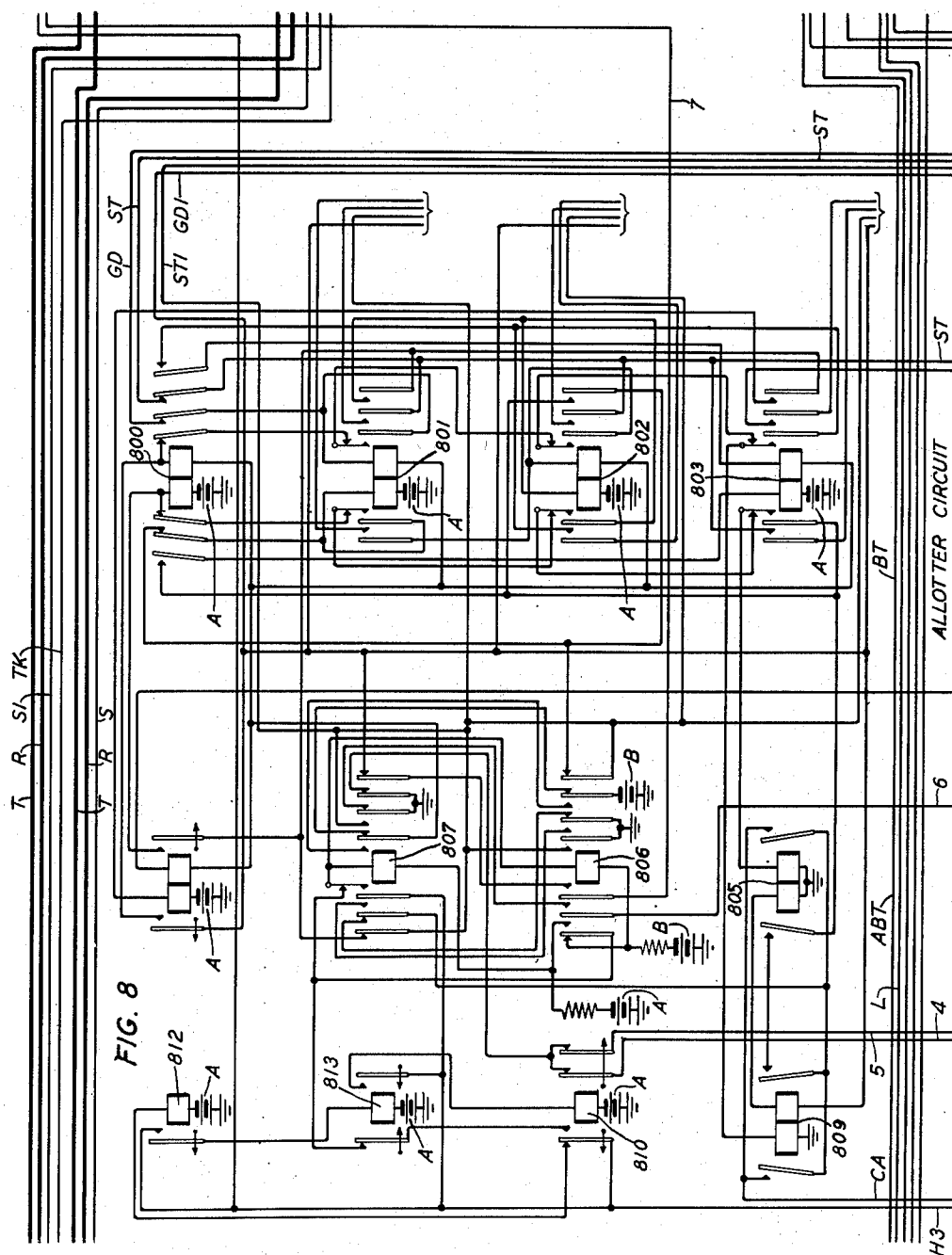
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TELEPHONE SYSTEM

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14 Sheets-Sheet. 5



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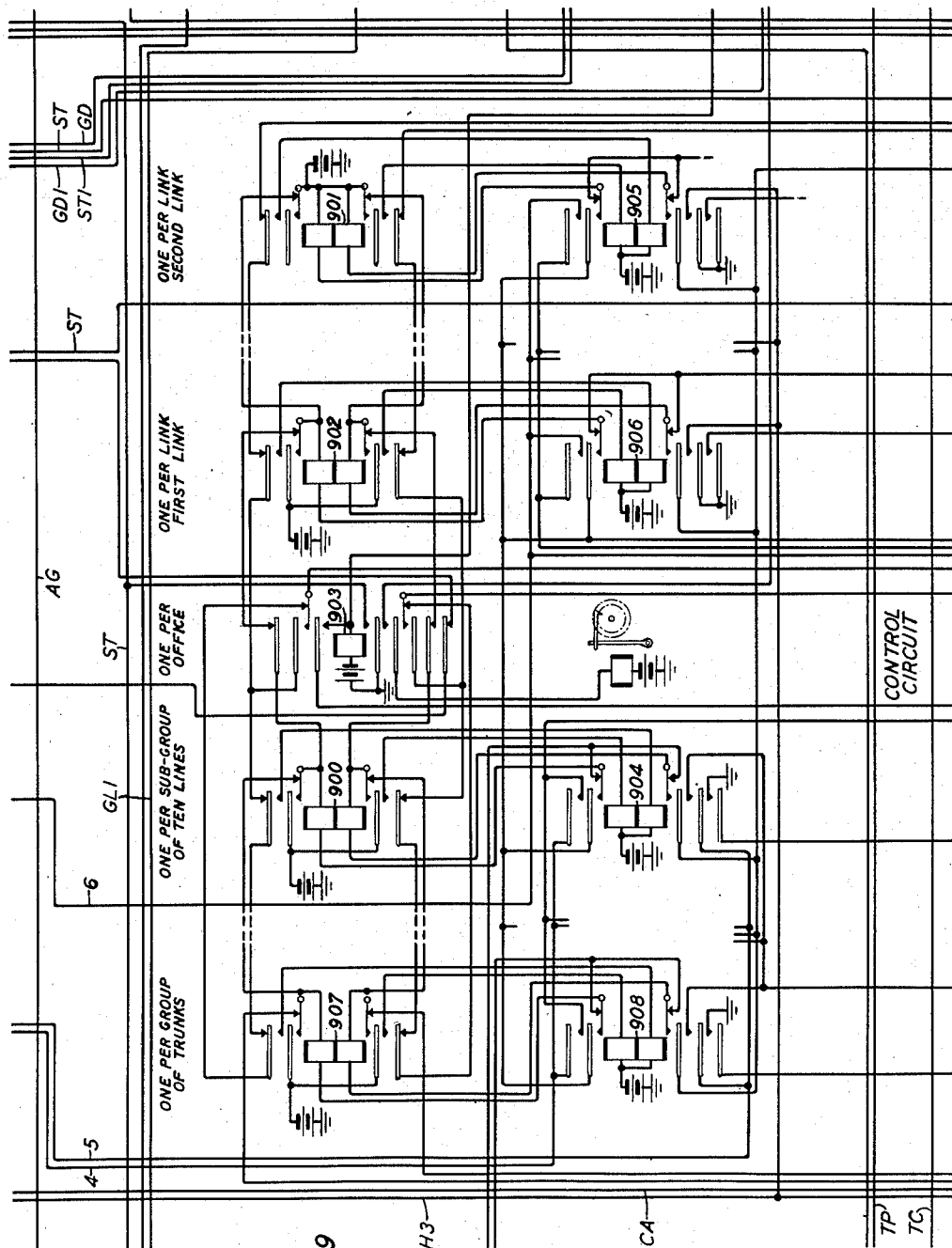


FIG. 9

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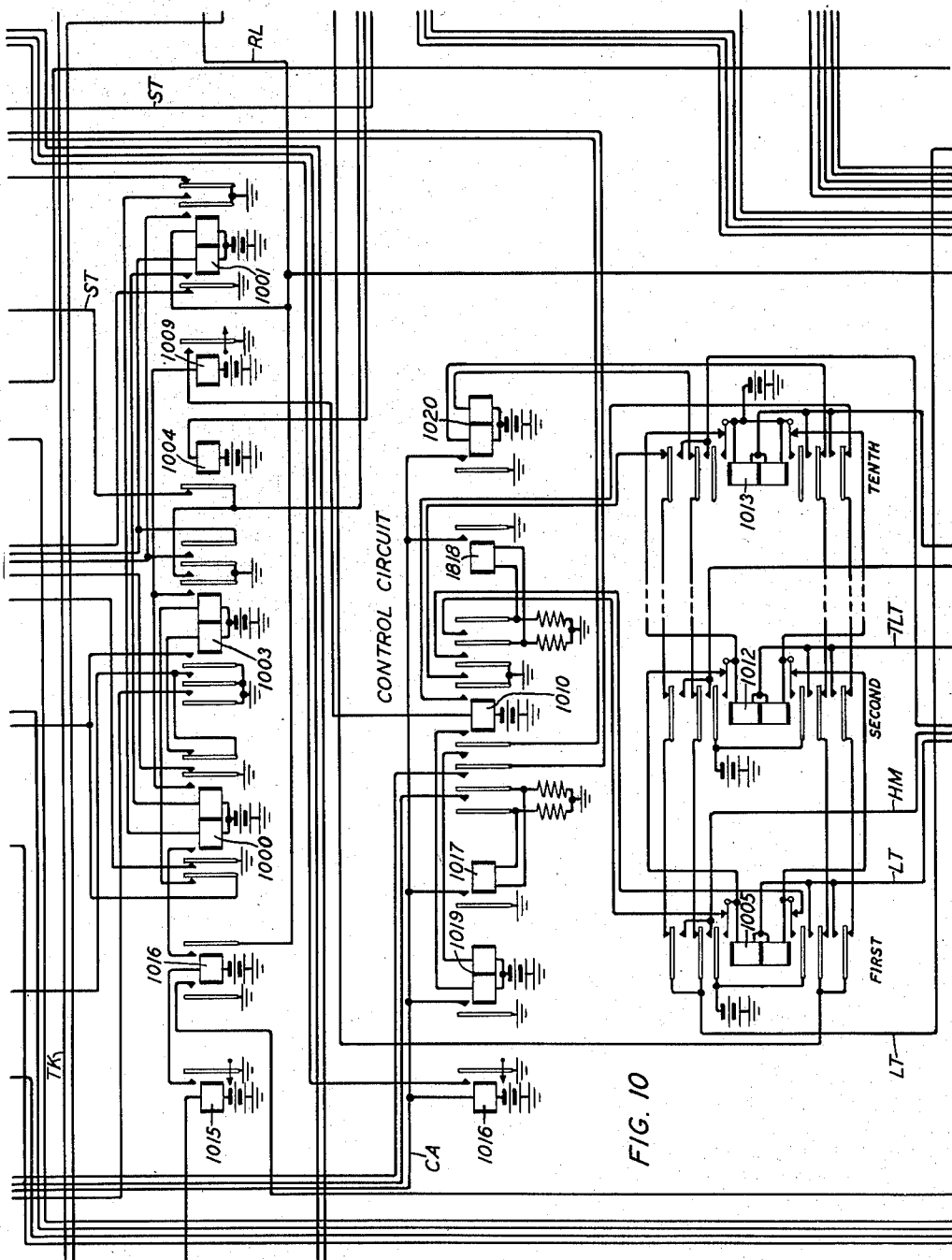


FIG. 10

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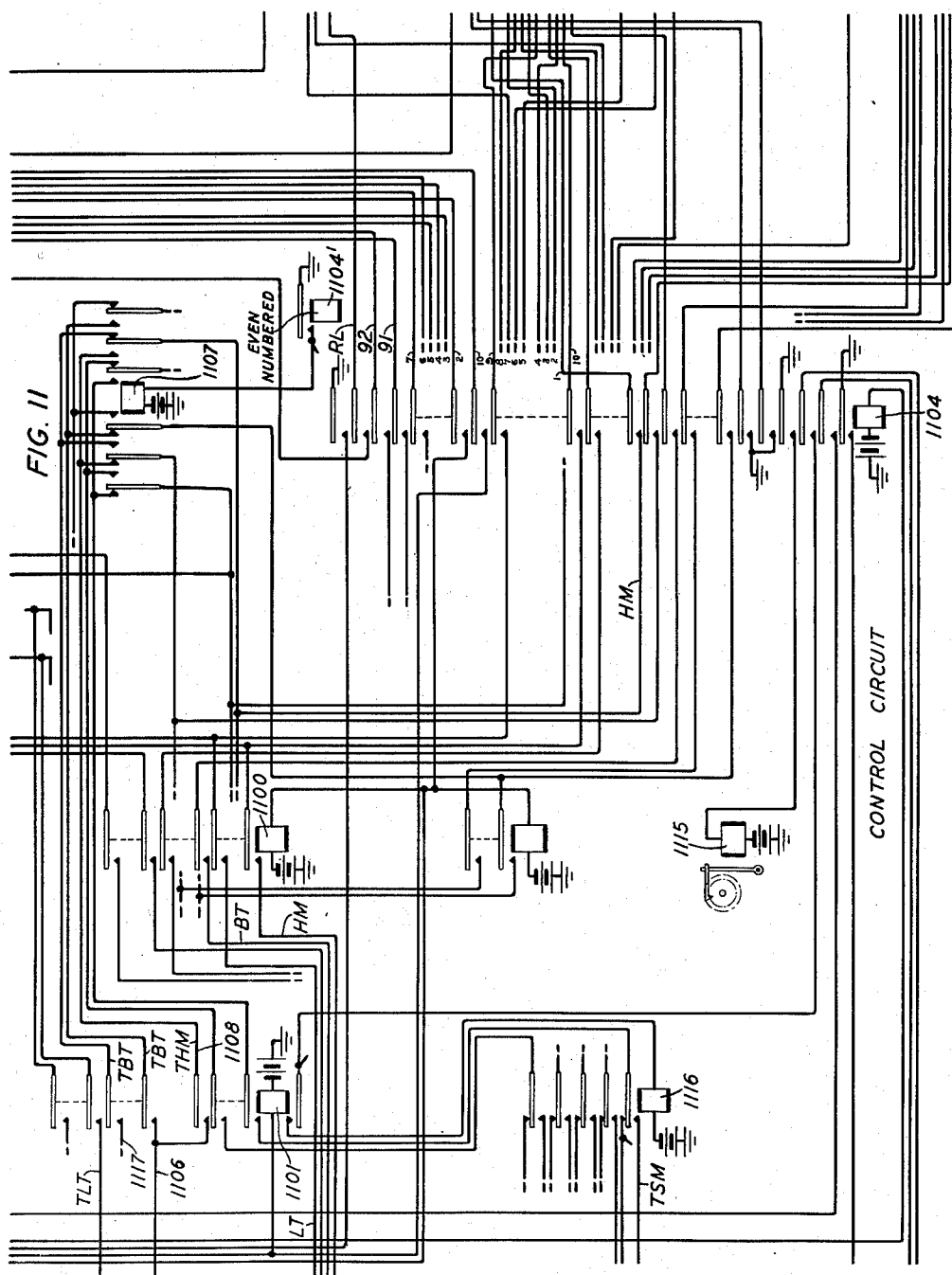
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TELEPHONE SYSTEM

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14 Sheets-Sheet 8



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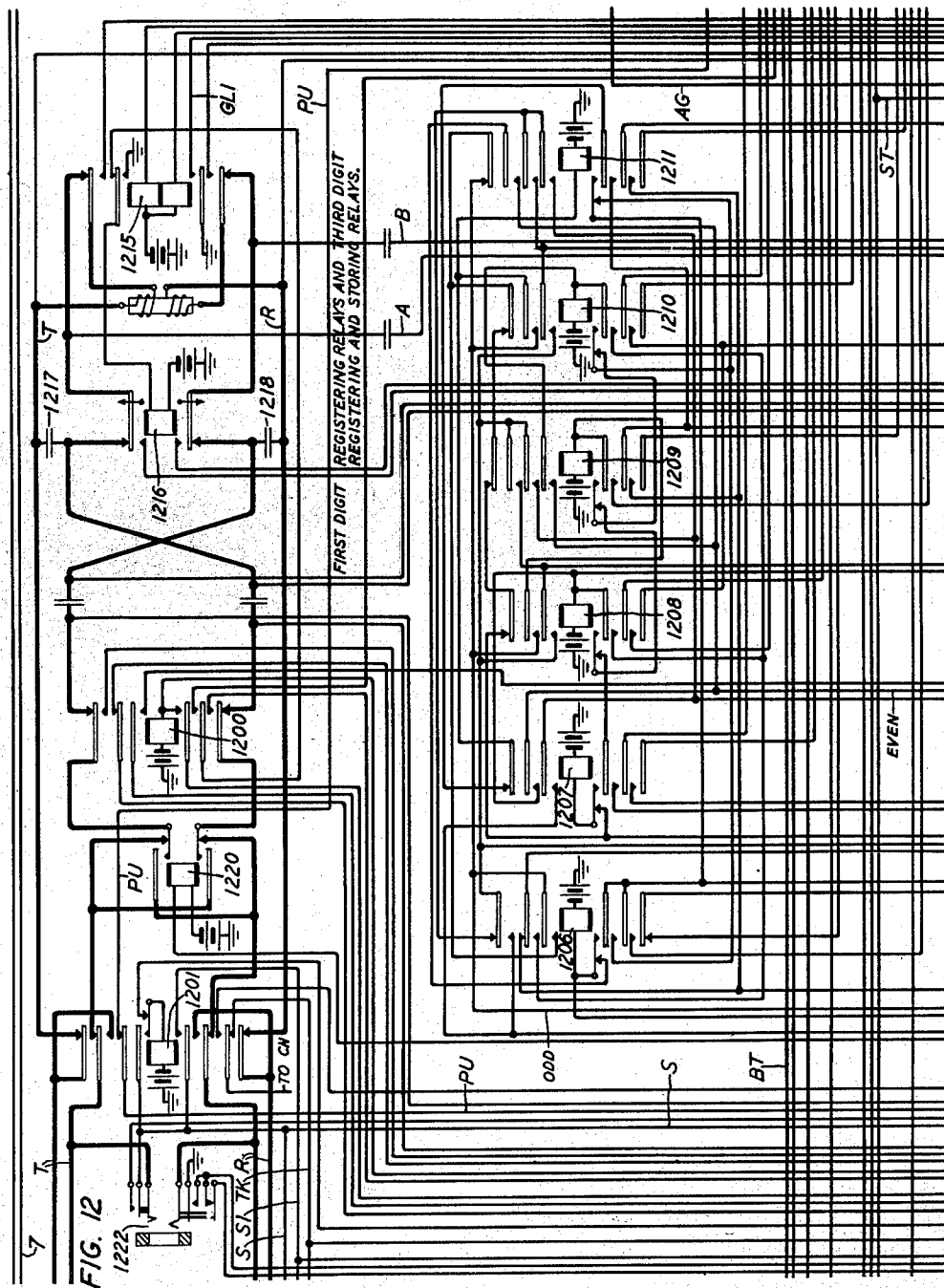
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14 Sheets-Sheet 9



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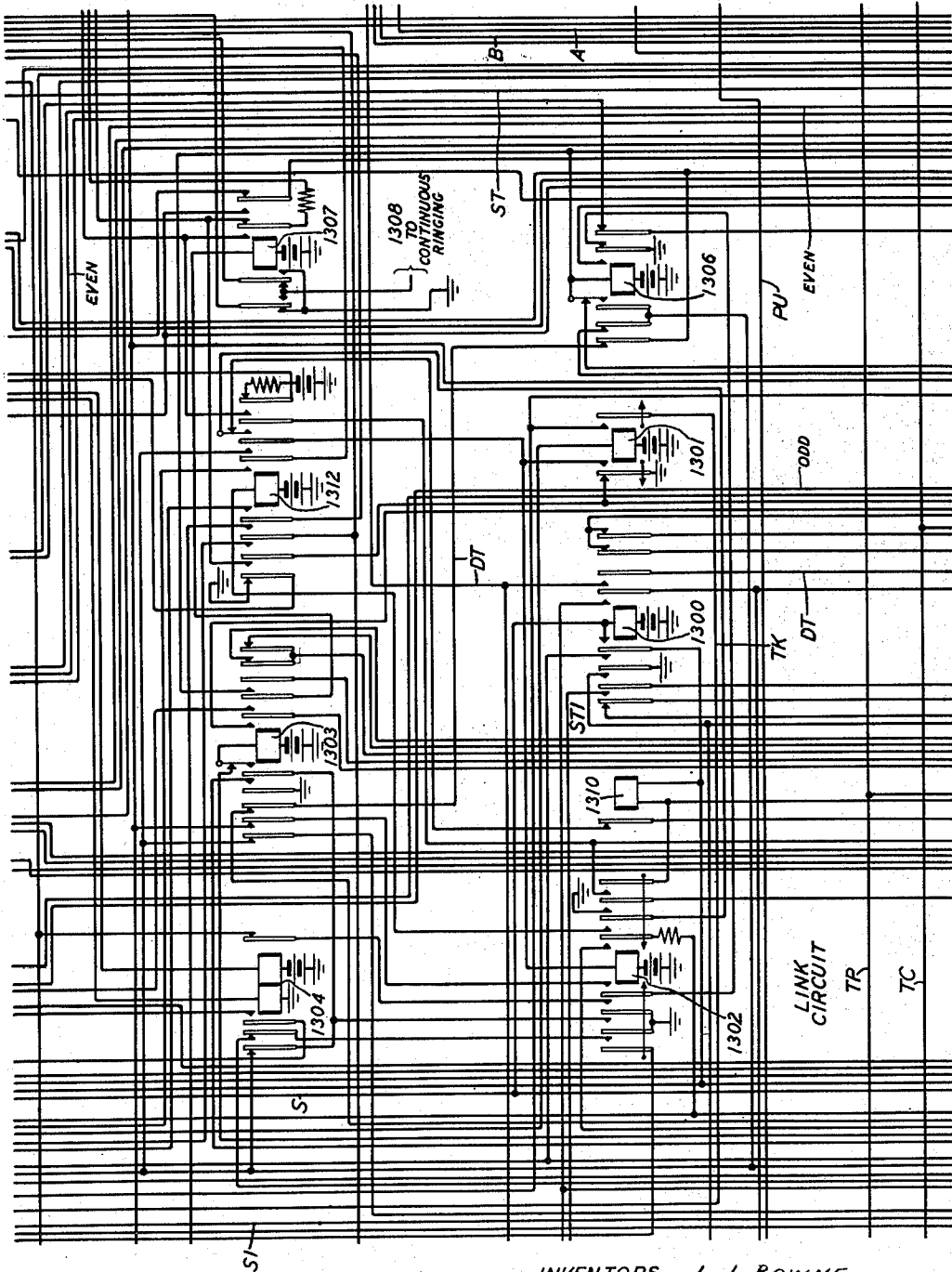
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TELEPHONE SYSTEM

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14 Sheets-Sheet 10



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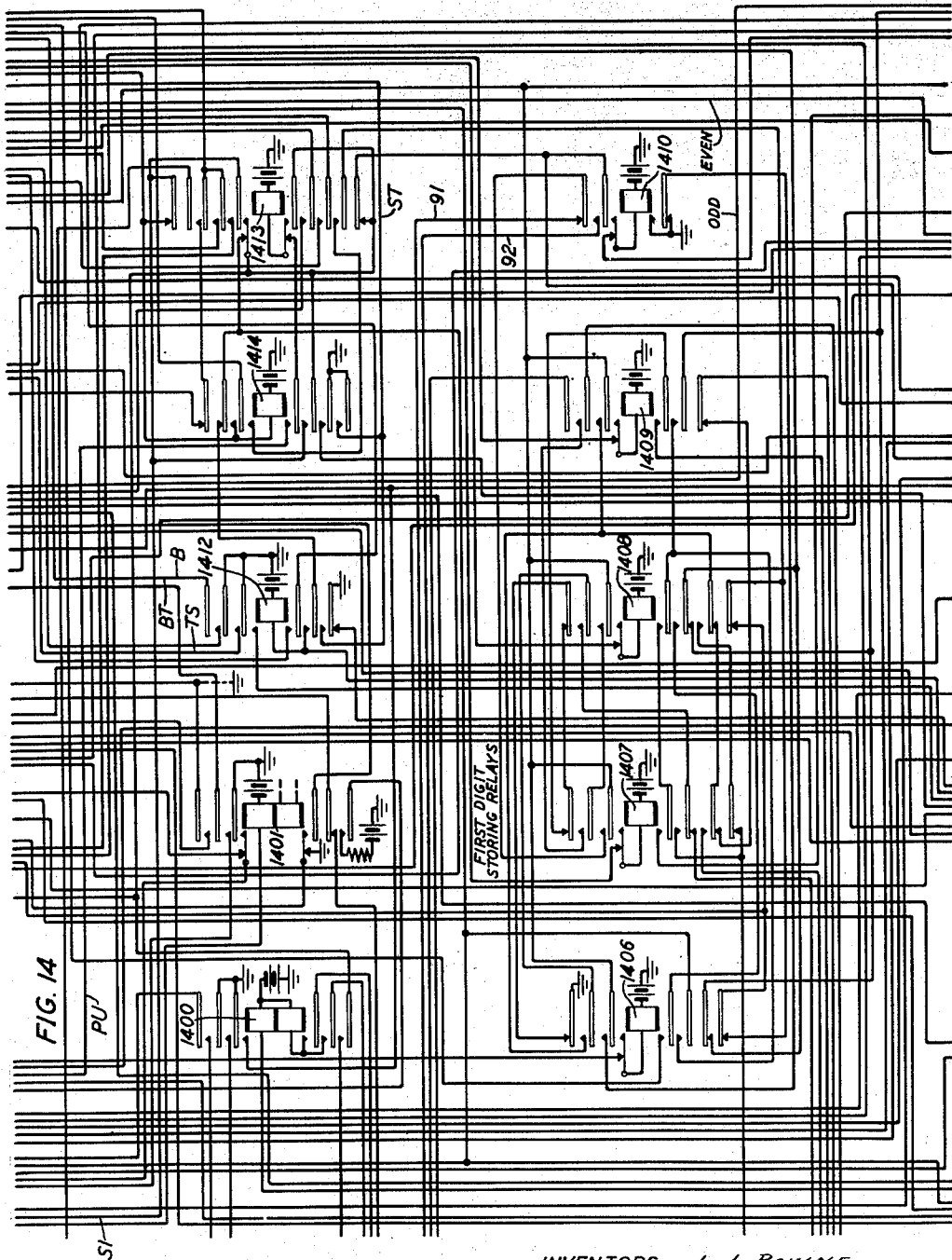
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TELEPHONE SYSTEM

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14 Sheets-Sheet 11



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TELEPHONE SYSTEM

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14 Sheets-Sheet 12

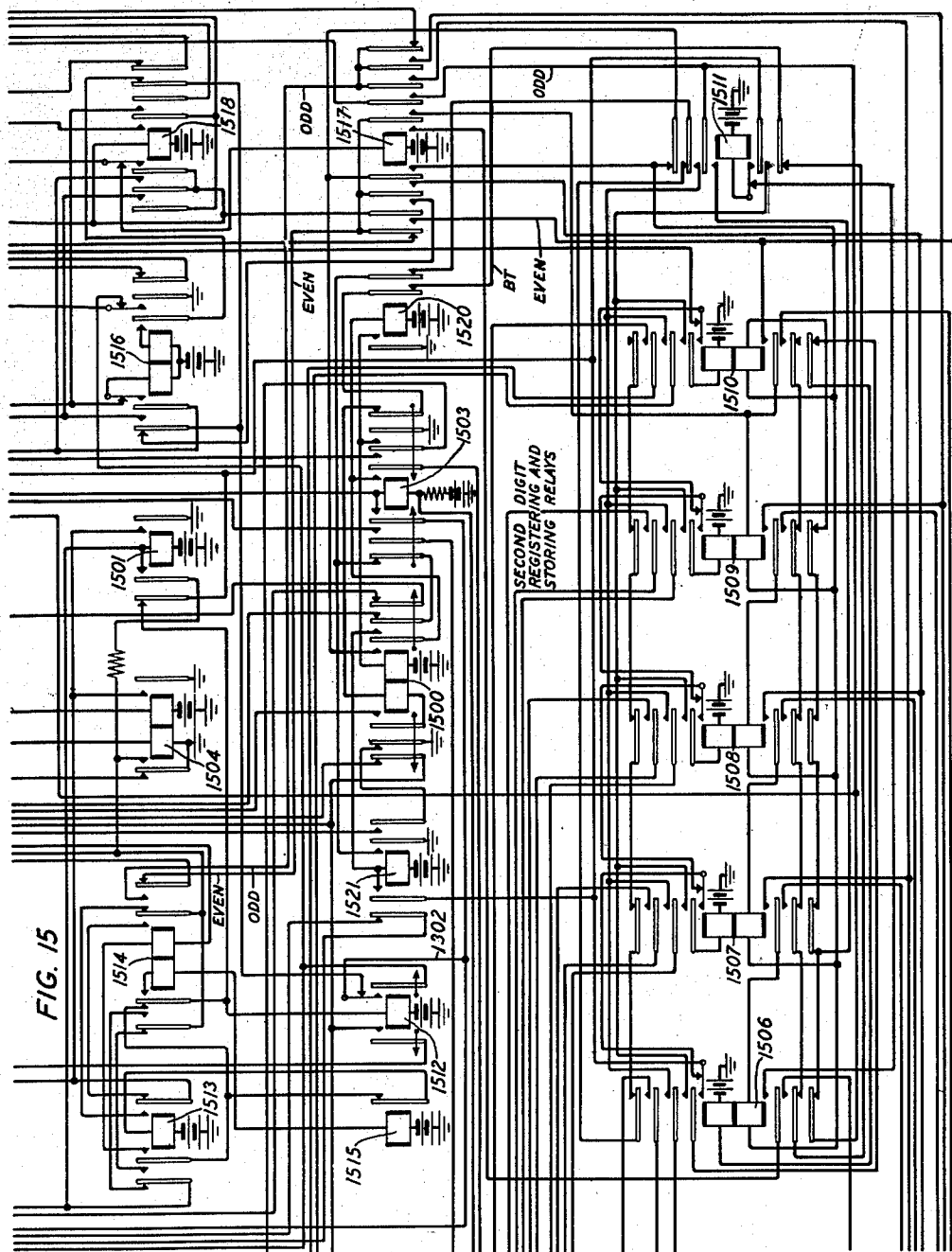


FIG. 15

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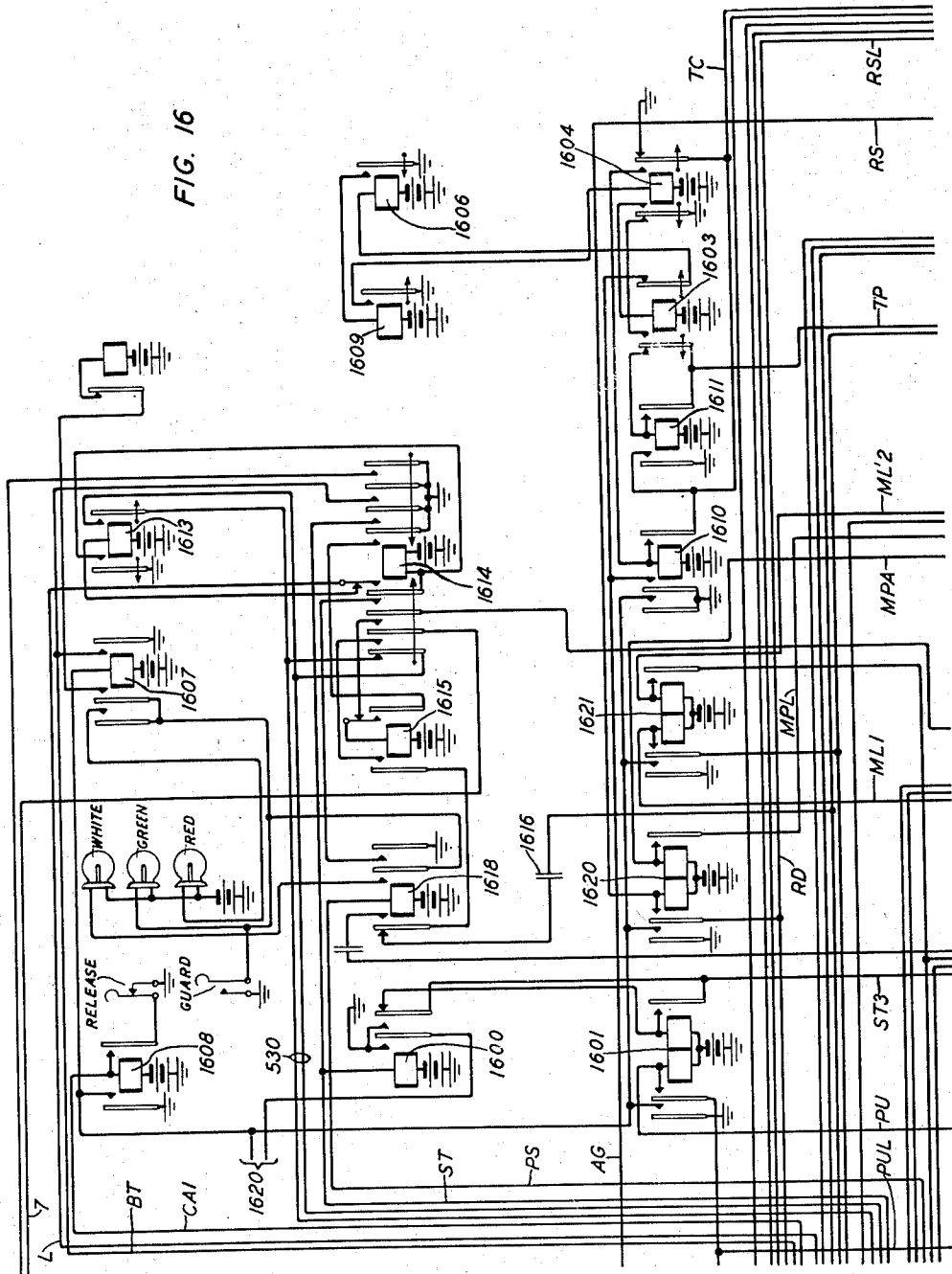
L. J. BOWNE ET AL
TELEPHONE SYSTEM

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FIG. 16



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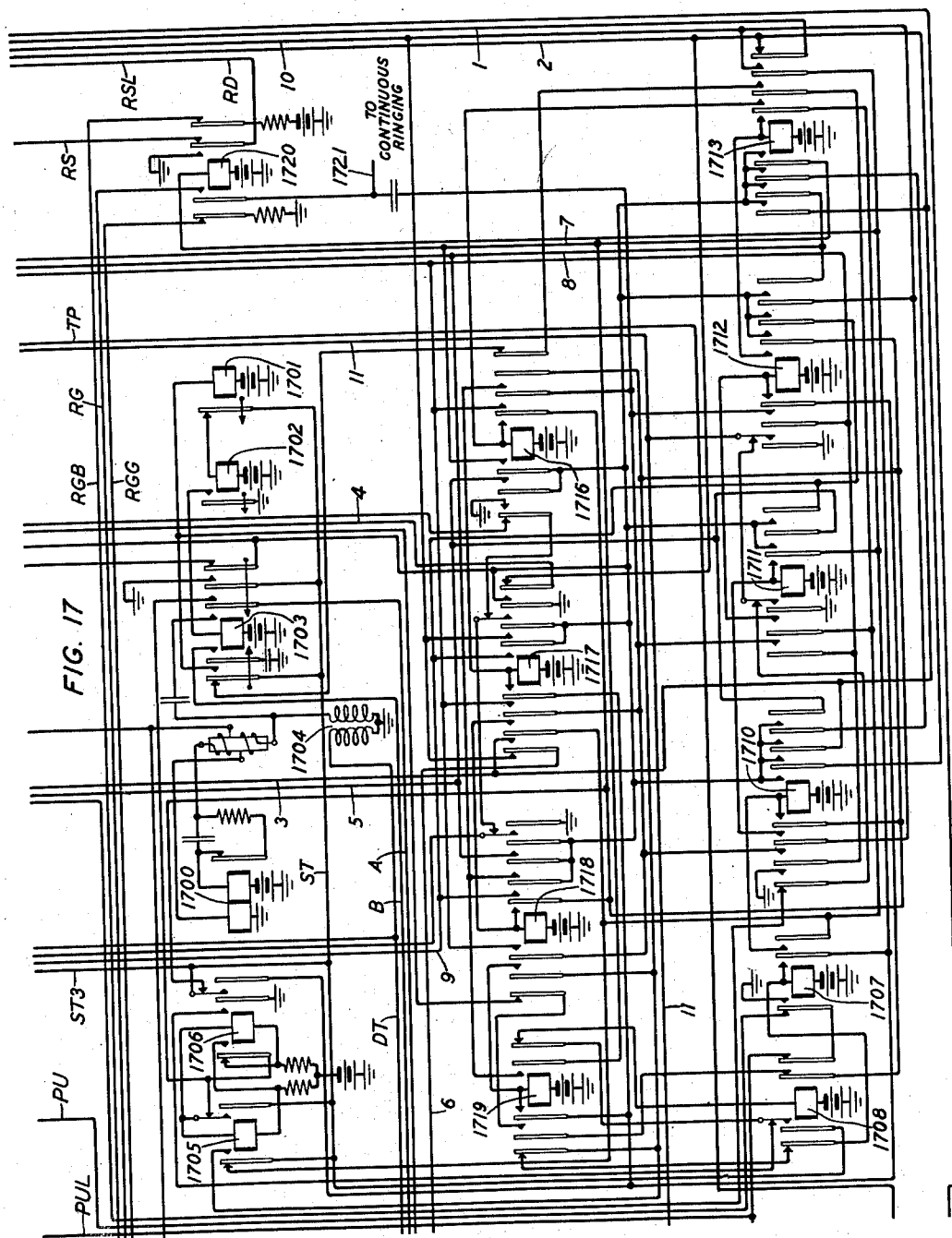
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UNITED STATES PATENT OFFICE

2,104,449

TELEPHONE SYSTEM

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Application August 12, 1936, Serial No. 95,530

19 Claims. (Cl. 179—18)

This invention relates to telephone systems and particularly to small capacity automatic telephone systems.

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

10 Heretofore systems have been provided in which connections may be extended from one subscriber's line to another over a cross-bar switch through a link circuit and in which the removal of a calling subscriber's receiver from the switchhook causes the calling line to be connected to one branch of a link circuit through the switch and the dialing of a called subscriber's number causes the called subscriber's line to be connected to the other branch of said link through the switch. A system of this type is disclosed in the patent to L. R. Waller 1,567,309 of December 29, 1925. Systems have also been provided in which in addition to connections between subscribers' lines, connections may also be extended from a subscriber's line to a trunk. A system of this type is disclosed in the patent to E. E. Hinrichsen 1,567,365 of December 29, 1925.

15 A feature of the present invention is an arrangement in a system of this general character in which a common control circuit is used for determining the progress of a call through the switch. This control circuit is seized when the calling subscriber removes his receiver from the switchhook and released when the calling line is connected to the link and again seized when the dialing of the called subscriber's number is completed and again released a short time thereafter. The release of the common control circuit the first time is controlled by the operation of a relay operated over a sleeve circuit established when a connection between the calling subscriber's line and the link is completed. The release of the control circuit the second time is controlled by the operation of another relay in case the called line is found idle and by the operation of a third relay in case the called line is busy on a call made to a subscriber of another line or on a call made to a called subscriber on the same line as the calling subscriber due to the busy condition of this line.

50 Another feature is an arrangement in which

connections may be established for tandem calls, that is, for a call incoming to the system over one trunk from a distant office and outgoing over another trunk to some other distant office. In this arrangement a special tandem cross-bar switch may be used exclusively for the establishing of tandem connections between trunks and to aid in the establishing of such through connections, temporary use is made of an idle link in the regular trunk and link connecting cross-bar switch.

10 In the system embodying the features of this invention, certain lines terminating therein have two conductors while others have but a single grounded conductor. In order to terminate the single-conductor lines with two conductors in the cross-bar switch in the same manner as the two-conductor lines, repeating coils are employed. The single conductor of a line is connected through the windings of one side of the repeating coil to ground and the windings of the other side of the repeating coil are connected in series to two conductors terminating in the cross-bar switch. It is a feature of the present invention to provide means for entirely eliminating the repeating coil from a single-conductor line when ringing out over such a line. When the ringing relay in the system is operated to apply ringing current it causes, over a special lead, the operation of a relay in the single-conductor line circuit. This relay disconnects the single conductor from the windings of the repeating coil and connects it to a ringing current source. This relay also opens an alternating current connection between the two windings of the other side of repeating coil and prevents a direct current connection from being closed between these windings. Thus, while the ringing relay connects the two conductors for the single-conductor line to a ringing current source, no ringing current can pass over these two conductors through the repeating coil and consequently cause no unnecessary drain on the ringing current source.

45 Another feature of the invention relates to the means for operating two sets of relays of the control circuit employed during the extension of a connection. One relay operates in each of these sets to mark a calling line and another 50

relay in one of said sets operates to mark the link used in the establishing of a connection. This means comprises two chain circuits for each set of relays with a fuse connected between each chain circuit and a single source of current. Each chain circuit of a pair is capable of operating said relays independently of the other but normally both chain circuits operate the relays. The chain circuits are so arranged with other relay combinations in the control circuit, that when a relay in a set is operated, the relays in said set located between said operated relay and the source of current are made inoperative while the remaining relays in the set are made ineffective in controlling the establishing of other connections during the establishing of the connection controlled by the operated relay.

Referring now to the drawings, Fig. 1 shows in diagrammatic form the arrangement in a small exchange of subscribers' lines and trunks in the system embodying the applicants' invention.

Fig. 2 shows the arrangement of the succeeding Figures 3 to 17 for the reading of the drawings. These Figures 3 to 17 show a complete system embodying the applicants' invention. Figs. 3 and 4 show two types of subscribers' lines. Fig. 5 shows the cross-bar switches and their selecting and holding magnets used in this system. Figs. 6 and 7 show various details of a trunk circuit. Fig. 8 shows an allotter circuit for link circuits. Figs. 9, 10 and 11 show a common control circuit. Figs. 12, 13, 14 and 15 show the details of a link circuit used for establishing a connection between lines or trunks. Figs. 16 and 17 show the details of a ringing equipment, tone, timing and alarm signal circuits required in this system.

Referring now particularly to Fig. 1, connections may be established between subscribers' lines A and B through the cross-bar switch C over a link in group D serving the switch C. The connection is established from the calling line A by the seizure of one end of an allotted link and the subscriber of the calling line then dials for the desired subscriber's line and operates switch C to connect the desired line to the other end of this link. Cross-bar switches of any well-known type may be used in which the operation of a horizontal and a vertical bar causes a connection between circuit contacts at the intersecting point. Connections may be made from a subscriber's line to a trunk E or F outgoing from the exchange or from a trunk E or F to a subscriber in the exchange and may be established in the same manner as between the two subscribers' lines, while a tandem connection may be made through the exchange from, for example, trunk E to trunk F through the cross-bar switch G. In this case the switch C and a link circuit are temporarily used during the establishing of the connection which is then transferred to switch G. Calls such as outlined above will now be traced in detail in the following description in connection with Figs. 3 to 17.

The first connection that will be described is from the subscriber of the line A to the subscriber of the line B in the exchange. The line A is a grounded return single-conductor line and the subscriber's set has been shown merely by a circle. When the subscriber of this line removes the receiver from the switchhook a circuit is completed for the operation of relay 100 from battery, winding of this relay, lower left-hand winding of repeating coil 101, contacts of relay 103,

upper winding of retardation coil 104 to the subscriber's set to ground. This causes the operation of relay 100 which closes a connection over the tip and ring conductors of the line for the line relay 500 from battery, left-hand winding of this relay, contacts of the holding magnet 501, ring conductor, the upper right-hand winding of the repeating coil 101, contacts of relay 100, lower right-hand winding of the repeating coil 101, the tip conductor, right-hand winding of the line relay 500, contacts of holding magnet 501 to ground. The line relay 500 closes a connection to ground for the GRP and LT leads. It should be observed that the relay 500 closes a circuit for relay 1005 over lead LT when relay 1100 is operated as hereinafter described, from battery, make-before-break contacts of relays 1013, 1012 and 1005, windings of relay 1005, contacts of relay 1100, lead LT, contacts of relays 502 and 500 to ground. This relay 1005 represents the first subscriber in a group, that is in this case, the subscriber of line A, to the control circuit in Fig. 9. The ground on the GRP lead causes the operation of relay 900 from battery make-before-break contacts of relays 901 and 902, contacts of relay 903, windings of relay 900, make-before-break contacts of relay 904 to the GRP lead, contacts of relay 502 to ground at contacts of line relay 500. It should be observed at this time that in the part of the control circuit shown in Fig. 9 a number of sets of group relays are shown, of which relays 901 and 905 are provided for a link (not shown) relays 902 and 906 are provided for the first link shown in detail in Figs. 12 to 15, relay 903 is provided for the whole exchange, relays 900 and 904 are provided for the particular group of ten lines in which the calling line is located and relays 907 and 908 are provided for a particular group of trunks. Other relays may be supplied in the connections between relays 900 and 904 on the one hand, and relays 907 and 908 on the other hand for additional group relay sets for other groups of lines and trunks, and between relays 902 and 906 on the one hand and relays 901 and 905 on the other hand for additional relay sets for other links. Relay 900 is locked from battery through its windings and its inner upper and lower armatures and contacts over lead GRP to the ground at line relay 500 independent of the battery at the make-before-break contacts of relay 901. Relay 904 now operates from battery, windings of this relay, outer upper and lower armatures and front contacts of relay 900 through intermediate relays (not shown), outer upper and lower armatures and contacts of relay 907, make-before-break contacts of relay 903, inner left-hand and right-hand armatures of back contacts of relay 1000 to ground in Fig. 10. Relay 900 in operating also disconnects ground from the armatures of the group relays towards the right such as 905 and 906 and other associated corresponding relays and disconnects battery from the armatures of the group relays towards the left such as relays 907 and other relays of that kind so as to prevent any of these relays from becoming effective while the control circuit is engaged in this call due to the operation of relays 900 and 904. If a relay such as 902 operates it is ineffective as the associated relay 906 cannot operate as the ground is disconnected by relay 900 and a relay such as 907 cannot operate as the battery is disconnected by relay 900. The operation of the relay 904 provided a path for locking the relay 900 independently of the ground

on the GRP lead, the locking circuit extending from battery, the operated armatures and front contacts of relay 900 and its windings, upper and lower inner armatures and front contacts of relay 904, contacts of relay 1001 to ground.

In Fig. 11 there is a relay 1100, which is provided for the particular group of subscribers' lines in which the calling line A is located and similar relays are provided for other groups but not shown. It may be mentioned here that there is also one similar relay provided for each group of trunks, only one of which has been shown. This relay is numbered 1101 and represents the group of trunks of which the trunk shown in Figs. 6 and 7 is one. Upon the operation of relay 904 the circuit is completed for the relay 1100 from battery, winding of this relay, contacts of relay 904 to ground. It should also be observed that in the allotter circuit shown in Fig. 8 there is one relay provided for each link, relay 800 for the first link, 801 for the second, 802 for the third and 803 for the fourth link, this circuit being provided with only four links. If the allotter circuit is normal and the first link circuit which has been shown in Figs. 12 to 15 is idle relay 800 is operated and maintained operated over a locking circuit from battery, its left-hand winding, inner left-hand armature and front contact, left-hand make-before-break contacts of relays 801, 802 and 803, right-hand winding of relay 805 to ground and another locking winding from battery at the third outer right-hand armature and back contact of relay 806, inner right-hand armature and back contact of relay 807, right-hand winding of relay 800, inner right-hand armature and front contact of this relay, right-hand make-before-break contacts of relays 801, 802 and 803, left-hand winding of relay 809 to ground. Relays 805 and 809 are therefore also operated at this time. As soon as relay 904 operated a circuit was closed for the operation of a start relay 1003 in the control circuit from battery, windings of this relay, contacts of relays 1000, 904, 810 and 807 to ground. Relay 1003 provides a locking circuit over its left-hand winding, contacts of relay 1000, and its second left-hand armature and front contact to ground. Relay 1003 now closes a circuit for the start lead ST to seize the first link by the operation of relay 1400. The circuit for relay 1400 may be traced from battery, upper winding of this relay, contacts of relays 1500, 1300 and 1401, the start lead ST through contacts of relays 800 and 1004 to ground at contacts of relay 1003. It should be observed at this time that there are duplicate sets of circuits for the operation of relays, 800 to 803, 907, 900, 902, 901, 1005, 1012 and 1013 and other relays. The batteries marked A are in reality a single battery with a fuse not shown between it and the various circuits and similarly the batteries marked B are a single battery with a fuse not shown between it and its various circuits. The purpose of these circuits through duplicate windings and contacts is to prevent breakdown of the circuits of these important relays. For example, if a false ground occurs in one of the battery chains thus blowing the fuse connected at the source as described, the relays in the chain will nevertheless operate on the other winding from battery through the other fuse. In case a false ground occurs on one of the ground chains the circuits will function normally when calls come in. Under all of the above conditions the circuits are arranged to detect these

conditions. Figs. 16 and 17 show such detection or alarm circuits. Therefore, if, for example, one of the chain circuits is opened for the allotter relays, the relay 809 or 805, as the case may be, will release when one of the relays 800 to 803 operates. This connects ground to the lead CA causing the operation of relay 1016, this relay in turn closing a circuit over the CA1 lead for the operation of relay 1608 which locks under the control of the release key and causes the operation of relay 1607. This relay closes partially the circuit for the buzzer and the red lamp shown in Fig. 16. When this condition is to be ascertained the guard key is operated and the green and red lamps light steadily to indicate this condition. Also in case a false ground appears on the battery chain of relays 907, 900, 903, 901 or 1005, 1012 and 1013, the operation of relay 1010 as described will connect the relay 1017 or 1018 to the chain contacts for these groups of relays, respectively. Then when the relay 1001 is operated at the end of a call, as will be described hereinafter, the particular relay operated in each chain circuit releases and if no other call is waiting battery will be connected directly to one end of the winding of the relay 1017 or 1018 through the ground chain circuit and this relay will then operate over a circuit in series with the resistance to ground as shown. Relay 1017 or 1018 operates the relay 1016 and an indication is given as usual. Similarly, if a ground chain is open for one of these groups of relays, or, if at the end of the call the normal ground applied by relay 1001 is removed and relay 1019 or 1020 will operate, as normally when relay 1010 is operated, these relays are connected differentially to the ground chain circuit. Relay 1016 will then operate to give the indication as usual. The circuits of the allotter are so arranged that if for any reason the start wire ST is not advanced properly an emergency path for advancing it under control of the relays 812, 813, 810, 807 and 806 is provided. At the time the control circuit grounds the ST lead by the operation of relay 1003, ground is also connected to lead H3 which operates relay 812. This relay in turn operates relay 813. The operation of relay 813 operates the relay 810 which releases relay 812. The release of relay 812 releases the relay 813 which operates the relay 807 over a circuit from battery through the winding of this relay and its make-before-break contacts, contacts of relay 813 and operated contacts of relay 810 to ground on lead H3. Relay 813 also opens the circuit for relay 810 which releases slowly to permit the above circuit for relay 807 to be closed. The operation of relay 807 disconnects battery from the primary or right-hand windings of the relays 800, 801, 802 and 803 and disconnects ground from the right-hand armature of relay 825 and armatures of relay 809. This relay also closes an obvious locking circuit for itself over lead H3 at its inner left-hand armature and front contact and disconnects ground from the leads 4 and 5 to prevent the control circuit from being seized. This relay also connects ground to contacts of the even numbered relays, such as 800 and 802. If, for example, relay 802 is operated, the ground from relay 807 will operate the next relay 803 from ground at relay 807, contacts of relays 806, 803 and 800, through the left-hand winding of relay 803 to battery. Relay 803 will operate and lock as usual and release relay 802. The release of relay 810 removes the short circuit from relay 806 which now operates from battery through a resistance, its winding, contacts of

relay 807 to ground on lead H3. The operation of relay 806 connects battery to the right-hand windings of relays 801, 802 and 803 and prepares a path for grounding leads 6 and 7 to the control circuit to release it by operation of relay 1001 in case it has failed to operate. It also connects ground through contacts of relay 807 to the right-hand armature of relay 805 and the armatures of relay 809. Relay 806 also disconnects the ground from the contacts of the even numbered relays 800, 802. The release of relay 810 also reoperates the relays 812, 813 and 810 which repeat the cycle of operations as previously described. The release of the relay 813 short-circuits the relay 807 which now releases. The release of relay 807 disconnects battery from the right-hand windings of relays 801, 802 and 803 and disconnects ground from the right-hand armature of relay 805 and the armatures of relay 809. It also connects ground to the odd numbered relays 801 and 803 and connects ground to the leads 4, 5 and 6 to the control circuit. If any of the numbered relays 800 or 802 were operated this ground from relay 806 will operate the succeeding even numbered relay, for example, if relay 801 were operated, relay 802 will operate from battery through the left-hand winding of this relay, contact of relay 801, contacts of relays 808 and 806 to ground. This relay then locks and releases the preceding relay 801. Thus this emergency circuit will be advanced to the start wire to select the succeeding link regardless of the regular advancement of this wire. Returning now to the operation of relay 1400, this relay closes a locking circuit for itself from battery, the lower winding, second lower armature and front contact to ground at the relay 1003. This relay also closes a circuit for the relay 1004 from battery to the winding of this relay, lower inner armature and front contact and second lower armature and front contact to the ground at contacts of relay 1003. Relay 1400 in operating opens the start circuit. Relay 1400 further closes a circuit for the select magnet 503 for the first link from battery, winding of magnet 503, contacts of relay 1400 to ground and a circuit for the operation of relay 1501, from battery, winding of this relay, contacts of relays 1300 and 1400 to ground. Relay 1501, in turn, closes a circuit for the operation of relay 1301 from battery, winding of this relay, contacts of relay 1200, contacts of relay 1501 to ground. Relay 1301 closes an obvious circuit for the operation of relay 1302. Relay 1302 closes a circuit for a dial tone to be transmitted over lead B to the calling subscriber's line from coil 1704 over lead DT. Coil 1704 receives dial tone from relay 1700 which is given a buzzing action by the circuit from ground contacts of relay 1306, 1302, 1393, relay 1700 to battery. The dial tone circuit will not be closed until relay 1300 is operated as hereinafter described. This circuit will then extend from coil 1704, the DT lead, contacts of relays 1300, 1516, 1303, 1306 to the B lead. Relay 1302 in turn closes a circuit for relay 1503 from battery, a resistance, winding of this relay, contacts of relays 1303, 1304 and 1302 to ground. Relay 1503 closes a circuit for the holding magnet 501 to connect through contacts 504 of switch C the calling line to the first link. The circuit for the holding magnet extends from battery, winding of magnet 501, the HM lead, contacts of relays 1100 and 1005, and the LT lead, contacts of relays 1503, and 1400 to ground. Magnet 501 closes an obvious circuit for the operation

of relay 802 and relay 800 is released. The grounds for the GRF and LT leads are removed and a ground applied on the BT lead to make this line busy. Relay 802 in operating closes a circuit for the permanent signal indication relay 1618 from battery through the winding of this relay over the PS lead to ground at relay 502. Relay 1500 is now operated over an obvious circuit by the operation of relay 1503. When the connection is established at contact 504 a circuit is completed for the operation of relay 1300 from battery, winding of this relay over the sleeve lead S connected at contacts 504, to the HM lead, to ground through contacts of relays 1100, 1005, 1503 and 1400, that is, the same circuit used for the holding magnet 501. Relay 1300 locks over its inner left-hand armature and front contact through contacts of relays 1521, 1302 and 1401 to ground, independent of the ground through the control circuit. This ground connection also serves to hold the magnet 501 operated over the sleeve S independently of the ground through the control circuit. Relay 1300 opens the circuit for relay 1501, but this relay is held operated by an obvious circuit through contacts of relay 1504 which operate as hereinafter described. A circuit is also completed over the tip and ring conductors through contacts 504, contacts of relays 1201 and 1200 to battery and ground over windings of relay 1504 to operate this relay. Relay 1504 holds relay 1501 operated as described.

The control circuit is now released momentarily as there is no further need for this circuit until dialing is completed. This is accomplished as follows: It should be noted that as soon as relay 1300 operates the relay 801 of the allotter circuits for the second link is operated over a circuit from battery, contacts of relay 806, contacts of relay 807, right-hand winding of relay 801, contacts of relay 800, the GD lead, contacts of relay 1300, the GD1 lead, right-hand winding of relay 809, left-hand winding of relay 805 to ground. This holds relays 809 and 805 operated during the operation of allotter relay 801. The relay 801 now locks from battery, its left-hand winding, its inner left-hand armature and front contact, the corresponding make-before-break contacts of relays 802 and 803, the right-hand winding of relay 805, and it also locks through its right-hand winding, from battery contacts of relays 806 and 807, its right-hand winding and its inner right-hand armature and front contact, the corresponding make-before-break contacts of relays 802 and 803 to ground through the left-hand winding of relay 809. Relay 801 in operating releases relay 800 by opening its locking circuits through both windings of this relay. Relay 801 advances the start lead ST to the next link. Returning now to relay 1300, this relay also closes a circuit for the operation of relay 1001, from battery, its right-hand winding, the RL lead contacts of relays 1400, and 1300 to ground. This relay in operating closes an obvious circuit for the operation of relay 1000. Relay 1001 releases relay 900 and relay 1000 releases relay 904. Relay 904 releases relay 1100. Relay 1000 also opens the circuit for start relay 1003 which now releases causing the release in turn of relays 1400, 1004, 1001 and 1000. Relays 1009 and 1010 which were operated on the operation of the start relay 1003 for test purposes as previously described are also released.

It should be noted that the original operating circuit for relay 1400 was opened by the opera-

tion of relay 1300. The relays in the control circuit as shown in Figs. 9, 10 and 11 are now all returned to normal and consequently this control circuit is available for the establishing of other connections until dialing starts. The relays that are now operated in the system due to the calling subscriber removing his receiver from the switchhook are relays 1501, 1504, 1301, 1302 and 1300, the circuits are now ready for dialing.

The calling subscriber may now dial the number of the desired subscriber's line which comprises three digits. The first will select the group of ten in which the called subscriber's line is located, the second digit will select the called line and the third digit will select the ringing code to be applied to the called line. The link shown is provided with registering or counting relay groups for recording these three digits. In Fig. 12 the relays 1206 to 1211 are the register relays for the first digit. These relays are also used for the registering and storing of the third digit, the first digit being stored on special storing relays 1406 to 1409 in Fig. 14. The second digit is recorded and stored on the register relays 1506 to 1511 in Fig. 15. If now the subscriber dials the first digit by releasing and operating relay 100 to open and close the loop connection over the tip and ring conductors through the right-hand windings of repeating coil 101, the first impulse will release relay 1504. This releases relay 1501 and the release of this relay closes a circuit for the operation of relays 1512 and 1513. The circuit for relay 1512 extends from battery through the winding of this relay, contacts of relay 1501, contacts of relays 1413 and 1302 to ground and the circuit for relay 1513 extends from battery through the winding of this relay, contacts of relays 1515 and 1514 and from this point on over the same circuit as relay 1512 was energized to ground at relay 1302. Relay 1512 is slow in releasing and remains operated during the pulsing. When now the pulsing relay 1504 is reoperated at the end of the first pulse relay 1501 reoperates from battery, winding of this relay, contacts of relays 1513 and 1514 to ground at contacts of relay 1504, and relay 1501 locks directly to this ground. Then relay 1514 is operated over a circuit in series with relay 1513 from battery through the winding of relay 1513, contacts of relays 1515 and 1513, right-hand winding of relay 1514, contacts of relays 1303, 1512 and 1413 to ground at the contacts of relay 1302. When relay 1504 was first released it opened the operating circuit for relay 1301, but this relay is slow in releasing so that it remains operated during dialing. Relay 1514 places a ground on the odd pulsing lead to operate the first register relay 1207 in Fig. 12 from battery through the winding of this relay and its make-before-break contacts, contacts of relays 1208, 1209, 1210 and 1211, contacts of relays 1517, 1514, 1303, 1512, 1413 and 1304 to ground at relay 1302. The relay 1207 is locked through its lower inner armature and front contact over contacts of relays 1208, 1209, 1210, 1211, 1516 and 1512 and from there to ground at relay 1302. It should be noted that the right-hand winding of relay 1514 was short-circuited by the ground at the outer left-hand armature and back contact of relay 1501 so relay 1514 could not operate until relay 1501 has operated. As relay 1504 responds to the second impulse by releasing, it causes the release of relay 1501 as hereinbefore described and closes a circuit for the operation of relay 1515. This circuit may

be traced from battery, winding of this relay, left-hand winding of relay 1514 and operated contacts, contacts of relay 1501 to ground at relay 1302. Relay 1515 in operating opens the circuit for relay 1513 which now releases, but relay 1514 remains operated as long as relay 1501 is released. When now relay 1504 operates at the end of the second impulse, relay 1501 is again operated over a circuit at this time closed from battery through the winding of relay 1501, normal contacts of relay 1513, and operated contacts of relay 1514 to ground at the contacts of relay 1504. Relay 1501 in operating releases relays 1514 and 1515. Relay 1514 removes the ground from the odd pulse lead and applies it to the even pulse lead and causes the operation of the second register relay 1208 in Fig. 12. The circuit for this relay may be traced from battery, winding of relay 1208, contacts of relays 1207, 1517, 1514 and 1512 to the ground hereinbefore traced at contacts of relay 1302. Relay 1208 locks over its lower inner armature and front contact and contacts of relays 1209, 1210 and 1211 to the same ground as relay 1207 was locked at relay 1302 hereinbefore traced. The relay 1208 opens the locking circuit for relay 1207 which now releases. On succeeding impulses incoming to the pulsing relay 1504 the relays 1513, 1514 and 1515 will operate and function in the same manner. On each odd impulse relay 1514 will be operated to ground the odd pulsing lead and on each even impulse relay 1514 will be released to ground the even pulsing lead to the counting relays. Thus, the register relays will be operated and released in succession as the impulses are received over the odd and even leads from relay 1514. The operation of the register relays in response to these pulses is as follows: As already explained the first impulse causes the operation of relay 1207 and this relay in operating prepares the circuit for the second relay 1208. When relay 1514 releases at the conclusion of the second impulse this relay is operated as described. Relay 1208 prepares the circuit for the odd pulsing lead to relay 1209. This ground on the even pulse lead also at this time causes beside the operation of relay 1208, the operation of relay 1516 from battery, left-hand winding of this relay and its left-hand make-before-break contacts, contacts of relay 1306 to ground on the even pulsing lead. Relay 1516 prepares an operating circuit for relays 1306 and 1517 to be operated as will hereinafter be described. On this third impulse, therefore, relay 1209 will operate and relay 1208 release and on the fourth impulse relay 1210 will operate and relay 1209 release. On the fifth impulse relay 1211 will operate and relay 1210 will release. On the sixth impulse relay 1206 will operate but relay 1211 will not release. Relay 1206 locks under control of relay 1516 from battery, winding of relay 1206 and its lower inner armature and front contact to the ground at the second right-hand armature and front contact of relay 1516. On the seventh impulse relay 1207 will again be operated and relay 1211 will release. On the eighth impulse relay 1208 will operate and relay 1207 will release. On the ninth impulse relay 1209 will operate and relay 1208 will release. On the tenth impulse relay 1210 will operate and relay 1209 will release. A permanent locking ground for the register relays is not provided until relay 1516 is operated in response to the second impulse. This is provided so that in case

of a preliminary impulse being received when relay 1512 releases at the end of the first impulse, relay 1207 will release and the circuit will be restored to normal condition before the preliminary impulse has been received. If, however, more than one impulse is received the associated relay 1516 operates as mentioned and provides a locking circuit for the register relays so that they will not restore when relay 1512 restores at the end of the first digit. Assuming that more than one impulse is received on the register relays a certain one of the register relays remains operated and in case of digits above 6 relay 1206 also remains operated at the end of the digit dialed. When relay 1512 now releases, relays 1306 and 1517 are operated, relay 1306 over a circuit from battery through the winding of this relay, its make-before-break contact, contacts of relays 1516, and 1512 to ground at relay 1302. Relay 1517 operates from battery through the winding of this relay, contacts of relay 1518, make-before-break contact of relay 1306 to the ground at relay 1302 as hereinbefore traced. These two relays lock over a ground at the inner left-hand armature and front contact of relay 1306, contacts of relay 1304 to ground at contacts of relay 1302.

Relay 1517 transfers the odd and even pulsing leads to the register relays for the second digit, that is, relays 1506 to 1511, inclusive, which now respond to impulses controlled by relay 1514 except that in this case the first register relay 1507 will operate and lock if only one impulse is received. In this case when relay 1512 operates on the receipt of the first impulse, relay 1516 is released. It should be noted that the original energizing circuit and locking circuit for relay 1516 through its left-hand winding was opened on the operation of relay 1306 while a substitute locking circuit was provided through the right-hand winding of this relay and contacts of relay 1518 through contacts of relay 1512 to ground at relay 1302 when relay 1512 was released at the end of the first digit. This locking circuit is now therefore opened and relay 1516 releases when relay 1512 operates. Relay 1516 releasing prepares circuits for the subsequent operation of relay 1518 as will hereinafter be described. With relay 1516 released and relay 1512 operated the first set of register relays will have their locking grounds transferred through contacts of relay 1512 to ground at relay 1302 through the right-hand make-before-break contacts of relay 1516 so that when relay 1512 is released at the end of the second digit, these register relays will release. However, the reason for releasing the counting relays after the first digit has been registered, is to prepare them for the reception of the third digit. As hereinbefore mentioned, the first digit is stored on the storing relays 1406 to 1410. The storing of the first digit as determined by the operation of the register relays, is as follows: If the first digit dialed is "2", relay 1208 is, of course, operated and this causes the operation of the storing relay 1408 from battery, winding of this relay and its make-before-break contacts, contacts of relays 1208 and 1518 and contacts of relay 1306 to ground. However this operation of a storing relay it will be noted does not take place until the end of the digit when relay 1306 is operated as hereinbefore described. The storing relay 1408 locks directly through its upper inner armature and front contact to the ground at relay 1306. If the first digit is "3", storing relays

1407 and 1408 will operate. If the digit is "4", relay 1409 will operate. If the digit is "5", relays 1407 and 1409 will operate. If the digit is "6", relay 1406 will operate. If the digit is "7", relays 1407 and 1406 will operate. If the digit is "8", relays 1408 and 1406 will operate. If the digit is "9", relays 1407, 1408 and 1406 will operate. If the digit is "10" relays 1409 and 1406 will operate. Whichever combination of storing relays is operated in response to the first digit, they will prepare, as will hereinafter be described, the control of the switch C to select the group of lines in which a desired subscriber's line is located through operations in the control circuit herein-after described.

Returning now to the transmission of the second digit, it was mentioned that the relays 1506 to 1511, inclusive, operate in the same manner as the relays 1206 to 1211, inclusive. Register relay 1510 will operate when the digit is "1" over a circuit as follows, battery winding of relay 1520, contacts of relays 1500 and 1517, lower winding of relay 1510, contacts of relays 1509, 1508, 1507, 1506, 1517 and 1514 over the odd lead to ground at relay 1302 as hereinbefore traced. Relay 1510 locks from battery, upper winding and make-before-break contacts of this relay, contacts of relays 1509, 1508, 1507, 1506, 1413 to ground at relay 1302. Similarly other register relays are operated and locked by other digits, relay 1509 by digit "2", relay 1508 by digit "3", relay 1507 by digit "4", relay 1506 by digit "5", relays 1506 and 1511 by digit "6", relays 1511 and 1510 by digit "7", relays 1511 and 1509 by digit "8", relays 1511 and 1508 by digit "9", relays 1511 and 1507 by digit "10". At the end of the last pulse of the second digit the register relay or relays which may have operated in response to this digit remain locked under control of relay 1413. The locking circuit, for example, for relay 1510 may be traced from battery through the upper winding of this relay at its upper inner armature and front contact, make-before-break contacts of relays 1509, 1508, 1507 and 1506, lower outer armature and back contact of relay 1413 to ground at relay 1302. When now relay 1512 releases at the end of the second digit, relay 1518 operates from battery, winding of this relay, contacts of relays 1517, 1516 and 1512 to ground at relay 1302 and locks through its own contacts independent of relay 1517. Relay 1518 in operating releases relay 1517 by the opening of its make-before-break contacts. The register relays operated for the first digit are released due to the release of relay 1512 as the holding ground for these relays was transferred under control of relay 1512 on the release of relay 1516. Relay 1518 also in operating opens at its outer armature and back contact the ground connection from the register relays for operating the storing relays so that no further control can be exercised over these storing relays. After the setting of the register relays for the second digit the circuits function to respond to the third digit, that is, relay 1514 will apply ground to the odd and even pulsing leads which now have been transferred by the release of relay 1517 back to the first set of register relays in Fig. 12. These relays will now respond to the impulses the same as before. When the first impulse is received in addition to operating relay 1207, relay 1516 will now be operated and locks through contacts of relay 1518 to ground at relay 1302. The circuit

for relay 1516, in this case, extends from battery, left-hand winding of this relay and its left-hand make-before-break contacts, contacts of relay 1518 over the same circuit as relay 1207 to ground at relay 1302. The register relays in Fig. 12 are now set in accordance with a third digit. At the end of this digit the register relays which are operated lock to ground at contacts of relay 1516. These relays, as stated, determine the ringing code that is to be sent out on the line. At the end of the third digit, relay 1303 operates over a circuit from battery, winding of this relay and its make-before-break contacts, contacts of relays 1518, 1516 and 1512 to ground at relay 1302. This relay locks through its inner left-hand armature and front contact to ground at relay 1302. Relay 1303 now closes a starting circuit for the operation of relay 902 in the control circuit for this link from battery through the make-before-break contacts of relay 901, windings of relay 902, make-before-break contacts of relay 908, contacts of relay 1503 to ground at relay 1303. Relay 906 then operates from battery through its windings, contacts of relays 902, 900, 904 and 903 to ground at contacts of relay 1000. Relay 906 locks relay 902 from battery through the inner upper and lower armatures and front contacts of this relay and its windings, inner upper and lower armatures and front contacts of relay 906, contacts of relay 1001 to ground. Relay 906 closes an obvious circuit for the operation of relay 1104. Relay 1104, as usual, closes through various leads between the link and the control circuit and operates the peg count register 1115 over an obvious circuit. If it is assumed that the called subscriber's line is located in the first group of ten lines the relay 1100 will operate from battery, winding of this relay over contacts of relays 1104, 1407 and 1408 to ground at contacts of relay 1406. It will be remembered that relay 1408 is operated on the first digit comprising two impulses. It should be noted that relay 1503 now releases due to a short circuit for its holding circuit being closed by the operation of relay 1104 from ground through a resistance to battery for this relay. It should be noted that the selector magnet 506 is immediately operated upon the operation of relay 1104 through ground supplied at the upper inner armature and front contact of this relay for this magnet so that the holding magnet on the called line may be operated depending on which line is called. If the subscriber at B is the one called which is numbered 9 in the first group of 10, the relays 1508, 1511 in the second digit register relays would be operated. If the called line is idle relay 1500 will release as soon as relay 1503 is released and thus close a circuit for the holding magnet 508 for this line from battery, winding of this magnet, on the HM lead, contacts of relays 1100, 1104, 1508, 1511, 1520, 1503, 1500 to ground at relay 1412. However, had the called line been busy there would have been a ground on the BT lead due to the operation of magnet 508 and relays 502 and 1412 would have operated before relay 1500, which is slow to release, had they had time to release on the release of relay 1503. The circuit for this relay would be as follows: from battery through the winding of relay 1412, contacts of relays 1503, 1520 (the latter relay released on release of relay 1503), contacts of relays 1511, 1506, 1507, 1508, 1104, 1100 over the

BT lead, contacts of relay 502 to ground at magnet 508 supplied from relays in the link used by the called subscriber's line. Consequently, relay 1500 will not release and thus cause relay 1521 to operate on the release of relays 1503 and 1520. This circuit may be traced from battery through the winding of relay 1521, contacts of relays 1500, 1503, 1511, 1508, 1104, 1100 and the HM lead to the ground at the contacts of this busy line through switch C and the sleeve lead S as hereinbefore traced. Relay 1521 locks over its inner left-hand armature and front contact to ground at relay 1302. With relay 1412 operated relay 1500 will now release. As relay 1412 supplies a locking circuit for itself through its second lower armature and front contact to ground at relay 1302 this ground short-circuits relay 1500. With relay 1412 operated and relay 1500 released the control circuit is released by the operation of relay 1001 from battery, right-hand winding of this relay, contacts of relays 1104, 1500, 1412 to ground. Relay 1001 closes an obvious circuit for the operation of relay 1000 and this relay in turn releases relay 906. Relay 906 releases relay 1104 and this relay in releasing causes the release of relays 1100 and 1001. Relay 1001 releases relay 1000 so that the control circuit is now completely released. Relay 1412, on the other hand, places a busy tone on the calling line over the A and B leads from the busy tone source in Fig. 17. The operation of the busy tone means in Fig. 17 is started by the ground supplied to the TS lead at the upper middle armature and front contact of relay 1412 to cause a buzzing action of relay 1700 and ground supplied over the ST lead operates relay 1609 to supply a ground to cause a buzzing action of relays 1701, 1702 and 1703 to close the leads A and B to supply the busy tone from coil 1794 alternately energized by relay 1700. The action of these relays will be explained more fully in connection with the ringing of subscriber's line.

If it is assumed that the line is idle there will be no ground on leads BT and HM of the desired line, relay 1412 will not operate and relay 1500 will release so that the holding magnet 508 of the desired subscriber's line will operate as described. Consequently, the calling subscriber's line will be connected at contact 511 in switch C to the first link. The ground, above mentioned, from the lower outer armature and back contact of relay 1412 now extends over the HM lead through the sleeve contacts of group 511 at switch C over lead S1 to cause the operation of relay 1414, extends over contacts of relay 1413, winding of relay 1414 to battery. Relay 1414 in operating provides a locking circuit for itself through its second upper armature and front contacts and contacts of relay 1413 to ground at relay 1302. This relay now establishes a connection to ground at its lower outer armature and front contact for the starting of the ringing interrupter as shown in Fig. 17 to ring the desired subscriber's line as will be hereinafter described. It will also place a ground on the S1 lead to hold the holding magnet of the called line operated independent of the ground from the lower outer armature and back contact of relay 1412 as traced over the HM lead. The ground on the S1 lead is supplied from contacts of relay 1302 over the second lower armature and front contacts of relay 1414. Relay 1414 also supplies a ground at its third lower armature and front contact for the operation of relay 1001 from

battery, right-hand winding of relay 1001, contacts of relay 1104 to said ground at relay 1414. Relay 1001 closes an obvious circuit for the operation of relay 1000 and this relay in turn releases the start relay 1003, while the relay 1001 releases relays 902 and 906. Relay 1000 closes an obvious circuit relay 1009 which then operates relay 1010 for the various tests as will hereinafter be described. The release of relay 906 causes the release of the relay 1104 which in turn releases relay 1100. Relay 1104 releases relay 1101 and relay 1430 in the link circuit, and this in turn releases relay 1004 in the control circuit. Relay 1003 releases relay 1009 which releases relay 1010. Thus the control circuit is completely released after the called subscriber's line has been connected to the link circuit and prior to the sending of the ringing code, the operation of which will now be described. The ground applied by relay 1414 for the ringing interrupter supply circuit closes a circuit for the operation of relay 1600. This relay in turn closes a circuit for ground for the ST3 lead leading to Fig. 17 and causes the operation of relay 1702. This relay then closes a circuit for relay 1703. Relay 1703 closes the A and B leads to the link circuits but this is without effect at this time, these links being used only for busy tone transmission as hereinbefore described. Relay 1703 also causes the operation of relays 1705 and 1701 from the start lead ST3. Relay 1701 opens the circuit for the relay 1702 which in turn releases relay 1703. Relay 1703 removes the ground from the shunt around the relay 1706 causing it to operate to the ground at the start lead ST3 over the contacts of relay 1705. The relay 1701 is released and again starts the cycle of operation between the relays 1702, 1703, 1705, 1701 and 1706 as described. Relay 1703 operates five-tenths of a second every second. When the ground is removed from the shunt around the relay 1706 it operates in multiple with the relay 1705. Relay 1705 operates the relay 1707 from battery, winding of this relay, contacts of relays 1708 and 1705 to ground on ST3. Relay 1706 closes a circuit for the operation of relay 1708 from battery, winding of this relay, contacts of relays 1719, 1708 and 1706 to ground. Relay 1708 locks at its inner left-hand armature and front contact to ground on the start relay ST3. The operation of relay 1708 opens the original energizing circuit for relay 1707 which is locked by relay 1706. On the next operation of the relay 1703, relay 1705 is shunted and releases followed by the release of relay 1706. Relay 1705 in releasing operates relay 1710 over a circuit from battery, winding of this relay and contacts of relays 1707, and 1705 to ground on lead ST3. Relay 1710 locks under control of relay 1706 to the ground at lead ST3, while relay 1706 in releasing releases relay 1707. On the next operation of the relay 1705, relay 1711 operates from battery, winding of this relay, contacts of relays 1710 and 1705 to ground on lead ST3, and when 1706 operates it releases relay 1710. On the next release of relay 1705 relay 1712 operates from battery, winding of this relay, contacts of relays 1711 and 1705 to ground on lead ST3. When relay 1706 releases it provides a locking ground for the relay 1712 from battery, inner left-hand armature and front contact of this relay, contacts of relay 1706 to ground on lead ST3. Relay 1706 in releasing opens the circuit for relay 1711. Relay 1705 on the next operation closes a circuit for the oper-

ation of relay 1713 from battery, winding of this relay, contacts of relays 1712 and 1705 to ground on lead ST3. As relay 1706 then operates relay 1712 is released and a locking circuit is provided for relay 1713 from battery, inner right-hand armature and front contact of this relay, contacts of relay 1706 to ground on lead ST3. On the next release of relay 1704, relay 1716 is operated from battery, winding of this relay, contacts of relays 1713 and 1704 to ground on lead ST3. As relay 1706 releases, relay 1713 is released and a locking circuit is provided for relay 1716 from battery, winding of this relay and its inner right-hand armature and front contact, contacts of relay 1706 to ground on the ST3 lead. As relay 1705 is again operated, it causes the operation of relay 1717 from battery, winding of this relay, contacts of relays 1716 and 1705, to ground on the ST3 lead. As relay 1706 operates it releases relay 1716 and provides a locking circuit for relay 1717 from battery, winding of this relay and its inner left-hand armature and front contact, contacts of relay 1706 to ground on the ST3 lead. Relay 1705 again releases and operates relay 1718 from battery through the winding of this relay, contacts of relays 1717 and 1705 to ground on the ST3 lead. As relay 1706 releases, it releases relay 1717 and closes a locking circuit for relay 1718 from battery, winding of this relay and its inner right-hand armature and front contact, contacts of relay 1706 to ground on the ST3 lead. Relay 1705 again operating causes the operation of relay 1709 from battery, winding of this relay, contacts of relays 1717 and 1704 to ground on lead ST3. As relay 1706 operates, it releases relay 1718 and provides a locking circuit for relay 1709 from battery, winding of this relay and its inner left-hand armature and front contact, contacts of relay 1706 to ground on the ST3 lead. When relay 1719 operates, it releases relay 1708. The relay 1705 is then again released and when relay 1706 releases, relay 1719 is released. When relay 1705 again operates relay 1707 operates and the cycle of operations are repeated as described. The operation of such relays 1703 to 1719 and the release of these relays in conjunction with the ground impulses supplied by relays 1703, 1705 and 1706 apply ground impulses to the leads 1 to 12 and lead TU, respectively, as shown leading to Fig. 12 to repeater relays 1206 to 1211. It should be noted during the operation of these relays 1703 to 1719 that relay 1720 is operated when relay 1713 is operated and relay 1703 is released, and also operates when relay 1719 is operated and relays 1708 and 1718 are released and relay 1703 is operated. Relay 1720 in operating grounds the RD lead, opens the RS lead, removes battery and ground respectively from the RGB and RGG leads and applies a continuous ringing current on the RG lead from a source connected at 121. The purpose of the operation of relay 1720 in this manner will become apparent in the following description.

In the present system as many as twenty parties may be connected to the same line and twenty ringing codes are therefore provided. The following chart shows the combination of impulses comprising the twenty ringing codes.

The chart shows the code signals themselves, how the ringing battery is applied, how the various pulse leads 1 to 12 are employed in producing the codes, which of the register relays 1206 to 1211 are operated for the various codes and

which of the register relays of the first digit are operated for the various codes.

1215 will be operated for a long period to give a long impulse from source 1308 over the ring

Code	Ringing battery		Pulse leads used	Ringing digit register relays operated	1st digit register relays operated
	On tip	On ring			
	Operated	Not operated			
1			11	1207	Any digit relays except 1406 and 1408
2			2-11	1208	
3			3-11	1209	
4			4-11	1210	
5			5-11	1211	
6			11-12	1206-1211	
7			7-12	1206-1207	
8			8-12	1206-1208	
9			9-12	1206-1209	
10			10-12	1206-1210	
11			1	1207	Relays for digit 8 1406 and 1408
12			2	1208	
13			3	1209	
14			4	1210	
15			5	1211	
16			6	1206-1211	
17			7	1206-1207	
18			8	1206-1208	
19			9	1206-1209	
20			10	1206-1210	

From this chart it is evident that relay 1307 is operated when a code in either of the groups of codes 6 to 10 or 16 to 20 is sent. The code relay 1206 will then also be operated from an even impulse lead. Hence relay 1307 is operated over a circuit from battery, winding of relay 1307, contacts of relay 1303 to the even lead. This also closes a circuit for the ringing source at 1308 for the tip conductor and a ground return for the ring conductor as controlled by relay 1215 which is operated in accordance with the code. When codes 1 to 5 and 11 to 15 are sent, the relay 1307 is not operated and consequently ringing current is supplied to the ring lead and ground return to the tip lead. The relay 1215 is operated to send the code over the tip and ring conductors and is operated in accordance with the code. The system is so arranged that when any other digit but 8 is dialed as the first digit, codes 1 to 10 are sent and when the first digit is 8, codes 11 to 20 are sent. The codes are determined by the operation of this relay 1215 in accordance with the settings of the register relays 1206 to 1211 as shown in the chart. To illustrate this signaling the operations that take place when a few of the codes are sent will be described.

For example, if code 1, which consists of a long impulse, is to be sent, any one of the first digits, except 8, may be dialed and this will cause either of the register relays 1406 or 1408 to remain in released condition and the register relay 1207 will be operated. Relay 1307 will not be operated at this time. It should be noted that when the circuits are ready to send this code as well as any other codes, relay 1413 will be operated as soon as relay 1707 operates which takes place at the beginning of each cycle of operations of the relays 1707 to 1719. This circuit may be traced from battery, winding of relay 1413, contacts of relays 1413, 1414, 1201, 1708, 1707 to ground. This relay connects the code leads to relay 1215. The impulses now coming in over lead 1 have no effect on relay 1215 as it should be noted that there is a long impulse on lead 11 as follows: From ground at relay 1703, contacts of relays 1710, 1711 and 1712 operated, lead 11, contacts of relays 1206, 1406 or 1408, 1413 and 1414, lower winding of relay 1215 to battery. Hence, relay

conductor to the subscriber on the line responding to this code. A twenty party line has not been shown but it should be understood that any standard line of this kind may be employed with the ringers for the different parties applied on the tip side for ten parties and on the ring side for the other ten parties or twenty parties bridged.

If code 6 is dialed comprising two long impulses, relays 1211 and 1206 are operated. Relay 1307 is operated at this time. Hence a first long impulse will be transmitted over lead 11 until relay 1712 is released, in this case, over a circuit as follows: Ground at contacts of relay 1703, contacts of relays 1210, 1211, 1212 in succession, lead 11, contacts of relays 1406 or 1408, 1211, 1307, 1413, upper winding of relay 1215 to battery. Then a second long impulse will be sent over lead 12 when relays 1716, 1717 and 1718 are operated, from ground over contacts of relays 1703, 1716, 1717, 1718, 1206, 1406 or 1408, 1413, 1414, lower winding of relay 1215 to battery.

If code 11 is dialed comprising two short impulses close together followed by a long interval and then a short impulse, relay 1307 will not be operated. The first digit will be 8 causing the operation of relays 1406 and 1408 and relays 1211 and 1207 will be operated. Impulses from the lead 1 will be used. The circuit in this case may be traced from ground, contacts of relays 1703, 1710, 1713, lead 1, relays 1207, 1413, 1206, upper winding of relay 1215 to battery.

If code 16 is dialed comprising four short impulses close together, a long interval and a short impulse, relay 1307 is operated. The first digit will be 8 causing the operation of relays 1406 and 1408. Relays 1211 and 1206 will be operated. The circuit in this case will be traced from ground contacts of relays 1703, 1710, 1712, 1717, lead 6, relays 1406, 1408, 1211, 1307, 1413, upper winding of relay 1215 to battery. When relay 1215 operates, as described, the tip and ring conductors of the called line are transferred from the transmission battery through the windings of relay 1304, to release the ringing code as described and causes the operation of relay 1216. When relay 1215 releases relay 1216 releases slowly and momentarily holds the called subscriber's line

connected to a ground on the tip and battery on the ring conductor before the line is transferred back to the transmission circuit. This is for the purpose of draining the ringing charge which may have been left on the line by the ringing current before the line is again transferred back to the transmission circuit in order that relay 1304 may not be falsely operated due to the discharge of this generator charge. Ringing tone is also returned to the calling subscriber through the condensers 1217 and 1218. When the called subscriber removes the receiver relays 1215 and 1216 are released, relay 1304 operates over the loop circuit, removing the locking ground from the relays in this circuit and the ringing ceases. Battery is applied for transmission purposes to the called subscriber from relay 1304 while talking battery for the calling subscriber is transmitted through the windings of relay 1504. Conversation between the subscribers may now take place and when the subscribers hang up the link is released.

A description will now be made of a reverte call, that is, when a subscriber on a party line desires a connection with a station on its own line. In this case he dials the regular directory number and the link circuit will find the line busy. In this case as in any ordinary busy call, the ground will be present on the BT and HM leads. The ground on the BT lead will prevent relay 1500 from releasing and cause the operation of the busy tone relay 1412 over a circuit as hereinbefore described in connection with a call to a busy line. Relay 1412 in operating locks and closes a shunt circuit for relay 1500 from the locking ground at its second lower armature and front contact. Relay 1500 is slow in releasing. Simultaneously with the operation of the busy tone relay 1412, the ground over the HM lead causes the operation of relay 1521 over a circuit as hereinbefore traced. Relay 1521 locks in operated position through contacts of relay 1500. It will now be noted that relay 1521 opens the short circuit for the relay 1310 at its outer left-hand armature and back contact. Ordinarily, on a call to a busy line this relay 1310 would now operate but in this case the ground connected at the inner left-hand armature and front contact of relay 1521 from the locking circuit, for this relay, will be extended before relay 1500 is released back over the HM lead and through the sleeve lead of the calling line, which in this case is the same as the called line, and over the sleeve connection through the inner left-hand armature and front contact of relay 1300 to shunt the winding of relay 1310. Consequently, although relay 1521 is operated relay 1510 is prevented from operating and therefore when relay 1500 is released a circuit will be completed for the operation of relay 1312 from battery through the winding of this relay, contacts of relay 1302, make-before-break contact of relay 1312, armature and back contact of relay 1310, outer right-hand armature and front contact of relay 1521 to ground at the second left-hand armature and back contact of relay 1500. Relay 1312 closes a locking circuit for itself through its third outer right-hand armature and front contact, ground at the make-before-break contact of relay 1401. When relay 1500 releases relay 1001 is also operated over a circuit as hereinbefore described from a ground at contacts of relay 1412 thus causing the release of the control circuit. Relay 1412 now prepares a circuit for transferring the calling line to the called

line end of the link at the first and second inner right-hand armatures and front contacts of this relay as will be described hereinafter. The ringing shunt for draining the ringing charge from the line is also transferred to armatures and back contacts of relay 1720 in the tone circuit, Fig. 13. The subscriber now hears the usual busy tone and hangs up causing relays 1504 and 1501 to release, these relays causing the release of relay 1301. Relay 1301 closes a circuit for the operation of relay 1200 from battery through the winding of this relay, contacts of relay 1312 and left-hand armature and back contact of relay 1301 to ground. Relay 1200 locks to ground at relay 1300 which is held up due to relay 1302 being held under control of relay 1304. Relay 1302 has its new holding circuit closed by relay 1312 and may be traced from battery through the winding of this relay, second right-hand armature and front contact of relay 1312, contacts of relay 1304, contacts of relay 1302 to ground. The original operating circuit for this relay was opened on the release of relay 1500. Relay 1200 now transfers the calling subscriber from the transmission path through relay 1504 through operated contacts of relay 1312 to the transmission path through relay 1304. This transfer circuit may be traced from the upper and lower armatures and front contacts of relay 1200, inner left- and right-hand armatures and front contacts of relay 1312, tip and ring conductors through contacts of relay 1215 and relay 1216 through the windings of relay 1304 to battery and ground. Relay 1200 also closes a circuit for the operation of relay 1414 from battery through the winding of this relay, contacts of relays 1200, and 1304 to ground at relay 1302 and the circuit will now therefore function in the same manner as for any other call except that in this case when the regular ringing code is sent out on one side of the line there is an additional ringing code consisting of two short rings per code cycle is sent out on the other side of the line. This ringing tone is supplied from source 1721 through contacts of relay 1720 when this relay is operated as hereinbefore described, with the relays 1710, 1711 and 1712, 1716, 1717 and 1718, as these relays provide ringing tone for the circuit. Thus, when relay 1312 is operated and depending on whether 1307 is operated and released, the two short code signals will be transmitted either over the tip or the ring conductor to the called line, to operated contacts of relay 1216 and normal contacts of relay 1215. When now either the called subscriber or the calling subscriber removes his receiver, relay 1304 will operate and this relay in operating restores these circuits to normal. Ground being removed from the sleeve lead will release the holding magnet in the switch C and the line relay of the line operates and functions to provide transmission battery to the line and to prevent the line from seizing this or any other link as the relay 502 is held operated by the line relay 500 until the connection is released.

On grounded return lines, such as the one shown at A, the ringing code has to be applied in the following manner: When relay 1215 operates in a link to transmit a signal it should be noted that it grounds a lead GL1 at its lower inner armature and front contact. This ground connection is established through the switch C over the lead GL1 to the line A to cause the operation of relay 103. This relay follows the code signals to apply current from a ringing source

to the single conductor of the line. This relay also opens the connection at its left-hand back contact from the single conductor that extends through the left-hand windings of the repeating coil 101 and opens an alternating current connection at its right-hand contact through the right-hand windings of the repeating coil 101 over the tip and ring conductors established through the circuits to the ringing source at 1308. This causes no unnecessary drain on this latter source of ringing current in connections of this kind. On a reverive call this GLI lead is connected through contacts of relay 1312 to the switch C at the connection made through contacts 504 as this is the only connection made to the line whereas in calls to subscribers in other lines a connection is extended directly through the contacts 511 at the called end of the link connection at the switch C.

If a call is made from a coin box subscriber's line a special lead CN is grounded and is connected through a fourth contact at the cross-point of switch C where this line appears. Such a line has not been shown in the switch but the lead CN is shown for the link illustrated. Ground on this conductor CN operates relay 1220 from battery through the winding of this relay 1304, contacts of relay 1201, and the connection through the switch to the ground on the coin line. Relay 1218 reverses battery on the coin line when it is required that a charge shall be made for the call.

The operations of the circuit will now be described in connection with the selection of a trunk from a calling subscriber's line. Only one trunk has been shown in Fig. 7 with associated connections throughout the first link and control circuit, etc. The trunks may be divided in groups with the limit of five trunks in each group. One of these groups may be called master office trunks and two other groups may be defined as non-master office trunks. A master office trunk group may be selected by dialing the digit 0. Of the two non-master office trunk groups one is provided with five trunks and may be dialed with the numerals 9 and 1 and the other non-master office trunk group may comprise four trunks and may be dialed by the numerals 9 and 2. If it is assumed that a calling subscriber has seized the link shown in the drawings and then dials the code 0 he will receive a connection to a trunk in the master office group. The trunk shown in Fig. 7 is one of these latter trunks shown connected through the switch C. In this case the storing relays 1406 and 1409 for the first digit will be operated over a circuit closed by the operation of the register relay 1210 as follows: From battery, winding of relay 1409 and its make-before-break contacts, contacts of relays 1210 and 1518 to ground at contacts of relay 1306. Relay 1409 closes a locking circuit for itself to ground at contacts of relay 1306. Relay 1406 operates from battery, winding of this relay and its make-before-break contacts, contacts of relay 1206 when it operates during dialing to ground at relay 1306 and relay 1406 locks to the same ground at relay 1306. It is assumed, of course, that relay 1104 has operated in the control circuit due to the operation of the corresponding relays 902 and 906 for the first link and consequently the link circuit has been connected to the control circuit through to the trunk relay 1101 that connects the trunks of the first group in the switch C, therefore when relays 1406 and 1409 operate a circuit is completed for this relay from

battery, winding of this relay 1101, contacts of relay 1104, lead 10, contacts of relays 1409 and 1406 to ground. Relay 1303 is operated due to the operation of relays 1406 and 1409 from battery, winding of this relay and its make-before-break contacts, contacts of relays 1409, 1406 and 1304 to ground at the contacts of relay 1302. This relay locks over a circuit directly through contacts of relay 1302 and its own contacts. A circuit is then closed for the operation of relay 1510 from battery through the winding of relay 1520, contacts of relays 1500 and 1511, winding of relay 1510, contacts of relays 1509, 1508, 1507, 1506, 1303, 1510, 1509, 1508, 1507, 1506, 1413 to ground at 1302. The leads for this group of trunks are connected up through the control circuit through contacts of relay 1101. The leads THM and TBT for the trunks are connected together at the contacts of this relay except the THM and TBT leads for the last trunk. If now the first trunk is busy there will be a ground on the THM lead for this trunk over lead 1106 from contacts of relay 701. Relay 1509 will then operate from battery, winding of relay 1520, contacts of relays 1500, 1511, winding of relay 1509, contacts of relays 1510, 1104, 1007, THM lead, contacts of relay 1101, lead 1106 to ground at relay 701. If the second trunk is busy a ground will also be present on the THM lead for this trunk and relay 1508 will be operated in the same manner. The succeeding relays will then be operated until an idle trunk is found. If, however, all the trunks in the group are busy, the relays 1510, 1509, 1508, 1507 and 1506 will be operated in succession and there will then be found a ground on the TBT lead for this trunk but not on the THM lead and the relay 1412 will be operated to give a busy tone to the calling subscriber in the usual manner. Relay 1412 operates in a circuit from battery through the winding of this relay, contacts of relays 1500, 1503, 1520, 1511, 1506, 1104, 1007, said TBT lead, contacts of relay 1101 to the ground on the lead 1117 of the last trunk corresponding to lead 1106 of the first trunk as shown. If, however, the first trunk is idle there will be no ground on lead 1106, consequently relay 1520 will release and the circuit for relay 1500 will be opened causing it to release. The circuit for the holding magnet 513 of this first trunk will, therefore, be closed from battery through the winding of this magnet 513, the THM lead, contacts of relays 1116, 1101, 1007, 1104, contacts of relays 1510, 1509, 1508, 1507, 1506, 1511, 1520, 1503, 1500 to ground at 1412, as the select magnet 506 is operated on the operation of relay 1104 the connection is now therefore established through contacts 514 of switch C from the link to the trunk in Figs. 6 and 7. The description of the connection of the trunk shown in Figs. 6 and 7 will be continued after a description is made relating to the choice of non-master office trunk groups.

If a non-master office is desired either of the two codes 91 or 92 may be dialed to select the trunks of the corresponding office. When code 91 is dialed storing relays 1406, 1407, 1408 and register relay 1510 will be operated as usual. Relay 1303 is then operated over a circuit from battery, winding of relay 1303 and its contacts, contacts of relays 1518, 1408, 1406, 1304 to ground at 1302. If code 92 is dialed relay 1410 will also be operated over a circuit from battery through the winding of this relay and its make-before-break contacts, contacts of relays 1517 and 1510 to the even lead over contacts of relays 75

1517, 1514 controlled by the pulsing relays 1500 and 1501, when the second digit 2 is dialed. If the code 91 is dialed, ground will be placed on lead 91 through contacts of relay 1104 to operate the proper trunk group relay corresponding to relay 1101 for the master office trunks. This ground may be traced through contacts of relays 1410, 1406, 1408, 1407, 1410, lead 91, contacts of relay 1104 to said trunk group relay, not shown.

10 If the first trunk of this group is busy, the ground on its HM lead corresponding to lead 1108 will cause relay 1509 to operate and the register relays will function as when the zero digit was dialed. If, on the other hand, the code 92 is dialed the relays will function to select an idle trunk as previously described but, in addition, as relay 1410 is operated ground will be placed on lead 92 for the operation of the corresponding trunk group relay, not shown, but corresponding to relay 1101, instead of the lead 91 when the code 91 was dialed, the circuit being established over the upper outer armature and front contact of relay 1410. When these codes 91 and 92 are thus used for two non-master office groups, the 91 code will be limited to five trunks and the 92 code will be limited to four trunks. In this arrangement of trunking groups it is evident that the second digit must be less than five and if the second digit is 1 the group may have five trunks as the second digit counting relays 1510, 1509, 1508, 1507 and 1506 are used for hunting by being operated in succession, as described.

Returning now to the point where the connection was established from the link circuit to the first master office trunk in Figs. 6 and 7 by the operation of the holding magnet 513 the first effect will be that a connection is established over the contacts 514 in switch C for the operation of relay 1201 from battery through the winding of this relay and its make-before-break contacts, contacts of relay 1301, the TK lead, contacts 514, contact of relay 701 to ground. Relay 1201 locks at its upper armature and front contact to ground on the calling subscriber's sleeve lead S supplied at contacts of relay 1401 as usual. Relay 1201 connects the tip and ring conductors of the connection from the trunk through the contacts 514 of the switch C to the calling subscriber's loop. This causes the operation of relay 600 from battery and ground through its windings and contacts of relays 601 and 602, the tip and ring conductors, right-hand windings of repeating coils 603, contacts 514 and switch C, contacts of relay 1201 over the calling subscriber's loop. Relay 600 closes an obvious circuit for the operation of relay 605. This relay reverses the battery and ground connection of the tip and ring conductors of the trunk to the distant office and thus calls the attention of the operator at the master office to a call on this trunk. Relay 605 also closes a circuit for the operation of relay 706 over an obvious circuit and closes a ringing tone connection to the calling subscriber at its upper outer armature and front contact to indicate to the calling subscriber that the connection has been extended out over the trunk. Ringing tone comes through the tone coil 1704 through contacts of relay 700. Relay 706 closes an obvious circuit for the operation of relay 701 and grounds the sleeve lead S1 to the calling subscriber's circuit at its right-hand armature and front contact. This ground connection extends from ground at the left-hand make-before-break contacts of relay 708, right-hand armatures and front contacts of relays 703 and 603, contact 514 of switch C,

inner lower armature of front contact of relay 1201 to the sleeve of the calling subscriber to hold the holding magnet of the calling line in switch C. As the normal holding ground from relay 1401 will presently be removed, this ground on lead S1 also causes the operation of relay 1414. Relay 701 closes a connection to the TP lead for the operation of relay 708 when the timing out equipment operates as will be hereinafter described. This circuit may be traced from battery, left-hand winding of this relay, contacts of relays 700, 701, 708, lead TP to ground at relay 1603 in the timing circuit when it operates. This relay 701 also grounds the BT, AG and ST leads, and also closes at its third outer left-hand armature and front contact a multiple connection for the S lead established by relay 706. It also closes a circuit for the operation of relay 709 from battery, winding of this relay, contacts of relays 700 and 701, over the TK lead should the leads be grounded under conditions as will hereinafter be described. Ordinarily relay 709 does not operate. The ground on the BT lead makes the trunk busy at contacts of relay 1101 as described. The ground on the AG lead is to start testing devices by operating relay 1606 and ground on the ST lead is to start ringing tone.

When the operator answers, relay 711 is operated from battery and ground through its two windings, contacts of relay 605, left-hand windings of repeating coil 603, contacts of relay 611, over the tip and ring conductors to the operator at the central office. Relay 711 closes a circuit for the operation of relay 712 and this relay closes a circuit for the operation of relay 700. Relay 700 opens a circuit to the condenser 613 to remove the ringing tone to the calling subscriber and completes a circuit to contacts of relay 710 for coin line indications as will hereinafter be described. This relay 700 also closes a partial circuit for the lead ATB and opens the circuit for the AG lead, grounds the BT lead, opens the circuit for the left-hand winding of relay 708 and causes the release of relay 709, if it is operated over the TK lead indicating coin subscriber. Relay 709 in turn releases relay 710 and removes the coin tone. Relay 700 finally closes the holding circuit for the relay 706 through contacts of relay 701. The circuits are now in position for conversation.

The calling subscriber may give a flashing supervision to the distant operator over the trunk. When the subscriber flashes his switchhook, relay 600 follows the operation and in turn operates relay 605 to reverse the battery and ground to the distant office, the trunk connection being held at this time by the operator since the relay 706 is held at the contacts of relay 701 under control of relay 700.

The operator may check the calling line for coin tone indication by removing and reinserting the plug at the master office. Removal of the plug causes the release of the relay 711, which in turn releases the relay 712, and that in turn relay 700. The release of relay 700 operates relay 709 if there is a ground on lead TK to indicate coin subscriber, and this in turn operates the relay 710, which applies the coin tone. The tone is started over the TS lead. When the operator reinserts her plug, relay 711 reoperates and in turn operates relays 712 and 700. Relay 700 releases relay 709 and this in turn releases relay 710, which removes the coin tone indication. The circuit for this coin tone indication may be traced from ground to a condenser at the right-hand arma-

ture and front contact of relay 710, a contact of relay 700 to the ring conductor of the trunk over contacts of relay 611 and back over the tip conductor, contact of relays 611, 700 and 710, a condenser, tone lead DT through the left-hand winding of the tone repeating coil 1704.

If the calling subscriber disconnects, by replacing his receiver, before the operator disconnects, the relay 600 releases, which in turn releases relay 605 and this in turn reverses the battery and ground to the operator. If on the other hand the operator disconnects before the calling subscriber, relay 711 releases and in turn releases relay 712. Relay 712 releases relay 700 and grounds the AG lead and closes a circuit for the left-hand winding of relay 708 to the TP lead and grounds the start lead ST. If the subscriber fails to replace the receiver on the switchhook within a minimum of two minutes or maximum of five minutes, the ground pulse is received over the TP lead, which will in turn operate the relay 708, and relay 708 will lock to ground over a circuit that may be traced from battery over the left-hand winding of this relay, contact of relay 700 and 701, to ground at its inner right-hand armature and front contact. Relay 708 closes a connection to the TC lead and after two minutes interval ground is removed from this lead, which in turn removes ground from the S lead and the connection is automatically released.

If a call is made by an operator at a distant office over the trunk shown in Figs. 6 and 7 to call a subscriber in the office shown, the following operations take place. When this trunk is seized by the operator at the distant office, relay 711 operates, which in turn operates relays 712 and 700. Relay 712 closes a partial circuit for relay 602 and a partial circuit for relay 716. Relay 700 opens the circuit to the condenser 613 and closes a partial circuit for the ATB lead (all trunks busy chain). It also opens a circuit to the AG lead and grounds the BT, TLT and GRP leads and opens the circuit through the left-hand winding of relay 708 to prevent operation of this relay at this time. It also closes a partial circuit for the relay 706 and opens the circuit for relay 709 to prevent it from operating. Relay 602 is operated in the circuit from battery, its lower winding, make-before-break contact 716, contacts of relay 701 to ground at contacts of relay 712. This relay removes the relay 600 from the subscriber's line and provides a loop to the subscriber's line circuit through the right-hand winding of the repeating coil 703, from tip conductor, upper right-hand winding of repeating coil 703, contacts of relay 602, upper winding of this relay, contacts of relay 711, lower right-hand winding of repeating coil 703, the ring conductor of the connection to be established to the called subscriber's line as hereinafter described. Relay 602 also opens a circuit for the condenser 616 and relay 600.

The connections established by relay 700 cause an idle link to be connected to the calling trunk through the contact 517 of switch C. The operation of seizing the link is the same as when a calling subscriber seizes the link except that in this case the trunk group relays 907 and 908 provided for this group of trunks are operated. Relay 908 is operated over the GRP lead and relay 907 from ground at relay 1001. The trunk relay 1101 of this group of trunks is operated by relay 908. The line test relays 1005, 1012 and 1013, shown in Fig. 10, are connected through contacts of relay 1101 to ground over the TLT lead. In Fig. 11 there is shown the TLT lead

from the trunk shown in Figs. 6 and 7 connected to relay 1012 over contacts of relay 1101 and this relay 1012 then operates to complete the connection as described in connection with a call from a subscriber's line. The select magnet 503 is operated as usual on the operation of relay 1400 and when relay 1503 operates the holding magnet 513 is operated from battery through the winding of this magnet, the THM lead, contacts of relays 1116, 1101, 1007, 1012 and 1005, the LT lead, contacts of relay 1503 to ground at relay 1400 so that now the trunk is connected through contact 517 of switch C to the link. Then, as dial tone is received in the usual manner over the DT lead indicating that dialing may proceed, the operator proceeds to dial the number of the wanted subscriber's line. On the first break of the dial the pulsing relay 711 releases and relay 717 operates from battery through the winding of this relay, contacts of relays 711 and 701 to ground at 712. Relay 717 closes a circuit for the operation of relay 716 from battery, winding of this relay and its make-before-break contacts, contacts of relays 717 and 701, to ground at contacts of relay 712. Relay 716 locks over its left-hand armature and front contact to this ground at 711. Relay 717 now shunts out the right-hand windings of the repeating coil 702 and the bridged winding of relay 702 for the duration of each digit. Relay 716 locks under control of relays 712 and 701 and shifts the control of the lower winding of relay 602 to relay 717. Relay 711 transmits through its inner left-hand armature and front contact impulses over the tip and ring conductors through the link circuit to control the pulsing relays 1504 and 1501 to select the desired subscriber's line in the usual manner as hereinbefore described in connection with a call from any subscriber in the exchange. When dialing is completed the upper winding of relay 602 is again inserted between the right-hand windings of repeating coil 613 to maintain the loop to the called subscriber line, and the relay 717 releases. This leaves the upper winding of relay 602 inserted across the line loop through the link but relay 1304 does not operate. When the subscriber answers, it will be noted that relay 1304 operates and the link relays are released including relay 1414. Relay 1414 in releasing closes circuit for relay 1201 from battery, winding of this relay and its make-before-break contacts, contacts of relays 1414 and 1413 to the TK lead to ground at contacts of relay 701. Relay 1201 locks to the sleeve. Relay 1201 connects the called subscriber line directly to the trunk and relay 602 releases. Relay 600 is then operated from battery and ground through the windings of this relay, through the subscriber's loop as described. Relay 600 operates relay 605, which now reverses battery and ground to the operator, and relay 605 causes the operation also of relay 706. Relay 706 operates relay 701 and maintains ground on the sleeve lead. Relay 701 closes a partial circuit for the left-hand winding of relay 708 and maintains the all-trunk chain and places a holding ground on relay 706 under control of relay 700, and prepares a circuit for grounding the AG lead and holds a ground on the BT lead to keep the trunk busy and releases relay 716. When the subscriber replaces his receiver on the switchhook, relays 600 and 605 release and reverse battery and ground to the distant office. Relay 706 remains operated under control of relay 700 to maintain ground on the sleeve lead. When the operator connects, relays 711, 712, 700, 706 and 701 release in the

order described and the trunk restores to normal. The link is then fully reversed as described.

If a tandem connection is to be established through this system, the calling trunk will establish a connection through the cross-bar switch C over a link to the called trunk. When this connection is completed, the connection is transferred to the tandem switch and the connection to the link is released. The connection to the called trunk is established as already described. In this case as soon as the called trunk has been found in the cross-bar switch C, relay 1116 common to the group in which the called trunk is located operates as the associated relay 1101 is operated as described over a circuit from battery through the winding of this relay, contacts of relay 1101 of the called trunk group, contacts of relay 1104, contacts 517 of the calling trunk connection through the switch C over the TK lead to ground at the outer right-hand armature and back contact of relay 701 on the calling trunk. The operation of relay 1116 now operates the select magnet in the tandem switch TC for the level in which the called trunk is located as determined, of course, by the operation of this particular group relay 1116 of the group in which this trunk is represented by horizontal contacts in the switch TC. The circuit for this select magnet, which may be select magnet 520, is traced from battery through the winding of the select magnet 520, the TSM lead, upper inner armature and front contact of relay 1116, contacts of relay 1101, contacts of relay 1007 over the corresponding HM lead that corresponds to the certain register relay operated, depending on which trunk was selected. For example, if the first trunk in the group shown were selected, register relay 1510 is operated and a ground will be supplied for this lead HM through contacts of relay 1104 and over lead 1, contacts of relays 1510, 1509, 1508, 1507, 1506, 1511, 1520, 1503 and 1500 to ground at 1412. The operation of select magnet 520 closes a common circuit for the operation of relay 1015, which in operating closes an obvious circuit for the operation of relay 1016 and this relay in turn closes a connection to ground for the operation of the holding magnet 521 of the calling trunk in the tandem switch TL from battery through the winding of this magnet 521, contacts 517 of switch C, contacts of relay 1104 to ground at relay 1015. A connection will now, therefore, be established at contacts 522 from the conductors of the calling trunk to the conductors of the called trunk terminating at point 522. The switch C in the link will now be released. The operation of the magnet 521 closes a circuit for the operation of relay 611 in the calling trunk circuit from the battery winding of this relay, contacts of magnet 521 to ground. This relay opens a circuit for the repeating coil 708 and the tip and ring conductors to the switch C. This naturally releases the connection in the same manner as when an operator hangs up or, in the case of a call from a subscriber, the calling subscriber hangs up his receiver. Relay 611 connects a busy ground to the BT lead at its inner lower armature and front contact to prevent seizure of this trunk. It also connects at its inner upper armature and front contact a battery through a resistance through the TD lead. If the trunk shown in Figs. 6 and 7 may be considered for the moment as the called trunk, relay 608 is operated over the TD lead from battery through resistance and ground over contacts of relay 611 of the calling trunk to the TD lead, contacts 522 to the TD lead of the called trunk, contacts of

relay 611, of this called trunk and winding of relay 608 to ground. This removes ground from the TLT, GRP, and S leads and closes a connection to battery over a resistance 617 at its inner left-hand armature and front contact in shunt of the winding of relay 605 to prevent this relay from operation as relay 600 is now operated as usual. Relay 600 in operating extends the connection through the called trunk to call the operator at the distant office in the usual manner and when the operator answers the connections are established as hereinbefore described.

In the following description the operations of the circuits will be explained relating to the release of a link in case the called subscriber does not answer within a certain period, various tests for false ground connections and other troubles that may occur in the system and how alarms as indications of these conditions are detected. For example, it should be noted that when ground was applied to the AG lead as hereinbefore described to release a link, the testing equipment of Figs. 16 and 17 operates as follows: Relay 1606 operates from battery, contacts of relay 1603 to ground over lead AG. This relay operates relay 1609 and this relay in turn operates relay 1604, which operates relay 1603 and removes the ground from lead TC. The removal of ground from the TC lead has no effect at the present time on the link circuit, but the operation of relay 1603 releases relay 1606, which in turn releases the relays 1609 and 1604. The release of relay 1604 opens the circuit for relay 1603 and connects ground to the TC lead and also to the TP lead before relay 1603 releases. The ground on the TP lead operates relay 1401 from battery, upper winding of this relay, contact of jack 1222, contacts of relays 1302, 1304, 1401, lead TP to ground over contacts of relays 1603 and 1604. Relay 1401 locks under control of relay 1304 to ground at its own contact. Relay 1401 transfers the sleeve circuit from ground at contacts of this relay to ground on the TC lead. Now when the release of relay 1603 takes place, it disconnects the ground on the TC lead and again closes a circuit for relay 1606 and the above-mentioned cycle of operation is then repeated. This takes approximately two minutes and when after this period relay 1604 operates, it disconnects the ground from lead TC, causing the link to release by permanently removing the ground connection for the sleeve leads.

If an accidental ground develops on the TP lead, the connection would release at the desired time interval when ground is removed from the TC lead in the usual manner as the AG lead is grounded. In order to prevent this, relay 1611 operates from this ground on the TP lead and grounds the TC lead. The ground of the TC lead will then prevent releasing the connection. If the TC lead is accidentally grounded, the connection cannot be released by the timing relays. In either case when the AG lead is grounded by the supervisory link, the timing relays operate as described and when the relay 1604 operates, the relay 1610 operates from the ground on the TC lead and locks to the same ground. The relay 1610 operates the relay 1607 which functions to prepare an alarm circuit and connects a ground to the AG lead. This causes the timing relays to continuously go through their cycle of operations. If the trouble ground is a momentary condition, the relay 1611 will release as soon as trouble ground is disconnected from the TP lead, while the relay 1610 will release as soon as the

relay 1604 operates on the next cycle of the timing relay.

If trouble ground appears on the PU lead from the link circuit while the ringing interrupter circuit is normal, the relay 1601 operates on its left-hand winding from ground over this lead. Relay 1601 locks over this winding to the lead PUL and closes a circuit for the operation of relay 1607 to give an alarm.

If trouble ground appears on the interrupter start lead ST3, the relay 1601 will operate over its right-hand winding and lock to this ground. Relay 1607 will then operate as before.

The lead MPA is connected to the master pulsing lead over which the ground pulses for the ringing codes are connected in the link circuit. If a trouble ground should develop on this lead, the relay 1620 will operate over its right-hand winding and this relay will lock to ground over the lead MPL. The operation of relay 1620 closes a circuit for relay 1607. If a trouble ground should develop on lead RS while the interrupter relays are normal, this ground will be connected to the left-hand winding of relay 1620 and cause this relay to operate and lock on the same winding to lead RSL. Relay 1620 will operate relay 1607 as usual.

If either of the so-called master leads 11 or 12 is grounded while the ringing interrupter circuit is normal, the relay 1621 will operate over lead ML1 or ML2, as the case may be. The operation of relay 1621 closes circuits for locking to the trouble ground on leads 11 and 12 and operates the relay 1607 as usual.

The line 530 which is shown terminating in switch C may be used as a test line. Various tone signals are sent back to the calling testing operator to indicate whether or not any trouble condition exists in this office. If ringing tone is heard, it indicates that no alarm condition exists, while dial tone indicates a minor alarm; a major alarm is indicated by busy tone or the absence of any tone. This line may be seized in the same manner as the seizing of any other line by the testing operator. It will be noted that the operation of the holding magnet 531 closes a circuit over lead L for relay 1613. This relay closes a circuit for relay 1614 and short-circuits the tip and ring conductors of test line 530. Relay 1614 locks to the ground on lead L and releases relay 1613 and removes a short circuit for the tip and ring conductors of the test line 530. When now the timing means in the allotter circuit operates as hereinbefore described, a ground is received over lead 7 from the GD leads in the link circuit supplied at relay 1302. This closes a circuit for relay 1615 which completes a circuit from the ringing source at 1721 through condenser 1616 to tip conductor of the test line 530. This checks the timing relay in the allotter and the operation of the ringing interrupter and indicates that the office is working satisfactorily. Relay 1614 also grounds the BT lead in the control circuit to make the test line busy and operates relay 1600 to supply the busy tone as hereinbefore described. The various conditions that may be determined and indicated over the test line when called may be divided into major and minor alarms. The minor alarms are indicated by the white lamps if the guard key is operated to give a low tone indication over the test line and the major alarms are indicated by red lamps if the guard key is operated to give a busy tone indication to said lines in case of a false ground, or if the allotter timing relay does not operate there will be

no tone signal received over the test line as relay 1315 will not operate. The operator that performs the test over the line 530 can therefore determine in general whether or not the trouble indicated requires immediate attention or is of such minor nature that it may be attended to in such routine inspections that are made at regular intervals.

What is claimed is:

1. In a telephone system, a cross-bar switch, lines terminating in said switch, a common control circuit for controlling the establishing of connections through the switch between a calling line and a called line, means responsive to a calling subscriber removing his receiver from the switch-hook for seizing said control circuit and for establishing a connection between the calling line and the switch by the aid of said control circuit and for thereafter releasing said control circuit, and means responsive when the calling subscriber has dialed a called subscriber's number for again seizing said control circuit and for establishing a connection between the switch and the called line by the aid of said control circuit to connect the calling line with the called line and for thereafter releasing said control circuit.
2. In a telephone system, a cross-bar switch, lines terminating in said switch, a control circuit for controlling the establishing of connections through said switch between a calling line and a called line, a relay means responsive to a calling subscriber removing his receiver from the switchhook for seizing said control circuit and for establishing a connection between the calling line and the switch by the aid of said control circuit and for thereafter operating said relay, means responsive to the operation of said relay for releasing said control circuit, a second relay, means responsive when the calling subscriber has dialed another subscriber's number for again seizing said control circuit and for establishing a connection between the switch and the called line by the aid of said control circuit to connect the calling line with the called line and for thereafter operating said second relay, and means responsive to the operation of said second relay for releasing said control circuit.
3. In a telephone system, a cross-bar switch, lines terminating in said switch, a common control circuit for controlling the establishing of connections through said switch between a calling line and a called line, means responsive to the calling subscriber removing his receiver from the switchhook for seizing said control circuit and for establishing a connection between the calling line and the switch by the aid of said control circuit, a relay, means for operating said relay in response to the establishing of a connection from the calling line to the switch, means responsive to the operation of said relay for releasing said control circuit, a second relay, a third relay, means responsive when the calling subscriber has dialed another subscriber's number for again seizing the control circuit and for establishing a connection between the switch and the called line to connect the calling line with the called line by the aid of said control circuit, means responsive on the completion of said last-mentioned connection for operating said second relay in case the called line is idle and for operating said third relay in case the called line is busy or in case of a revertive call, and means responsive to the operation of either of said second or third relays for releasing said control circuit.
4. In a telephone system, a cross-bar switch,

party lines terminating in said switch, a control circuit for controlling the establishing of connections through said switch between subscribers on the same party line, means responsive to a calling subscriber removing his receiver from the switchhook for seizing said control circuit and for establishing a connection between the calling line and the switch and for thereafter releasing said control circuit, and means responsive when the calling subscriber has dialed the number of a subscriber on the same line for again seizing said control circuit and establish a connection to the same line by the aid of said control circuit and for thereafter releasing said control circuit.

5. In a telephone system, a cross-bar switch, party lines terminating in said switch, a control circuit for controlling the establishing of connections through said switch, means responsive to a calling subscriber removing his receiver from the switchhook for seizing said control circuit and for establishing a connection between the calling line and the switch by the aid of said control circuit and for thereafter releasing said control circuit, a relay operated when the calling line is connected to the switch, means thereafter responsive when the number of a subscriber on the same line has been dialed for again seizing the control circuit and establish a connection to the same line by the aid of said control circuit, means responsive to the completion of said last-mentioned connection for releasing said control circuit for releasing said relay, and means responsive to the release of said relay for completing the connection between the two subscribers.

6. In a telephone system, a cross-bar switch, party lines terminating in said switch, a control circuit for controlling the establishing of a connection through said switch, link circuits terminating in said switch, means responsive to a calling subscriber removing his receiver from the switchhook for seizing said control circuit and for establishing a connection from said subscriber's line at one connecting point of said switch to one end of a link circuit by the aid of said control circuit and for thereafter releasing said control circuit, a relay in said engaged link circuit operating when a calling line is connected to said link, means thereafter responsive when a subscriber's number on the same line has been dialed for again seizing said control circuit and establish a connection at another connecting point of said switch between said link and the calling line by the aid of said control circuit, means responsive to the completion of said last-mentioned connection for releasing said relay and for releasing said control circuit, means responsive to the release of said relay and to the calling subscriber replacing his receiver for ringing said other subscriber on said line, means responsive to the called subscriber removing his receiver from the switch hook for releasing said link and for preventing the reseizure of said control circuit and establishing of another connection through the switch as long as either subscriber's receiver remains off the switchhook.

7. In a telephone system, a cross-bar switch, lines each comprising a single conductor, a repeating coil having one side connected between the single conductor and ground and two conductors terminating in the switch and connected to the other side of the repeating coil, means for establishing a connection from a calling line to a called line through said switch, and means responsive to the establishing of such a connection for transmitting ringing current to the called line and for opening the connection between the

repeating coil and the called line and between the repeating coil and the switch.

8. In a telephone system, a cross-bar switch, two-conductor lines terminating in said switch, single-conductor lines each comprising a single conductor, a repeating coil having one side connected between the single-conductor line and ground and two conductors terminating in the switch and connected to the other side of the repeating coil, means for connecting a calling subscriber's line with a called subscriber's line through said switch, means responsive to the establishing of said connection for transmitting ringing current over the line conductors of the called subscriber's line if it is a two-conductor line and for transmitting ringing current over the single conductor if the called subscriber's line is a single-conductor line, and means operating in the latter case for entirely removing the repeating coil from the connection between the called subscriber's line and the switch.

9. In a telephone system, a cross-bar switch, two-conductor lines terminating in said switch, single-conductor lines each comprising a single conductor, a repeating coil having one side connected between the single conductor and ground and two conductors terminating in the switch and connected to the other side of the repeating coil, means for connecting a called subscriber's line with a calling subscriber's line through said switch, ringing relays, means responsive to the establishing of said connection for operating a ringing relay, means responsive to the operation of said ringing relay for applying ringing current over the line conductors of a called subscriber's line in case the called subscriber's line is a two-conductor line and for applying ringing current over the single conductor of a called subscriber's line in case the called subscriber's line is a single-conductor line and for entirely eliminating the associated repeating coil from the connection between the single conductor and the switch.

10. In a telephone system, a cross-bar switch, two-conductor lines terminating in said switch, single-conductor lines each comprising a single conductor, a repeating coil having one side connected between the single conductor and ground and two conductors terminating in the switch and connected to the other side of the repeating coil, means for connecting a calling subscriber's line with a called subscriber's line through said switch, ringing relays, means responsive to the establishing of said connection for operating a ringing relay, means responsive to the operation of said ringing relay for applying ringing current over the line conductors of a called subscriber's line in case his line is a two-conductor line and for applying ringing current over the single conductor of a called subscriber's line in case his line is a single-conductor line and for opening the connection between the single conductor and the repeating coil, and between the repeating coil and the two conductors terminating in the switch.

11. In a telephone system, a cross-bar switch, two-conductor lines terminating in said switch, single-conductor lines each comprising a single conductor, a repeating coil having one side connected between the single conductor and ground and two conductors terminating at the switch and connected to the other side of the repeating coil, an alternating current connection normally closed and a direct current connection normally open between the windings on said other side of the repeating coil, means for connecting a calling subscriber's line with a called subscriber's line

through said switch, ringing relays, means responsive to the establishing of said connection for operating a ringing relay, means responsive to the operation of said ringing relay for applying ringing current over the two conductors of a called subscriber's line in case said line is a two-conductor line, a relay associated with each single-conductor line, means responsive to the operation of said ringing relay if the called subscriber's line is a single-conductor line for operating the associated relay, means responsive to the operation of said associated relay for opening the connection between the single conductor and one side of the repeating coil to ground and for applying ringing current to the single conductor, a second relay, a circuit for said relay connected to the single conductor, and means responsive to the operation of said first relay for opening the alternating current connection and for opening the circuit for said second relay to maintain said direct current connection open.

12. In a telephone system, a cross-bar switch, lines, means for establishing connections between a calling line and a called line through said switch, said means including sets of relays, each relay having two windings, two energizing chain circuits for each set of relays, each circuit including a separate winding of each relay in a set, a source of current, and a fuse between each chain circuit and the source of current.

13. In a telephone system, a cross-bar switch, lines, means for establishing a connection between a calling line and a called line through said switch, said means including sets of relays and two identical chain circuits for each set of relays for operating one relay in each set during the establishing of a connection, a source of current, fuses, each fuse between an individual chain circuit and the source of current.

14. In a telephone system, a cross-bar switch, lines, means for establishing a connection between a calling line and a called line through said switch, said means including sets of relays, each relay having two windings, two chain circuits for each set of relays, a source of current, a fuse connected between each chain circuit and said source of current, a ground connection to both chain circuits of each set of relays connectable to the windings of said relays, means for connecting said circuits to ground through the windings of any one of said relays for the operation thereof, means controlled by an operated relay for rendering the relays in the chain circuits located between the associated fuse and the windings of the operated relay are made inoperative, and means controlled by said operated relay for rendering the remaining relays in a set ineffective in the control of the establishing of any other connection through the switch while any of said relays is operated.

15. In a telephone system, a first trunk and line connecting cross-bar switch, subscriber's lines terminating in said switch, trunks terminating in said switch, links for establishing connections between a calling line and a called line, or between a calling trunk and a called line or a calling line and a called trunk, a second tandem trunk connecting cross-bar switch, each of said trunks appearing in said second switch in two branches, one as a calling branch and the other as a called branch, and means for establishing a connection through said second switch between the calling branch of a calling trunk and the called branch of a called trunk.

16. In a telephone system, a selective switch, lines terminating in said switch, a common control circuit for controlling the establishing of

connections through the switch between a calling line and a called line, means responsive to a calling subscriber removing his receiver from the switchhook for seizing said control circuit and for establishing a connection between the calling line and the switch by the aid of said control circuit and for thereafter releasing said control circuit, and means responsive when the calling subscriber has dialed a called subscriber's number for again seizing said control circuit and for establishing a connection between the switch and the called line by the aid of said control circuit to connect the calling line with the called line and for thereafter releasing said control circuit.

17. In a telephone system, a first trunk and line connecting cross-bar switch, subscriber's lines terminating in said switch, trunks terminating in said switch, links for establishing of a connection between a calling line and a called line, between a calling trunk and a called line through said switch, a second tandem trunk connecting cross-bar switch each of said trunks appearing therein with two branches, one as a calling branch and the other as a called branch, and means for establishing a connection from the calling branch of one trunk to the called branch of another through said second switch with the temporary aid of a link and the first switch.

18. In a telephone system, a first trunk and line connecting cross-bar switch, subscribers' lines terminating in said switch, groups of trunks terminating in said switch, links for establishing a connection through said switch between a calling line and a called line, between a calling line and an idle trunk in any group or between a calling trunk in any group and a called line, a second tandem trunk connecting cross-bar switch each of the trunks in said groups terminating in said second switch in two branches, one as a calling branch and the other as a called branch, and means for establishing a connection from the calling branch of a calling trunk in one group to the called branch of an idle trunk in another group through said second switch through the temporary use of the first switch and the link to select the group and an idle trunk in said group to which a connection will be made through said second switch.

19. In a telephone system, a cross-bar switch, lines each comprising a single conductor, a repeating coil having one side connected between the single conductor and ground and two conductors terminating in the switch and connected to the other side of said repeating coil, means for establishing a connection from a calling line to a called line through said switch over said two conductors, a relay associated with each of said lines, ringing relays, means responsive to the establishing of such a connection for actuating a ringing relay and for actuating the relay associated with the called line under control of said operated ringing relay over a circuit connection including a conductor other than the two conductors over which the connection was established, and means responsive to the operation of said relay for entirely removing the repeating coil from the connection between the calling subscriber and the called subscriber.

LANGFORD J. BOWNE.

FREDERICK R. LAMBERTY.

GRACE MACDONALD STOKELY.

Executrix of the Estate of Ray L. Stokely, Deceased.