

Oct. 22, 1935.

G. V. KING

2,018,457

TELEPHONE SYSTEM

Filed May 22, 1934

9 Sheets-Sheet 1

FIG. 10

FIG. 1	FIG. 2	FIG. 3	FIG. 4
FIG. 5	FIG. 6	FIG. 7	FIG. 8
		FIG. 9	

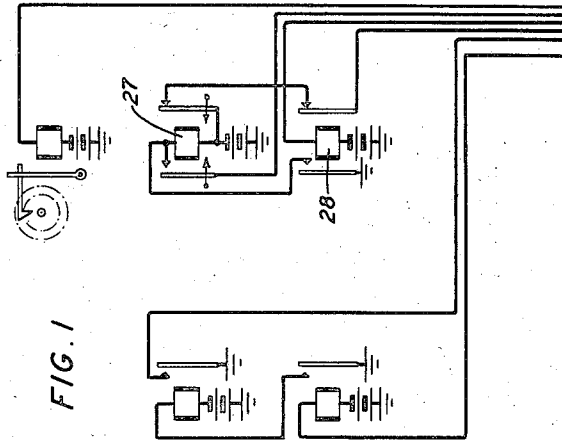
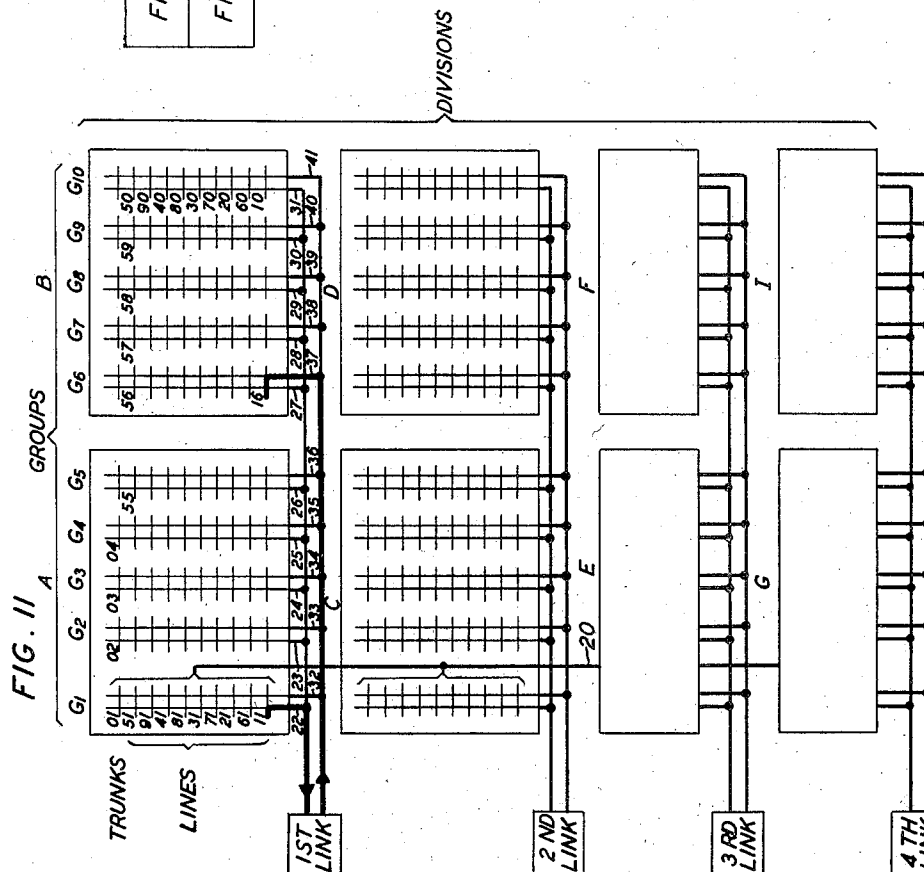


FIG. 1



INVENTOR
G. V. KING

BY

M. B. McHenry
ATTORNEY

Oct. 22, 1935.

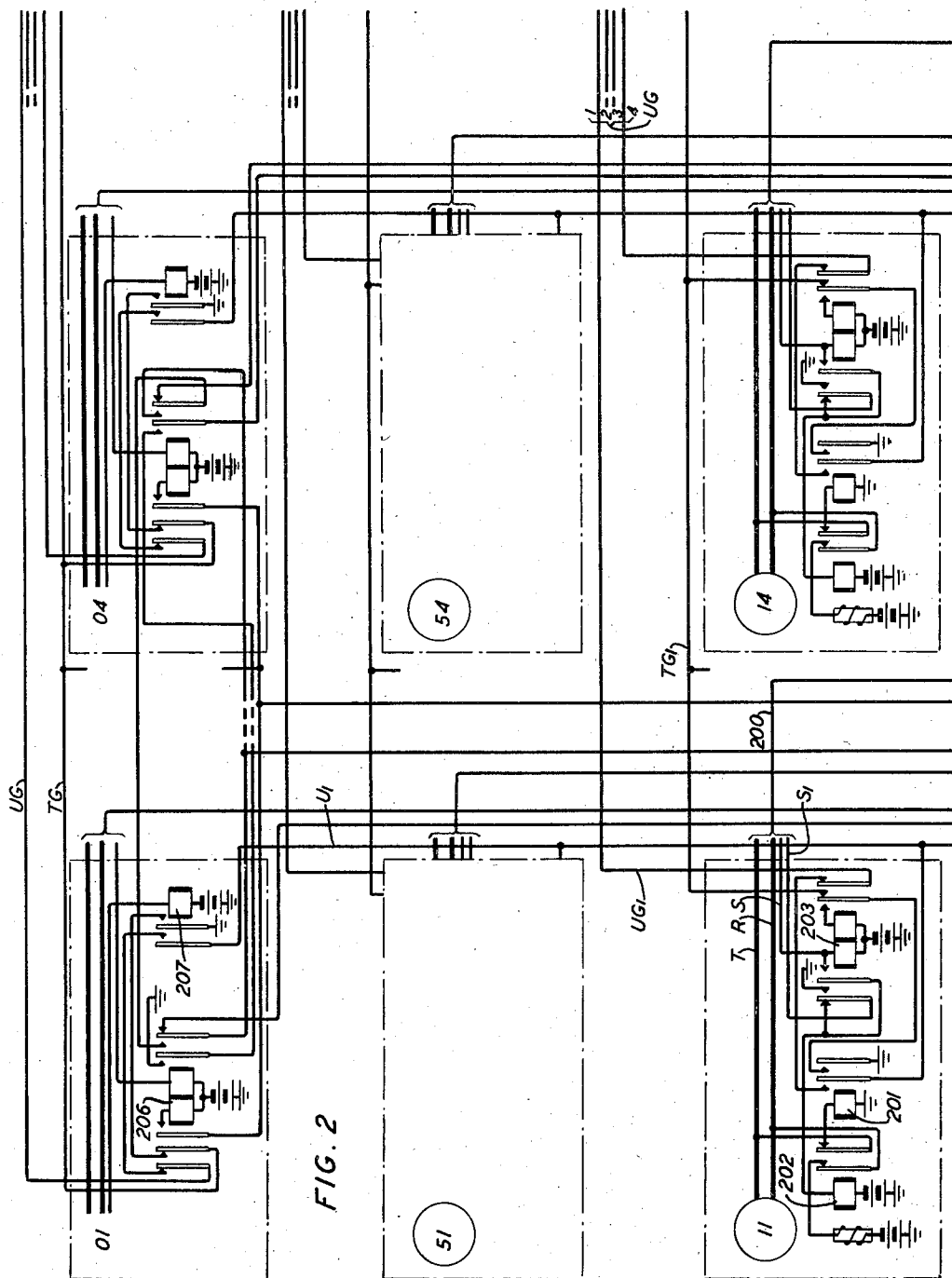
G. V. KING

2,018,457

TELEPHONE SYSTEM

Filed May 22, 1934

9 Sheets-Sheet 2



INVENTOR
G. V. KING

BY

M. J. McManey
ATTORNEY.

Oct. 22, 1935.

G. V. KING

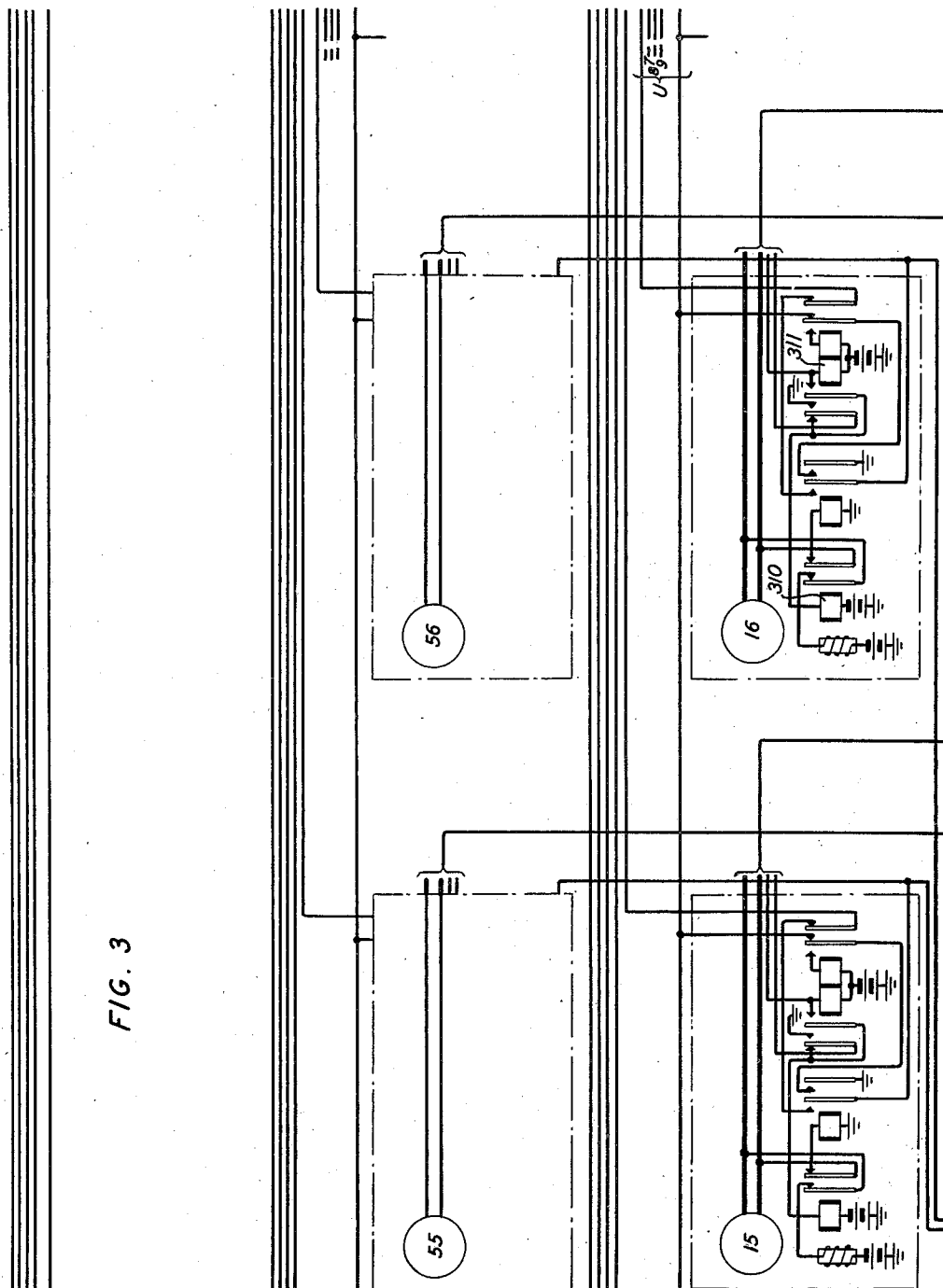
2,018,457

TELEPHONE SYSTEM

Filed May 22, 1934

9 Sheets-Sheet 3

FIG. 3



INVENTOR
G. V. KING

BY

James H. [Signature]
ATTORNEY

Oct. 22, 1935.

G. V. KING

2,018,457

TELEPHONE SYSTEM

Filed May 22, 1934

9 Sheets-Sheet 4

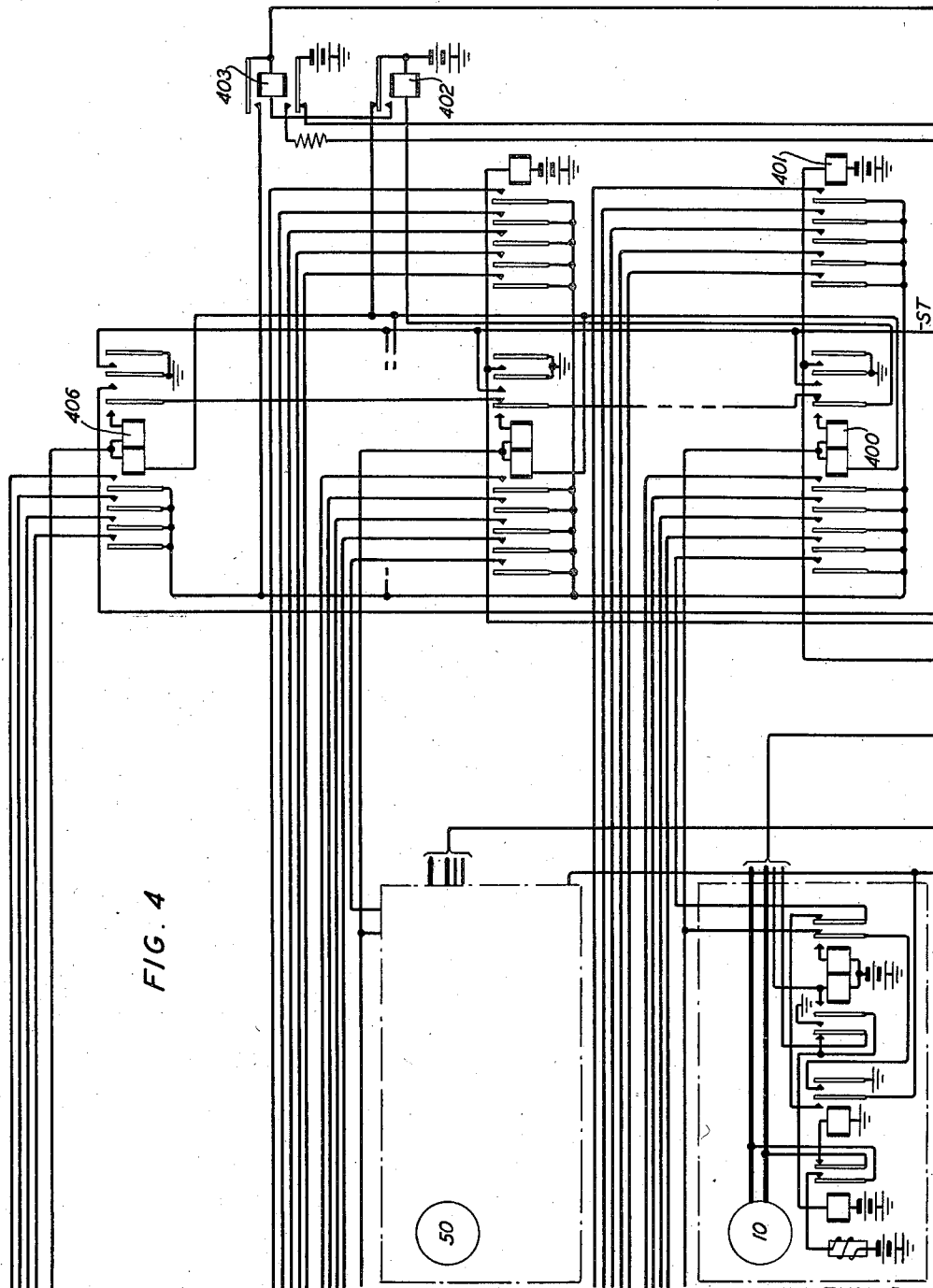


FIG. 4

INVENTOR
G. V. KING

BY
W. B. Kenney
ATTORNEY

Oct. 22, 1935.

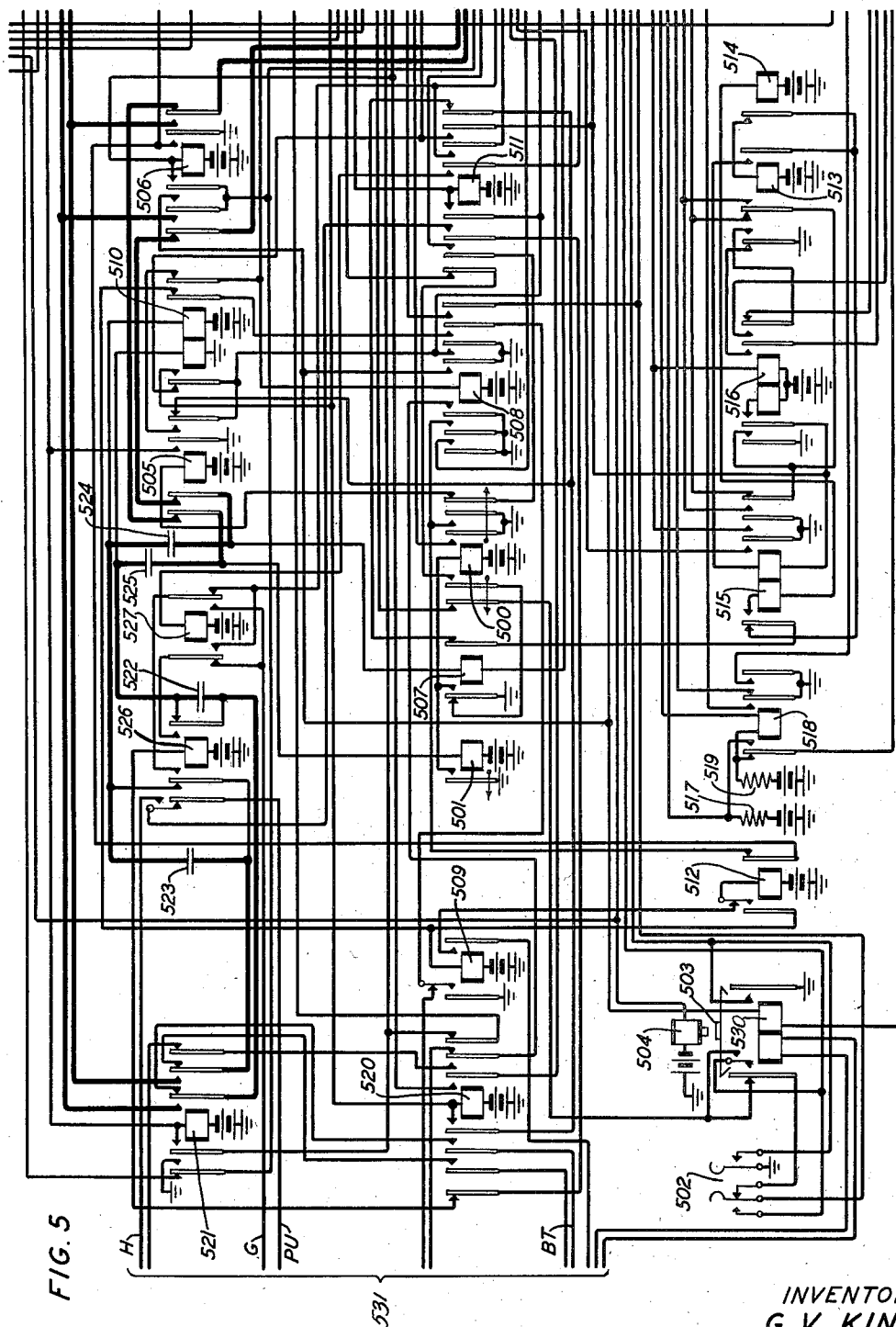
G. V. KING

2,018,457

TELEPHONE SYSTEM

Filed May 22, 1934

9 Sheets-Sheet 5



INVENTOR
G. V. KING

G. V. KING

BY

ATTORNEY

Oct. 22, 1935.

G. V. KING

2,018,457

TELEPHONE SYSTEM

Filed May 22, 1934

9 Sheets-Sheet 6

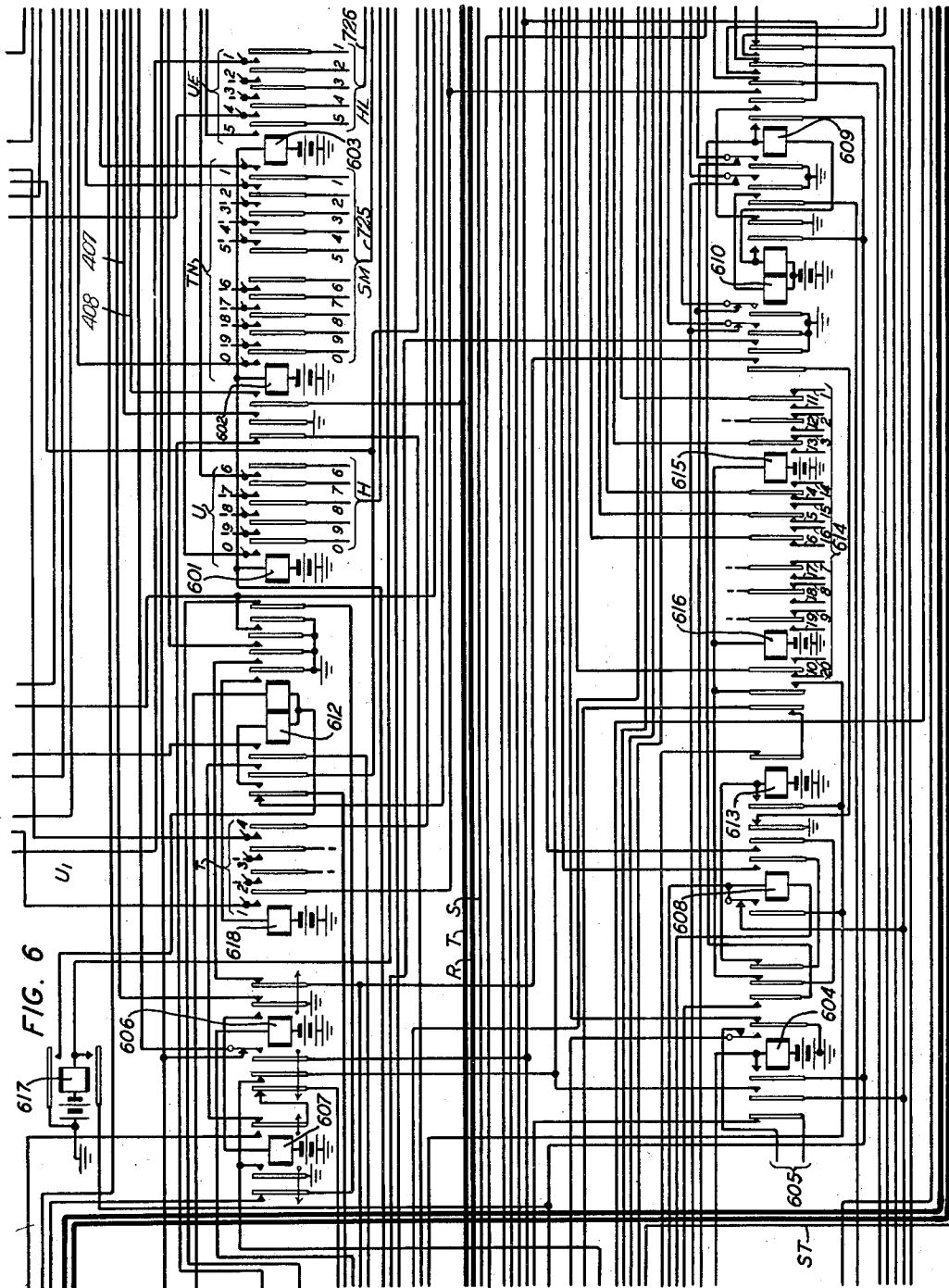


FIG. 6

INVENTOR
G. V. KING

BY

James W. McFadden
ATTORNEY

Oct. 22, 1935.

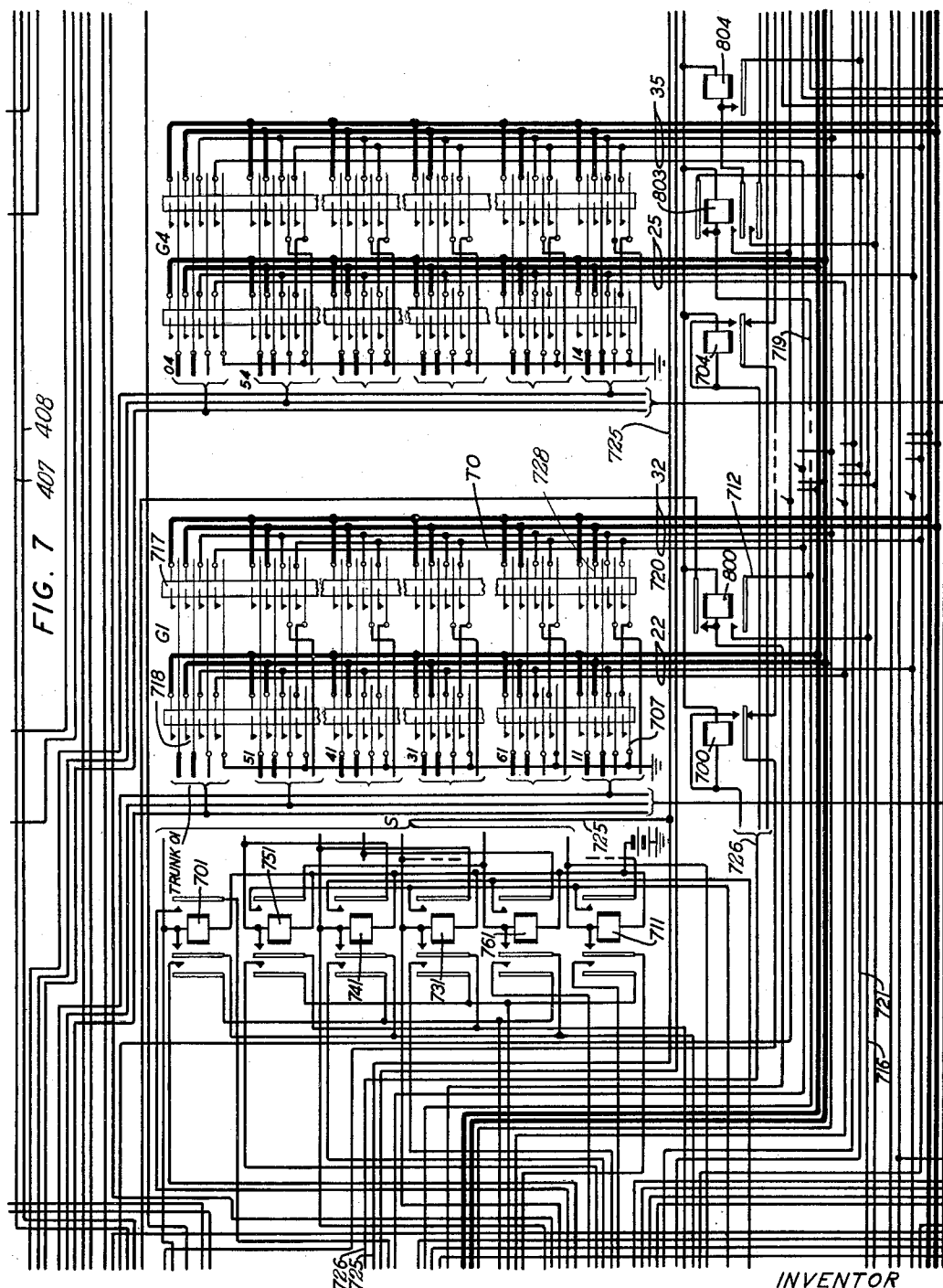
G. V. KING

2,018,457

TELEPHONE SYSTEM

Filed May 22, 1934

9 Sheets-Sheet 7



INVENTOR
G. V. KING
BY *[Signature]*
ATTORNEY

Oct. 22, 1935.

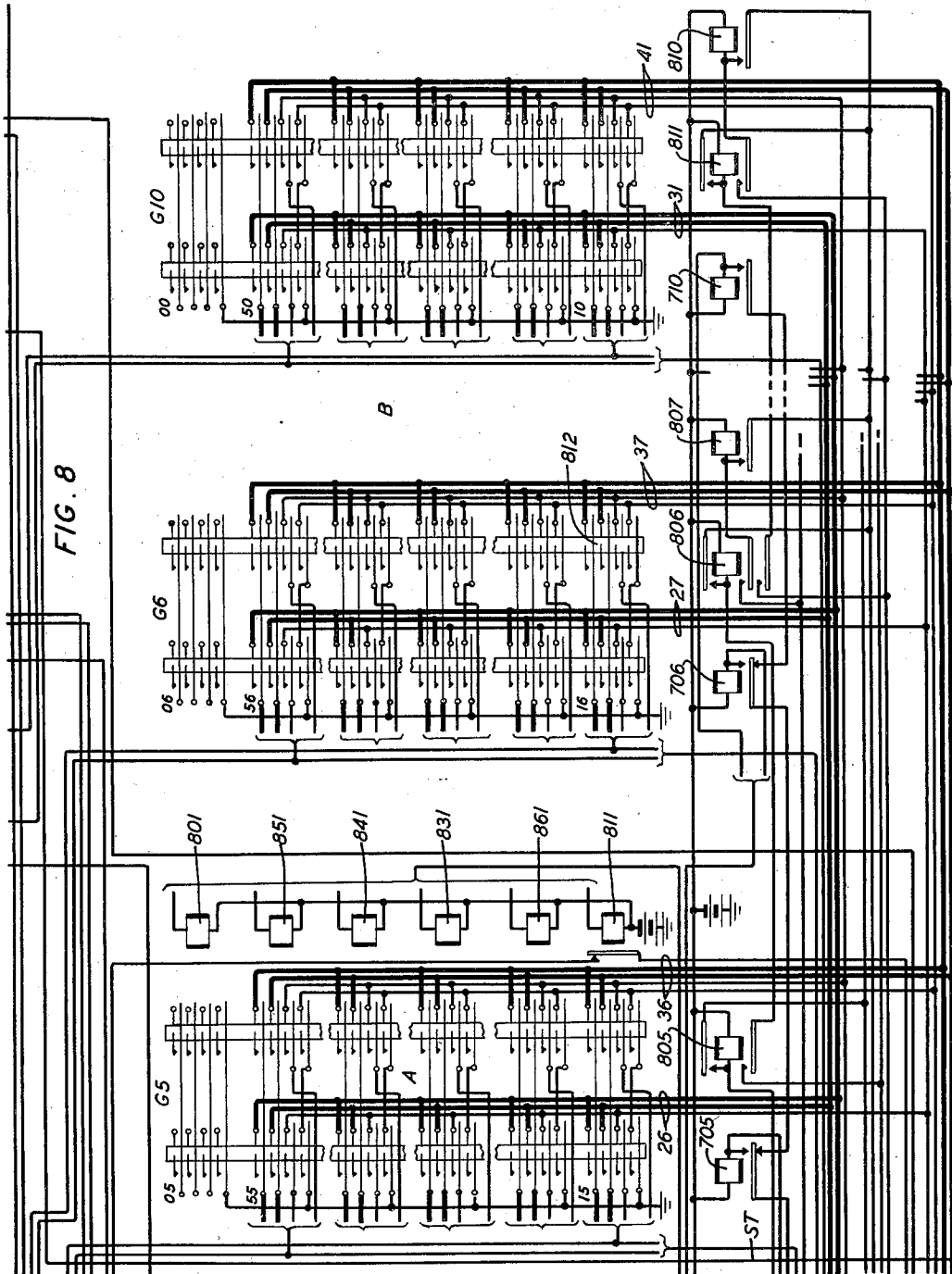
G. V. KING

2,018,457

TELEPHONE SYSTEM

Filed May 22, 1934

9 Sheets-Sheet 8



INVENTOR
G. V. KING

BY *M. B. McFenney*
ATTORNEY

Oct. 22, 1935.

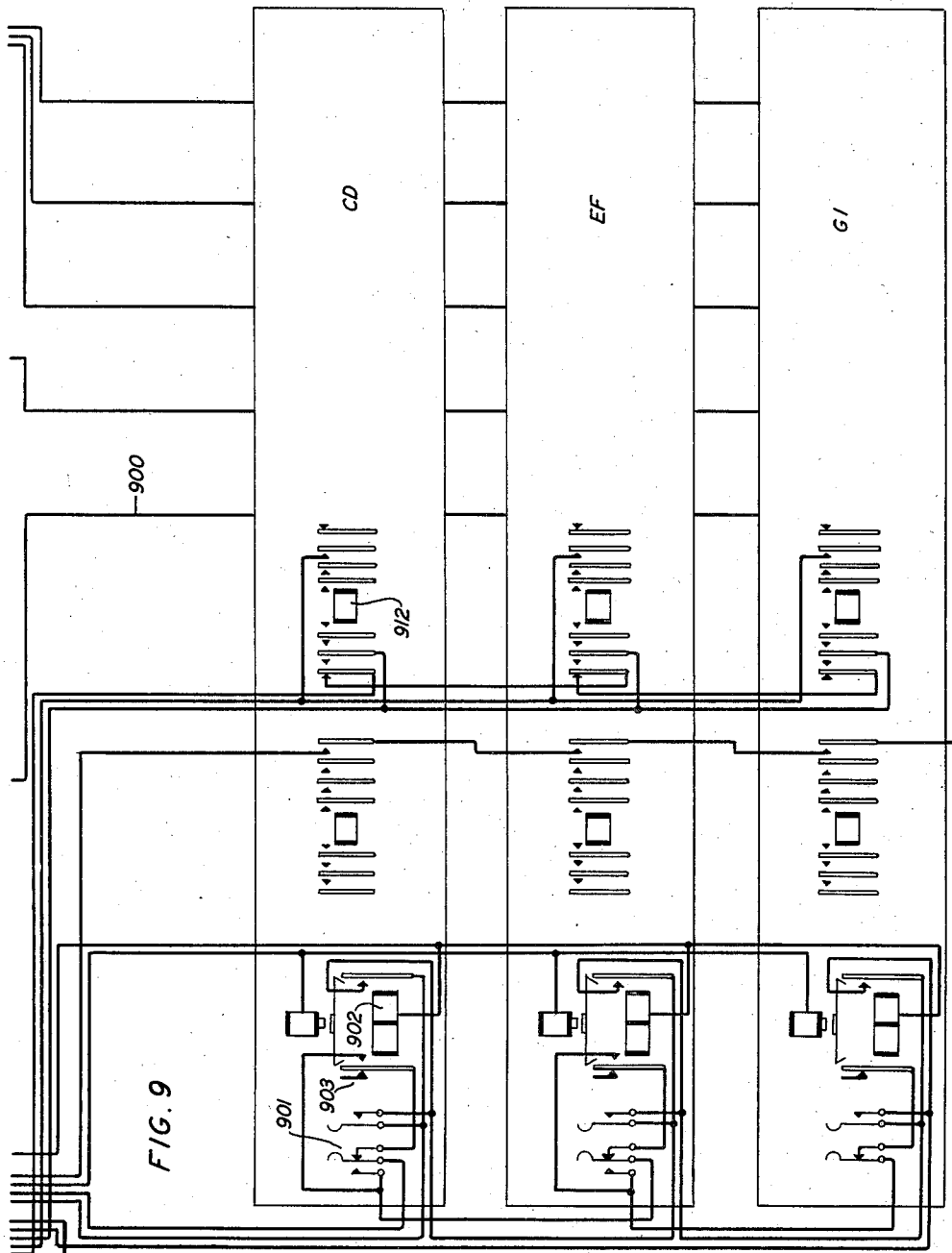
G. V. KING

2,018,457

TELEPHONE SYSTEM

Filed May 22, 1934

9 Sheets-Sheet 9



INVENTOR
G. V. KING

BY
G. V. King
ATTORNEY

UNITED STATES PATENT OFFICE

2,018,457

TELEPHONE SYSTEM

Gerald V. King, Chatham, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application May 22, 1934, Serial No. 726,901

9 Claims. (Cl. 179—18)

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

An object of the invention is to provide improved and economically arranged systems for automatically establishing connections between telephone lines by means of switching units of the cross-bar type.

Heretofore systems have been provided in which connections may be established from any line to any other line in a single cross-bar switch through linking arrangements. A system of this kind has been shown in the patent to L. R. Waller 1,567,309 of December 29, 1925. Other systems have been provided where lines have been divided into groups in the same cross-bar which with linking arrangements having incoming or calling branches and outgoing or called branches appearing at each group whereby a calling line may be connected to a called line through an idle link. A system of this kind is disclosed in the copending application of H. M. Bascom and O. A. Friend, filed October 7, 1933, Serial No. 693,676. In still other systems incoming lines have been arranged for connection with outgoing lines through cross-bar switches in such a manner that the incoming lines are multiplied to appear in groups in separate parts of a plurality of switches and with a different group of outgoing lines appearing in each switch. By this arrangement an incoming line may be connected only to a particular group of outgoing lines. A system of this kind has been disclosed in the patent to B. A. Betulander of June 16, 1925, 1,542,361.

A feature of the present invention is a system using cross-bar switches with lines and linking arrangements of the general types disclosed in the above mentioned systems and in which a plurality of switches are arranged in divisions with one or more switches in each division depending upon the capacity of the systems. All lines are multiplied to appear in each division and are arranged in groups in separate parts of the switches in each division and a single separate linking arrangement is provided for each division with a calling branch and a called branch appearing in each part of the switches in this division. Circuit means are provided whereby a calling line may be connected to a called line through an idle link and the associated division of switches, with the calling line connected directly to a calling branch and the called line connected directly to a called branch of this link. The branches used for the connections are those

that appear at the parts of the switches where the lines are located.

Another feature is an arrangement of this kind in which trunks may be multiplied to appear in each division and arranged with the lines in the groups in the separate parts of each division. Circuit means is provided whereby a calling line may be connected to an idle trunk through an idle link. A calling line is in this case also connected to a calling branch of the link and the trunk is connected to a called branch of the link. The branches used appear at the parts where the calling line and the idle trunk are located.

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

Figs. 1 to 9 show one embodiment of the invention with the circuit details complete for a portion of the lines and trunks only.

Fig. 10 shows the arrangement of Figs. 1 to 9 when reading the circuit; while Fig. 11 shows a schematic of the general arrangement of the links and switches.

Cross-bar switches have been used which may be of any well known type in which the operation of a horizontal bar and a vertical bar causes contacts at the intersecting point to establish a connection between a calling line and a called line, a calling line and a trunk or a trunk and a called line through a link.

Referring now specially to the arrangement shown in Fig. 11, the invention has been illustrated in connection with a system for ninety lines and from one to ten trunks making a total of one hundred connections. Four links have been shown 1, 2, 3, and 4, although more links may be used. Each link serves a division of switches, each division comprising two switches. The first division comprises switches A and B, the second division comprises switches C and D, the third division comprises switches E and F and the fourth division comprises switches G and I. All the lines and trunks are multiplied to appear in each division. The lines are arranged in groups G1 to G10 in separate parts of the switches, groups G1 to G5 appearing in switches A, C, E and G in the four divisions and the groups G6 to G10 appear in switches B, D, F and I in the four divisions while one trunk appears in each group and is multiplied from one switch to the other as indicated by the line 20 for group G1. The trunks appear in the first horizontal row of cross-connecting points and the lines appear in the remaining rows of nine horizontal cross-connecting points. The lines and trunks in each group are arranged to be connected to an in-

coming and an outgoing branch of the associated link. These branches are shown at 22 to 31 for the incoming branches and at 32 to 41 for the outgoing branches of the link 1 in the first division. Similar branches are provided for links 2 to 4 in the succeeding corresponding divisions as shown. Thus for each division comprising two switches, there appear ten groups of nine lines and one trunk in each group with an outgoing and an incoming branch of link 1 for each group. The lines and trunks may be numbered as shown in the first division. Connections may therefore be established from any subscriber's line in any group to any other subscriber's line in any group from any trunk to any subscriber's line and from any subscriber's line to any trunk. For example, if link 1 is idle and line 11 in group G1 is calling line 16 in group G6, a connection is established from line 11 to the branch 22 through the link 1, through branch 37 to line 16 as indicated by a heavy line.

Referring now in general to the Figs. 1 to 9 arranged as shown in Fig. 10, a complete system of the arrangement shown in Fig. 11 has not been shown but only sufficient details to clearly illustrate the working of the circuit in connection with link 1. For example, in Figs. 7 and 8 only portions of the switches A and B has been shown. In switch A, portions of the group G1, G4 and G5 have been shown, while in switch B portions of the groups G6, and G10 have been shown. In these groups mentioned only the contacts at the cross-connecting points of the lines appearing in the horizontal rows beginning with lines 11, 61, 31, 41 and 51 and the trunks appearing in the upper horizontal row of the groups shown, that is for example in the lower horizontal row lines 11, 14, 15, 16 and 10 appear and in the upper horizontal row trunks 01, 04, 05, 06 and 00 appear. To establish a connection through either of these switches, a magnet is provided for operating the horizontal bar corresponding to each row of lines and the row of trunks. These magnets corresponding to the rows mentioned have been shown and designated in switch A, 711, 761, 731, 741, 751 and 701, while in switch B the selecting magnets have been designated 811, 861, 831, 841, 851 and 801. These magnets may be called selecting magnets. A magnet is also provided for each vertical bar for the incoming branches and for each vertical bar for the outgoing branches. The magnets corresponding to the groups G1, G4, G5, G6 and G10 shown have been designated for the incoming branches 700, 704, 705, 706 and 710 and the magnets for the outgoing branches have been designated 800, 804, 805, 806 and 810. These magnets may be called holding magnets. The operation of a selecting magnet and a holding magnet for an incoming branch establishes a connection between a calling line and this branch while the operation of a selecting magnet and a holding magnet of an outgoing branch establishes a connection between a called line and this branch. In Figs. 2, 3 and 4 have been shown partly completely and partly by the aid of dash-dotted line boxes the subscribers' line circuits for the lines 11, 14, 15, 16, 10, 51, 54, 55, 56 and 50. Corresponding equipments for trunks 01 and 04 have been shown. In various places throughout these drawings, circuits from the various lines to the switches A and B have been bunched and indicated by a single line and a bracket at each end. It should be noted that at each cross-point of the switches four connections may be made, three of which are the usual tip, ring and sleeve

connections while the other is a supplementary connection wired in various ways depending on the type of connection as will be hereinafter described. In Fig. 4 besides the equipments for lines 10 and 50, there is shown a group of relays that are common to the lines or trunks in each horizontal row. In Figs. 5 and 6 there has been shown the relay equipment required for link 1. In Fig. 9, certain connections and equipment have been shown for the remaining links 2, 3 and 4 enclosed in boxes that have been marked CD for link 2, and switches, EF for the third and GI for the fourth link and switches in the corresponding divisions, and in Fig. 1 has been shown relays common to all the links.

Referring now in general to the method of establishing connections by means of this system and the type of lines between which connections may be established; it should be understood that certain of the lines may be single lines and others may be party lines. Of the party lines there may be two types, one having ten parties and another twenty parties on the line. Connections may be established from any line to any other line and the desired party on the called line may be called by means of an individual ringing code. Calls may also be established from any calling line to an idle trunk outgoing from the office and calls may be received by this equipment over a trunk incoming to a line, whether a single subscriber's line or a party line. Four digits must be dialed to establish a connection from any line to any other line. The first digit in case the call is intended for a single subscriber's line or a ten-party line, may consist of either two impulses or five to nine impulses, as the system is arranged to make a first digit having one impulse ineffective. If a twenty-party line is called, the first digit must be either three or four impulses. If three impulses are dialed, preliminary selection takes place in the system of one set of ten parties on this line and if four impulses are dialed, preliminary selections are made to select the other set of ten parties on the line. The second digit may consist of any number of impulses from one to nine and the second digit being the tens digit selects the horizontal row of ten subscribers' lines in which the desired subscriber's line is located. The third digit which is the unit digit may consist of from one to ten impulses and selects the desired subscriber's line in the horizontal row selected by the tenth digit, by selecting the vertical row in which this subscriber's line is located. The fourth digit may consist of from one to ten impulses and selects the proper ringing code if a ten or twenty party line has been selected, while if a single party line has been selected the fourth digit will, of course, always be the same to select a code signal individual to single party lines. If the calling line desires a trunk connection a single digit consisting of ten impulses must be dialed. This will select the single horizontal row in which the trunks are terminated and trunk hunting for an idle trunk takes place automatically to connect the calling line with an idle trunk.

A description will now be made of the actual operations taking place when the calling subscriber 11 dials to establish a connection with a called subscriber 16 over link 1, assuming that the called subscriber 16 is a single party line. A description will then be made of the different operations required when calls are made to party lines and to secure a trunk, followed by a description of a call from a trunk to a subscriber's line.

When a call is originated by the removal of the switch-hook at the subscriber's station 11 relay 201 is operated from battery through contacts of relay 202 over the ring conductor back over the subscriber's loop and through the tip conductor, contacts of relay 202, winding of relay 201 to ground. The T, R and S leads are connected as shown by the conductors 200 to the contacts of the switch A at the cross-point for this line and the incoming branch 22 and outgoing branch 32 and multiplied to corresponding cross-points of link 1 at all of the other links as indicated by the line 900. Relay 201 in operating connects ground to the lead TG1 for the operation of relay 400 which with the relay 401 is common to all the lines in this horizontal row. This connection may be traced from battery and contacts of relay 402, left-hand winding of relay 400, lead TG1, contacts of relay 203, contact of relay 201 to ground. This causes the operation of relay 400 and relay 400 closes an obvious circuit for the operation of relay 401. Relay 400 in operating closes a circuit for the operation of relay 402 from battery through the winding of relay 402, the right hand winding of relay 400 to ground at relay 201. Relay 402 in operating opens the circuit from battery through the left-hand winding of relay 400 so that these relays are now locked from this battery through the right-hand winding of relay 400. Relay 400 closes a connection to ground for the start lead ST for the operation of relays 601, 602 and 603 in link 1 if this link is idle. The circuit for these relays may be traced from battery through the windings of these relays, contacts of relay 500, contacts of relay 500 and key 502, start lead ST to ground at relay 400. If link 1 had been busy, this start lead connection from ground at relay 400 would have been transferred through the operation of relay 530 at the left-hand armature and front contacts to the circuit through the key 901, contacts of relay 902, to the lead 903 which leads to the relays in link 2 corresponding to relays 601, 602 and 603 in link 1. If link 2 is busy, the connection would have been transferred to the succeeding idle link. Relay 530 will be operated when link 1 has been seized as will presently be described and lock its armatures in operated position by the hooked armature 503 of relay 504 to maintain it operated as long as the link is busy. When the link becomes idle, relay 504 will operate and release relay 530.

Relays 601, 602 and 603 in operating cut through the TN leads 0 to 9 to the SM leads to the ten selecting magnets of the switches A and B. Six selecting magnets of each switch have been shown. These connections are indicated by lead 725 and its brackets. One of these selecting magnets will be operated due to the horizontal row in which the calling line is located. As the calling line is located in the first or lower row in the switch A, the selecting magnet 711 will be operated over a circuit from battery through the winding of this magnet, lead 725, the No. 1 contact and armature of relay 603 and corresponding TN lead to ground at relay 400. The corresponding selecting magnet 811 will also be operated. This is immaterial in this case as the calling line is located in switch A. A connection is also established through the relays 601, 602 and 603 for the holding magnets of the incoming branches of link 1 for all the groups in switches A and B. However, the only one that will be operated is holding magnet 700. The circuit for this magnet may be traced from battery through

its winding through the connection represented by lead 726, the corresponding holding leads HL, the No. 1 contact and armature of relay 503, the U1 lead of group UE, armature and front contact of relay 201, an armature and back contact of relay 203, lead UG1 of the group US1 an armature and front contact of relay 401 and an armature and front contact of relay 403 to ground on the lead 407 at an armature and front contact of relay 602. The operation of these two magnets 711 and 700 causes a connection to be established at the cross connecting point 707 for the tip ring and sleeve conductors of the calling line 11 to the corresponding conductors of the branch 22 of link 1. Relay 602 also closes a connection at its inner left-hand armature and front contact from the tip conductor of the incoming branch of the link over the lead 408, through a resistance to battery at the lower armature and front contact of relay 403. The battery over the lead 408 now aids in the operation of relay 501 as this relay is now also connected to the calling line in multiple with the line relay 201 in the calling subscriber's line circuit and might not operate over the loop over the subscriber's loop. The circuit for the operation of this relay 501 may be traced from battery, winding of relay 501, contacts of relay 535, contacts of relay 506, the ring conductor of the incoming branch 22 of link 1, the ring connection at the cross-point 707, the ring conductor of the calling line over the calling subscriber's loop, over the tip conductor, contacts of relay 202, winding of the line relay 201 to ground. The connection to the battery at contacts of relay 403 aids in the operation of this relay. Relay 501 in operating closes an obvious circuit for the operation of relay 500. Relay 507 is now also operated over the tip conductor from the battery on the lead 408 at the contacts of relay 403, contacts of relay 603 to the tip lead, and armature and back contact of relay 506, contacts of relay 505, winding of relay 507, contact of relay 604, to ground at the dial tone source at 605 (not shown). This connection from the dial tone source 605 also extends through the cross-connecting point at 707 to the tip conductor of the calling subscriber's line to transmit dial tone to the calling subscriber to indicate that the circuit is ready for dialing.

In the meantime the operation of relay 500 opens the circuit for relays 601, 602 and 603 at its outer left-hand armature and back contact and the release of these relays 601, 602 and 603 opens the circuit for the selecting magnets 711 and 816 so that these magnets are now released. While the holding magnet 700 has closed a holding circuit for itself through its armature and front contact, contacts of relay 509, contacts of relay 500 to ground. The holding magnet 700 maintains the connection at 707 independent of the selecting magnet 711. Relay 500 now causes the operation of relay 508 from battery, winding of this relay, contacts of relay 602 contacts of relay 500 to ground. The operation of relay 508 closes a circuit for the operation of relay 509 from battery through the winding of this relay, contacts of relay 510, contacts of relay 503, make-before-break contact of relay 509 to ground at an interrupter circuit connected at 531 (not shown). Relay 509 locks at its left-hand armature to ground and closes at one point a circuit for the operation of relay 512, from battery through the winding of this relay, make-before-

break contacts thereof through contacts of relay 509 to a ground from an interrupter circuit at 531 (not shown) that will be supplied after a certain interval thereafter. When relay 512 operates it locked at its left hand armature and front contact in parallel with relay 509. The purpose of these relays is to release the holding magnet 700 after the lapse of this interval in case the calling subscriber does not dial within this period. It should be noted that relay 530 is also operated by the operation of relay 508 to advance the start wire for receiving on the next idle link a succeeding call. This circuit may be traced from battery at the armature and back contact of relay 403, winding of relay 530 to ground at relay 508. It should be noted that relay 403 has released by this time due to the release of relay 400 with relay 402 on the operation of relay 203 which takes place simultaneously with the operation of relay 530. The circuit for relay 203 may be traced from battery, left-hand winding of this relay over the sleeve leads through the connection at the cross-connecting point 707 to ground at relay 508. This causes the release of relays 400 and 402 which in turn causes the release of relay 403. Relay 530 in operating is locked by the armature 503 of relay 504 to maintain the link busy and to transfer as stated the start lead to the next link.

Dialing for the desired subscriber's line will now take place. As hereinbefore stated the first digits determine the kind of party desired, whether a single, ten-party or twenty-party line. In case of a single or ten-party line the first digit may be any digit except, 1, 3 and 4 and the operations caused by the first digit is the same in all cases. In the case of a twenty-party line the digits 3 or 4 should be dialed. The operation is then somewhat different. If now the calling subscriber dials, for example, the digit 6 to secure a connection to a single party line or a ten-party line the relay 507 is released at the beginning of the first impulse. Relay 501 may be slow-to-release and thus assist in maintaining relay 509 operated during the pulsing. The release of relay 507 closes a circuit for relay 606 from battery, through the winding of this relay, contacts of relays 511 and 500 to ground at the left-hand armature and back contact of relay 507. Relay 606 closes an obvious circuit for the operation of relay 607. These two relays remain operated during the pulsing as they are slow in releasing. Another relay operated by the release of relay 507 is the relay 513 from battery, through the winding of this relay, contacts of relays 514, 515, 507, 511 and 505 to ground at relay 508. The operation of relay 513 closes a circuit for the operation of the first selecting magnet 711 and the companion selecting magnet 811 from battery, selecting magnets 711, 811 in parallel contacts of relay 609, contacts of relay 516, contacts of relay 513 to ground. At the end of the first impulse when relay 507 is again operated a circuit is closed for the operation of relay 515 from battery, winding of relay 513, contacts of relay 514, contacts of relay 513, right-hand winding of relay 515, contacts of relay 607 to ground. Relay 515 in operating, closes an obvious circuit for the operation of relay 516 through its right-hand winding. Relay 516 in operating closes a locking circuit for selecting magnets 711 and 811, while relay 515 in operating opens the original energizing circuit for these magnets. On the second impulse when the relay 507 is again released, a circuit is closed for the operation of

relay 514 from battery, through the winding of this relay, left-hand winding and contacts of relay 515 to the ground on relay 508 over the circuit hereinbefore described. Relay 514 in operating opens the circuit for relay 513 which now releases to close the circuit for the second selecting magnets, not shown, but whose energizing circuit is closed through the right-hand contacts of selecting magnet 711, through contacts of relay 609, contacts of relay 516 to ground at contacts of relay 513. At the end of the second impulse, relay 507 is again operated causing the release of relays 515 and 514. The release of relay 515 closes a locking circuit for the second selecting magnet through an inner left-hand armature and front contact of the second selecting magnet for switch A, over a connection through the outer right-hand armature and back contact of relay 515 to ground at the outer left-hand armature and front contact of relay 516. Relay 205 in releasing also opens locking circuit for the first selecting magnets 711 and 811. Relay 516 is maintained operated by relay 607 while the first selecting magnet has released and the second selecting magnet is held operated. During the succeeding impulses relays 513, 514 and 515 are operated alternately. That is, at the beginning of each odd impulse, relay 513 is operated and at the end of each odd impulse relay 515 is operated. At the beginning of each even impulse relay 514 is operated and relay 513 is released and at the end of each even impulse relays 515 and 514 are released. Each impulse causes the operation of corresponding selecting magnets. In this case the sixth selecting magnets 761 and 861 are operated on the sixth impulse. This being an even impulse, relays 513, 514 and 516 will be released at the end of the impulse. This is the end of the first digit. Relays 606 and 607 will also release. When relay 606 releases and before relay 607 is released, both relays being slow in releasing, a circuit is momentarily closed for the operation of relay 608 from battery, resistance 517, winding of relay 608, make-before-break contacts of this relay, selecting magnet 811, contacts of relay 606 to ground at contacts of relay 607. Relay 608 in operating closes a locking circuit for itself through its left-hand armature and front contact, contacts of relay 510 to ground at relay 508. When relay 607 releases, relay 518 is operated from battery, through resistance 519, winding of this relay, contacts of relays 608 and 510 to ground at relay 508. It should be noted that as long as the ground was supplied from relay 607, relay 518 was short-circuited through the connection through its outer left-hand armature and back contact to ground at relay 607. When relay 518 operates a circuit is closed for the operation of relay 604 from battery, through the winding of this relay to ground at relay 518.

As the holding circuit for relay 516 is opened on the release of relay 607, this relay in releasing opens the holding circuit for the sixth selecting magnets which are thereby released. Therefore, the net result of the operation of the first digit is to energize and lock relays 604, 608 and 518.

Now when the second series of impulses is transmitted for the tenths digit selection, it will be assumed that line 16 will be the called line. Therefore, the tenths digit will be one impulse. The effect of the release of relay 507 is to cause the operation of relays 513, 515 and 516 and to provide an operating and a locking circuit for the selecting magnets 711 and 811, in the same

manner as hereinbefore described. At the end of this impulse when relay 606 releases and before relay 607 is released, relay 608 will release as it is shunted by the ground connection from contacts of relay 607, through contacts of relays 606, 604 and 518, through resistance 517 to battery. When relay 608 releases and the ground is still applied from relay 607 a holding circuit is provided for relay 512 through the make-before-break contacts of relay 608. It should be noted that relay 518 was locked by the ground supplied through the left-hand armatures and front contacts of relay 508 when operated. This circuit may be traced from battery, resistance 519, winding of relay 518, make-before-break contacts of relay 608, contacts of relay 604, contacts of relay 606 to ground at contacts of relay 607. Relay 608 in releasing closes a circuit for relay 609 from battery, right-hand contacts of relay 606 to ground at contacts of relay 515. When the second impulse causes relay 507 to release relay 514 operates and relay 513 releases and a circuit is closed for the second holding magnet of the group G2 over lead 712, contacts of magnet 800, lead 716, contacts of relay 607, contacts of relay 516 to ground at contacts of relay 513. The circuit through the magnet can not be shown as this magnet is not shown. When the impulse ceases relay 515 releases and locks this second magnet over a circuit through its contacts to ground on leads 720 and 721, through contacts of relays 610, 513 and 516. However, the second holding magnet may not be directly operated from the second impulse, but an intermediate relay may be supplied to operate on the second impulse over the above mentioned path through lead 712. An arrangement of this kind will be explained further in connection with the operation of the sixth holding magnet 806. For the present it is sufficient to say that the path for the operation of the third holding magnet is closed by this intermediate relay so that on the third impulse the third holding magnet will be operated directly and provide a path for the operation of a similar intermediate relay for the fourth holding magnet. As this intermediate relay has been shown at 803 the circuit may be traced as follows, bearing in mind that on the fourth impulse relays 513, 515 and 514 are released: Battery, winding of relay 803, through contacts of the third holding magnet (not shown) leads 719 and 716, contacts of relays 609, 516 and 513. Relay 803 locks to ground at relay 516 over lead 721. Holding magnet 804 does not operate as relay 606 is operated. The purpose of this arrangement is to prevent two succeeding holding magnets from being maintained operated at the same time. When a succeeding holding magnet or succeeding relay is operated the preceding holding magnet or relay is released, thus preventing a momentary double connection winding of relay 610, winding of relay 609, contacts of relay 604 to ground at contacts of relay 608. Relay 610 does not operate in this circuit. As relays 513, 515 and 516 will release when relay 607 releases a holding circuit is now provided for the selecting magnets 711 and 811 in place of the holding circuit closed for these magnets when relay 515 operates. This circuit may be traced from battery, windings of magnets 711 and 811, contacts of relay 609, contacts of relay 610 to ground. When relay 607 releases the locking circuit for relay 518 is opened and relay 518 releases. The operation of relay 609 shifts the pulsing leads from the selecting magnets to the holding magnets.

This case the unit digit is six impulses. The operations in dialing this digit are the same as hereinbefore described except that the holding magnets 800 and succeeding holding magnets or intermediate relays are operated and released in succession until holding magnet 806 is operated to cause the connection to be established in the group of lines G6 at the cross-connecting point 812 between the conductors 37 and the conductors of the called subscriber's line 16. The operations are as follows: The first impulse causes the release of relay 507 and this causes the operation of relays 606 and 607 as hereinbefore described. As the release of relay 507 causes the operation of relay 513 this relay now closes a circuit for the holding magnet 800 in group G1. This circuit may be traced from battery, through the winding of magnet 800, contacts of relay 609, contacts of relay 516 to ground at the outer left-hand armature and front contact of relay 513. At the end of this impulse relay 507 is operated causing the operation of relay 515 and this relay causes the operation of relay 516. Relay 515 provides a locking circuit for magnet 800 from battery, winding of this magnet, its upper armature and front contact, to hold two succeeding holding magnets operated at the same time. The fifth impulse causes the fifth holding magnet to operate, that is, the magnet 805 and the sixth impulse causes the intermediate relay 806 to operate in the same manner as the intermediate relay 803. This relay in operating provides a locking circuit for itself through the lead 721 to ground at contacts of relay 516. As this is the last impulse the relays 607 and 606 would now release and also close a circuit for the operation of the corresponding holding magnet 807. This circuit extends from battery, winding of magnet 807, contacts of relay 806 to ground at contacts of relay 607 and the magnet locks up over its armature and front contact to ground on lead 721 at relay 516. The calling line 11 is now connected to the called line 16 through the connections at the cross-connecting points 707 and 812.

If the called subscriber's line is busy a ground will be found on the sleeve lead which causes the operation of the busy tone relay 520 before 607 has released and after relay 606 releases at the end of the sixth digit. The circuit for this relay may be traced from battery through the winding of relay 520, normal contacts of relay 606, operated contact of relay 607, contact of relay 521, sleeve lead to the called subscriber's line through the cross-connecting point 812 of group G6. Relay 520 provides a locking circuit for itself over contacts of relays 505 and 510, to ground at relay 508. Relay 520 provides a busy tone to the calling subscriber from the busy tone source connected to lead BT at 511, through contacts of relay 520 to the tip and ring conductors of the calling subscriber's line over contacts of relay 521 through condensers 522, 523, 524 and 525, contacts of relay 505, and 506, through the cross-connecting points 707. If, however, the called line is idle and when relay 606 releases and before relay 607 releases relay 608 again operates over the circuit as hereinbefore traced. Relay 607 is then released causing the operation of relay 518, which in turn causes the operation of relay 610 from battery, left-hand winding of this relay, contacts of relay 609, contacts of relay 518 to ground. It should be noted that the locking circuit through the right hand winding of relay 610 short-circuits relay 609 which now releases. Relay 610 maintains the holding magnet 807 operated as this magnet was held from lead 721

The third or unit digit may now be dialed. In

which extended to ground at relay 610. The holding circuit for selecting magnets 711 and 811 is opened by the operation of relay 610 and the circuits are now in condition for the transmission of the ringing code selecting digit.

Dialing for the proper ringing code may now take place. If the calling subscriber dials the digit 1 a particular code representing this digit will be transmitted to the called line which would be a single subscriber's line. This particular code may also be used for calling a single party on a single-party line or one of the parties on a ten-party line. Assuming that the code represented by one impulse is dialed, the first selecting magnets 711 and 811 will operate in the same manner as described in connection with the dialing of preceding digits. At the end of the impulse, when relay 507 is again operated, relays 515 and 516 are operated in circuits as hereinbefore described. The operation of relay 515 closes the locking circuit for magnets 711 and 811. Then as relay 606 is released, relay 608 is released. This causes the operation of relay 511 from battery, winding of this relay, contacts of relay 610, contacts of relay 608 to ground. Relay 511 in operating provides a locking circuit for itself to ground at relay 508 and for relays 513 and 515 to maintain these relays operated after relay 607 releases, so that the holding circuits for magnets 711 and 811 will be maintained. The holding circuit completed by relay 511 for these relays may be traced from battery, winding of relay 513, contacts of relay 514, contacts of relay 513, right-hand winding of relay 515, contacts of relay 511, contacts of relay 510 to ground at contacts of relay 508. Relay 511 also closes a circuit for the operation of relay 527 from battery, winding of relay 527, contacts of relay 511, contacts of relay 616 and 613 to ground at relay 515. Then relay 607 releases causing the release of relay 518 and the operation of relay 521 from battery, winding of relay 521, contacts of relay 607, contacts of relay 612, contacts of relay 520 to ground at contacts of relay 610. Relay 521 locks to the same ground directly. Relay 521 in operating closes a connection through from the called subscriber's line to contacts of relay 526. Relay 526 is now operated due to the operation of relay 511 from the pick-up lead PU at the ringing interrupter terminating at 531 (not shown) over a circuit from battery through the winding of this relay, contacts of relay 520, contact of relay 511, outer left-hand armature and back contact of relay 526 to the pick-up lead PU. Relay 526 in operating provides a locking circuit for itself through a holding lead H of the ringing interrupter at 531 through its outer-left-hand make-before-break contacts and the original circuit traced for this relay. When relay 526 operates the called subscriber's line is extended to contacts of relay 527 and a circuit is completed for the transmission of the ringing code from the first code conductor 1 in a group marked by the bracket 614, that lead through the ringing interrupters (not shown) but controlled by the leads from the interrupter at 531. The codes produced on the conductors in the group at 614 may consist of current impulses of different combinations such as long or short impulses arranged in different numbers of impulses for each code as is well known in the art. The circuit for this ringing code may be traced from the lead 1 in the group at 614, contact of relay 615, contacts of selecting magnet 711, contacts of relay 511, left-hand armature and front contact of relay 527,

contacts of relay 526, contacts of relay 521, to the ring conductor of the called line over the cross-connecting point at 812, and back over the tip conductor through the connecting point 812, contacts of relays 521, 526 and 527 to ground at the lead G in the ringing interrupter connected at 531. These ringing interrupter circuits may be so arranged that between each code transmitted, the ground on the holding lead H is removed to cause the release of relay 526 and if the subscriber has not answered, the pick-up lead will again cause relay 526 to be operated to repeat the code. If the called subscriber answers when relay 526 is released, a connection is completed through the called subscriber's loop for the operation of relay 510, from battery and ground through the windings of the relay 510 through contacts of relays 526 and 521 and the tip and ring conductors over the calling subscriber's loop, causing the release of relay 509 to dismiss the time release circuit which was started to release the link after a certain interval if the subscriber failed to dial within that interval. Relays 513, 515 and 516 are also released. The release of relay 515 causes the release of the selecting magnets 711 and 811 to disconnect the code ringing lead. The operation of relay 510 also closes a circuit for relay 520, from battery, winding of this relay, contacts of relay 510 to ground at contacts of relay 508. Relay 520 opens the circuit for relay 526 to prevent it from operating again. The talking connection is now therefore completed between the two subscribers, as indicated in heavy lines in the drawings.

When the calling subscriber hangs up his receiver, at the end of conversation, relay 501 is released causing the release of relays 500 and 508, causing the opening of the holding circuit for all relays operated and returns the circuits to normal.

In case of reverte calls, that is, if the called party is on the same line as the calling party, the calling party will receive the usual busy tone. As he knows that this is a reverte call, he will hang up and wait for the called party to be rung. In this case when the calling party hangs up, relays 507 and 501 and 500 will release, but relay 508 will remain operated as on the release of relay 500 a circuit will be completed for the operation of relay 505, from battery, winding of this relay, contacts of relays 500 and 511, the fourth connection through cross-connecting point 728, as the connection has been established at this point to the same line as the called line, to ground at the fourth connection at cross-connecting point 707. The operation of relay 505 now establishes a new holding circuit for relay 508 to hold the connection until the called subscriber answers. This circuit may be traced from battery, winding of relay 508, contacts of relay 510, contacts of relay 505 to ground of relay 508. Now, when the called subscriber answers and relay 510 operates, relay 508 releases causing the release of the connection through the link. The calling and called subscribers may then converse over their own line.

Reference will now be made to the different operations when party lines are called. In regard to the ten-party lines the operations as stated are the same as in the case of a single subscriber's line but with a minor exception, namely that the parties are divided in two groups of five each on the line so that one set of five parties must be rung with the codes on the tip conductor and the other set of five parties must be rung with the

codes on the ring conductor. It should be noted that in dialing an odd digit as the first digit, relay 515 is operated and in dialing an even digit this relay is not operated. Advantage is taken of this fact to distinguish between the two sets of five parties each on a ten-party line in calling. When relay 515 is operated a circuit is closed for relay 615. If relay 515 is operated due to the dialing of an odd digit a circuit will be closed for relay 527 when later relay 511 is operated. This circuit may be traced from battery, winding of relay 527, contacts of relay 511, contacts of relays 616 and 613 to a ground at relay 515. In this case, therefore, the ringing code will go out on the ring conductor to call one of the subscribers' stations of the set of five associated with this conductor. On the other hand, if an even number is dialed relay 515 is not operated consequently preventing relay 527 from operating so that the code selection will go out on the tip conductor.

In case the calling subscriber had desired a party on a twenty-party line and one of the parties of one set of ten parties of the desired twenty-party line he would have dialed digit 3 and if he had desired one of the parties on the other set of ten parties on this twenty-party line he would have dialed the digit 4. Assuming first that he dials the digit 3. The operations will be the same as when he dials for a single or ten-party line with this exception that when the third selecting magnet 731 is operated and when relay 608 is operated, a circuit is completed for the operation of relay 613 from battery, winding of this relay, contacts of relays 604, 608, 731, 607, 516 and 513, to ground at contacts of relay 516. Relay 613 locks to ground at relay 508 through contacts of relay 510. This prevents relay 527 from operating when relay 511 is operated which closes the circuit for relay 527 at another point at the end of the third digit. Thus when the fourth digit is dialed the selected code on a lead 1 to 19 normally connected through contacts of relays 615 and 616 is transmitted over the ring conductor to select one party out of a set of ten as determined by the dialing of the digit 3 as the first digit. On the other hand if the subscriber had dialed 4 as the first digit relay 613 is not operated but this has no effect as relay 527 will not operate when relay 511 is operated to close the circuit for the relay 527 at another point at the end of the third digit as the circuit for relay 527 is at that time opened at still another point by the operation of relay 616 which relay with relay 615 are operated at the end of the first digit when relay 608 operates. The circuit for these relays 615 and 616 extends from battery, windings of these relays, contacts of relay 609 before it operates, contacts of relay 608 when it operates to ground supplied by the holding circuit for the fourth selecting magnet 741 from relay 516. These relays lock to ground at relay 508 through contacts of relay 510. Hence when the fourth digit is dialed a code will be transmitted over one of the leads selected by the corresponding selecting magnet from the corresponding leads 11 to 20 connected by the operation of relay 615 and 616 over the ring conductor to select one party out of the other set of ten as determined by the dialing of the digit 4 as the first digit.

If the calling subscriber decides to make a connection to a distant office he will dial the digit 0. In this case, the operations are the same as far as the calling subscriber seizing the incoming end of a link and dialing the digit 0 is

concerned as when a calling subscriber seizes a link and dials the first digit of any office number. The dialing of the digit 0 operates the selecting magnets 701 and 801. As this is the only digit, relays 606 and 607 will release and cause the operation of relays 608 and 516 as usual. The selecting magnet 701 will in this case close a circuit for the operation of relay 617 from battery through the winding of this relay, contacts of selecting magnet 701, contacts of relay 604 to ground. This relay in turn closes a circuit for the operation of relay 612 from battery, contacts of relays 27 and 28, right-hand winding of relay 612 to ground at contacts of relay 617. Relay 612 closes a substitute locking circuit for selecting magnets 701 and 801 from battery through the winding of this magnet, contacts of relay 612 to ground, as the original locking circuits will later be opened due to the subsequent release of relays 607 and 515. Relay 612 in operating closes an obvious circuit for relay 28 which in turn closes a circuit for the operation of relay 27. As long as these two relays are operated no other relay corresponding to 612 in any other link can operate to start hunting for an idle trunk. The original energizing circuit for relay 612 was opened on the operation of relays 27 and 28 but relay 612 is locked in series with relay 28 to ground on relay 617 which is held operated by a locking circuit to ground at relay 508. Relay 612 also operated relay 618 which connects the leads from each holding magnet to contacts of the cut-off relay of the corresponding trunk. Assuming now that trunk 01 is idle its cut-off relay 206 will be released hence a circuit will be completed for the holding magnet 800. This holding magnet will operate over a circuit from battery, through the winding of this magnet through the first armature and contact of relay 618 of the group marked T through contacts of cut-off relay 206, contacts of relays 612 and 27 to ground at contacts of relay 28. Holding magnet 800 in operating provides a locking circuit for itself through its armature and front contacts, through contacts of relay 606, to ground at contacts of relay 506 which latter relay is immediately operated when the connection is established between the trunk 01 and the subscriber's line connected to this link at the cross-connecting point 717. The circuit for the operation of relay 506 may be traced from battery through the winding of this relay, the lower contacts at the cross-connecting point 717 to ground. The ground connection established at the contacts of relay 508 for the sleeve lead of the calling subscriber will now be extended through contacts of relay 506 and the sleeve contacts of the cross-connecting point 717, for the operation of the cut-off relay 206 from battery through its right-hand winding and ground over the sleeve lead. Another effect of the seizure of the trunk 01 is that connections are made through means in the trunk for establishing a ground on the sleeve lead from the trunk so as to hold the cut-off relay 206 operated after the ground from the sleeve lead at relay 508 in the link is removed. This ground will also hold relay 506 operated from battery through its winding and inner left-hand armature and front contact, through the sleeve connection established 70 at the cross-connecting point 717 over the sleeve lead to the trunk. This ground will also hold relay 203 operated after the ground is removed at relay 508 as it should be noted that when relay 506 is operated the connections over the tip

and ring conductors from the calling subscriber are disconnected from the connections through the relays 501 and 507 so that these relays will release and the tip and ring conductors are connected to the tip and ring conductors of the trunk. As relays 501 and 507 will now release relays 500 and 508 will also release to remove the holding ground for the various relays operated at this time, that is, in this case relays 608, 518, 612, 27, 28 and 604. The release of relays 612, 27 and 28 permits another link to be used for trunk hunting as the battery is supplied at the right hand armature and back contact of relay 27 for the operation of the corresponding relay 612 in another trunk, such as, for example, relay 912 in link CD. The connection from the calling subscriber to the trunk will, as noted, now be extended through the link directly through the contacts of relay 506 without any encumbrances. The connection is held by the ground over the sleeve from the trunk and when this ground is removed relay 506 is released causing the release of the holding magnet 800 and when the calling subscriber releases the incoming branch of the link is disconnected by the release of the relay 203 and holding magnet 700.

If the call is incoming over a trunk for a subscriber in this exchange the seizure of the trunk, for example trunk 01, causes the operation of relay 207. The operation of this relay closes a connection for the seizing of an idle link by causing the operation of the corresponding relays 496, 492 and 403 and a relay corresponding to 401 if there are more than four trunks. In this case the selecting magnets 701 and 801 will be operated and the holding magnet 700 if the first link is idle so that the incoming connection will be established through the cross-connecting point 718. Otherwise the seizing of an incoming branch of an idle link is the same as when a subscriber seizes a link. The establishing of a connection to a desired subscriber's line from the trunk is identical with the establishing of a connection from a calling subscriber's line to a called subscriber's line in this exchange and therefore does not need any separate description.

What is claimed is:

1. In a telephone system, a plurality of cross-bar switches arranged in divisions, lines multiplied to appear in each division and arranged in groups in separate parts of each division a link for each division having a calling branch and a called branch appearing in each part of said division, and means for connecting a calling line to a called line through an idle link.

2. In a telephone system, a plurality of cross-bar switches arranged in divisions of one or more switches in each division, lines multiplied to appear in each division, and arranged in groups in separate parts of each division, a link for each division having a calling branch and a called branch appearing in each part of said division, and means for connecting a calling line to a called line through an idle link with the calling line connected directly to a calling branch of said link and the called line connected directly to a called branch of said link.

3. In a telephone system, cross-bar switches, lines multiplied to appear in all of said switches and arranged in groups in separate parts of said switches, a link for each switch having a calling branch and a called branch appearing in each

part of said switch, and means for connecting a calling line to a called line through an idle link.

4. In a telephone system, cross-bar switches, lines multiplied to appear in all of said switches and arranged in groups in separate parts of said switches, a link for each switch having a calling branch and a called branch appearing in each part of said switch, and means for connecting a calling line to a called line through an idle link with the calling line connected directly to a calling branch of said link and the called line connected directly to a called branch of said link.

5. In a telephone system, cross-bar switches, lines multiplied to appear in all of said switches and arranged in groups in separate parts of said switches, a link for each switch having a calling branch and a called branch appearing in each part of said switch, and means for connecting a calling line to a called line through a calling branch and a called branch of an idle link at the parts of the associated switch where said lines appear.

6. In a telephone system, cross-bar switches arranged in divisions of equal numbers of switches in each division, lines multiplied to appear in the switches of all divisions, and arranged in separate groups in separate parts of the switches, a link for each division of switches having a calling branch and a called branch appearing in each separate part of the associated switches, and means for connecting a calling line to a called line directly through a calling branch and a called branch of an idle link at the parts of the associated switches where said lines appear.

7. In a telephone system, a plurality of cross-bar switches arranged in divisions, lines multiplied to appear in each division and arranged in groups in separate parts of each division, trunks multiplied to appear in each division, a link for each division, and means for connecting a calling line to an idle trunk through an idle link.

8. In a telephone system, a plurality of cross-bar switches arranged in divisions, lines multiplied to appear in each division and arranged in groups in separate parts of each division, trunks multiplied to appear in each division and arranged in separate parts of each division, a link for each division having a calling branch and a called branch appearing in all parts of said division, means for connecting a calling line to a called line through an idle link, and means for connecting a calling line to an idle trunk through an idle link.

9. In a telephone system, a plurality of cross-bar switches arranged in divisions, lines multiplied to appear in each division and arranged in groups in separate parts of said divisions, trunks multiplied to appear in each division and arranged in separate parts of each division, a link for each division having a calling branch and a called branch, appearing in each part of said division, means for connecting a calling line to a called line through an idle link and means for connecting a calling line directly through a calling branch of an idle link and directly through a called trunk of said link to an idle branch, said connections being established at the parts of the associated switches where said calling line and said idle trunk appear.

GERALD V. KING.