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FIG. 13

FIG.4	FIG.8		
FIG.3	FIG.7		
FIG.2	FIG.6	FIG.10	FIG.11
FIG.1	FIG.5	FIG.9	

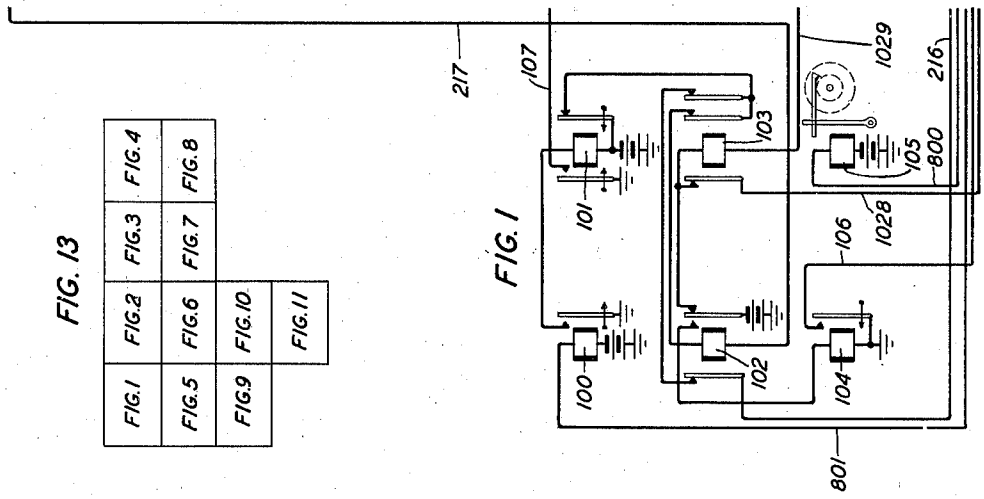

FIG. 1

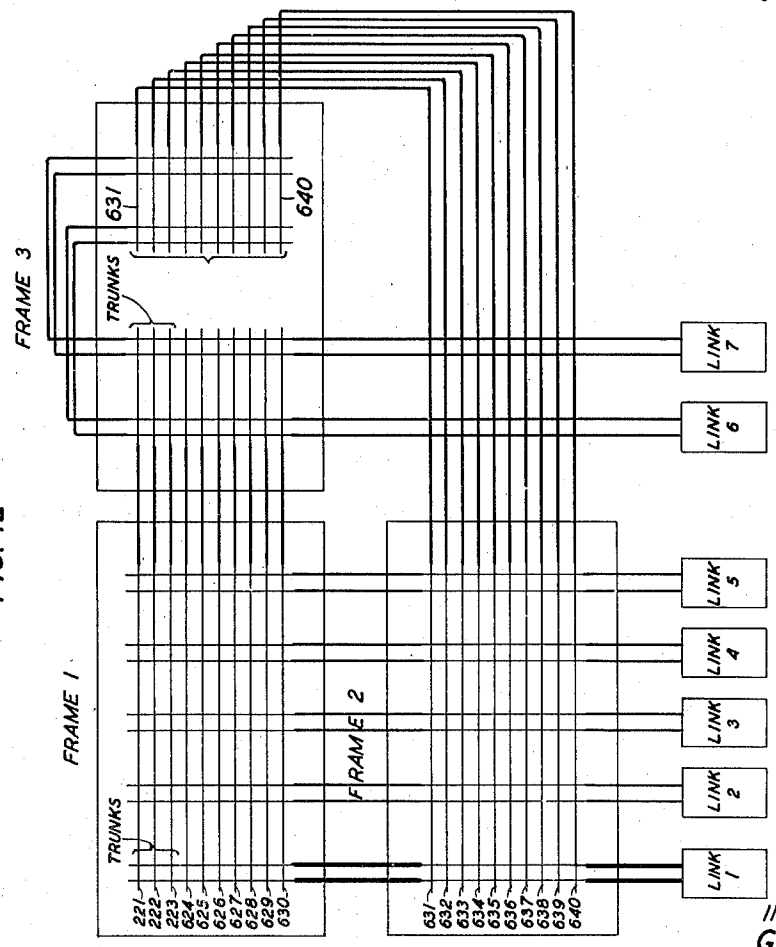

FIG. 12

INVENTOR
G. V. KING
BY P. C. Smith
ATTORNEY

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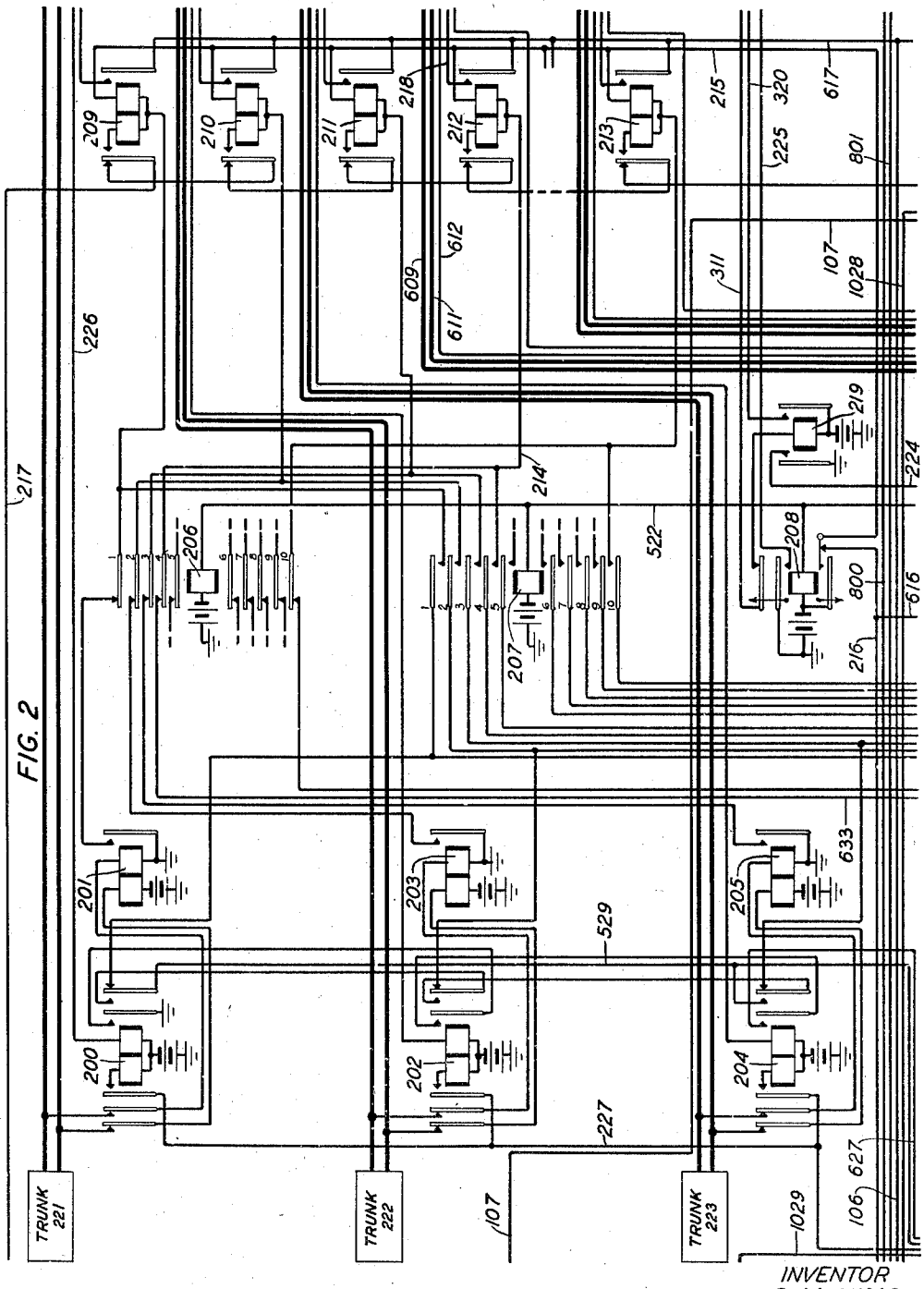

FIG. 2

INVENTOR
G. V. KING
BY
P. C. Smith
ATTORNEY

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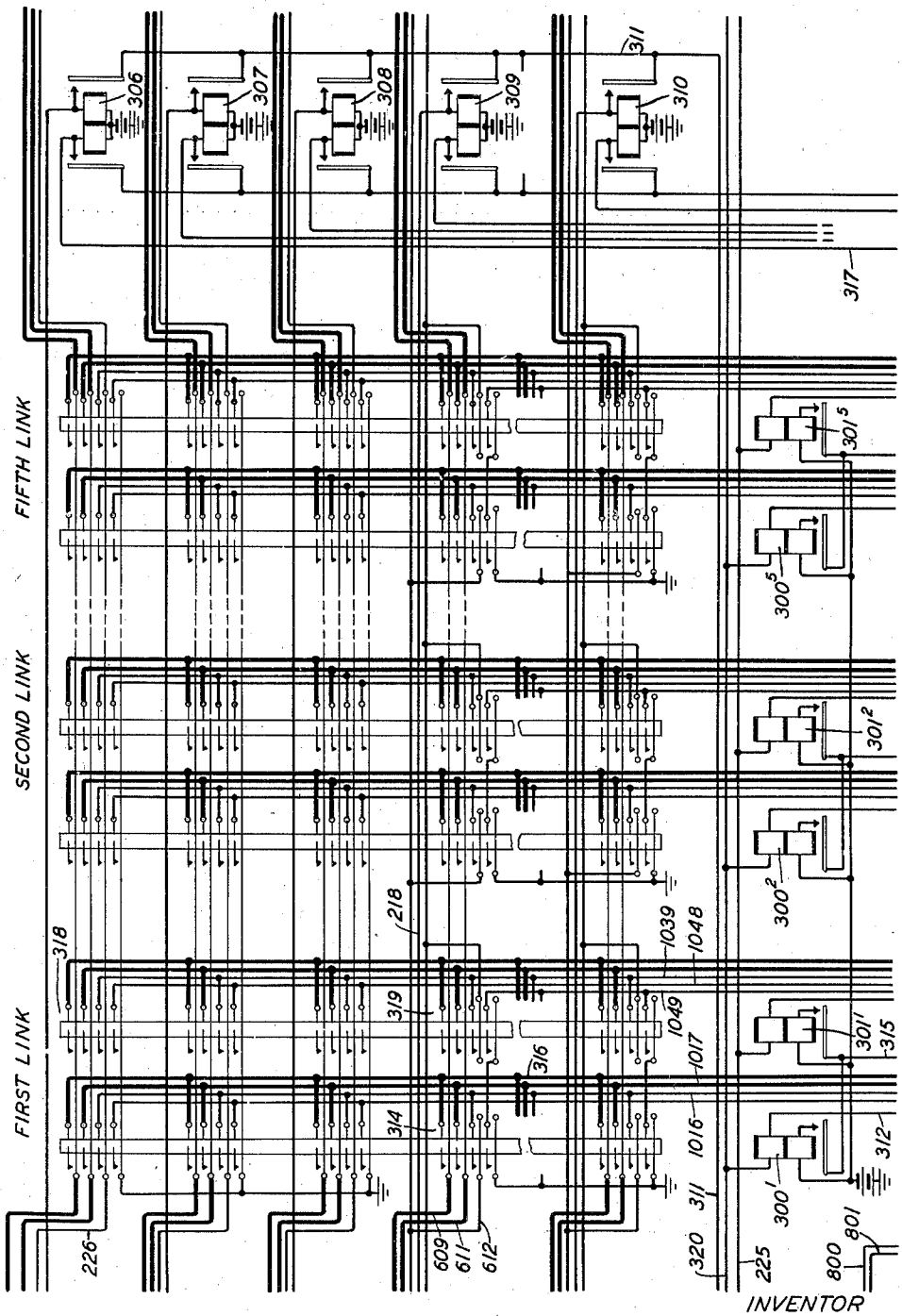

FIG. 3

INVENTOR
G. V. KING
BY P. C. Smith
ATTORNEY

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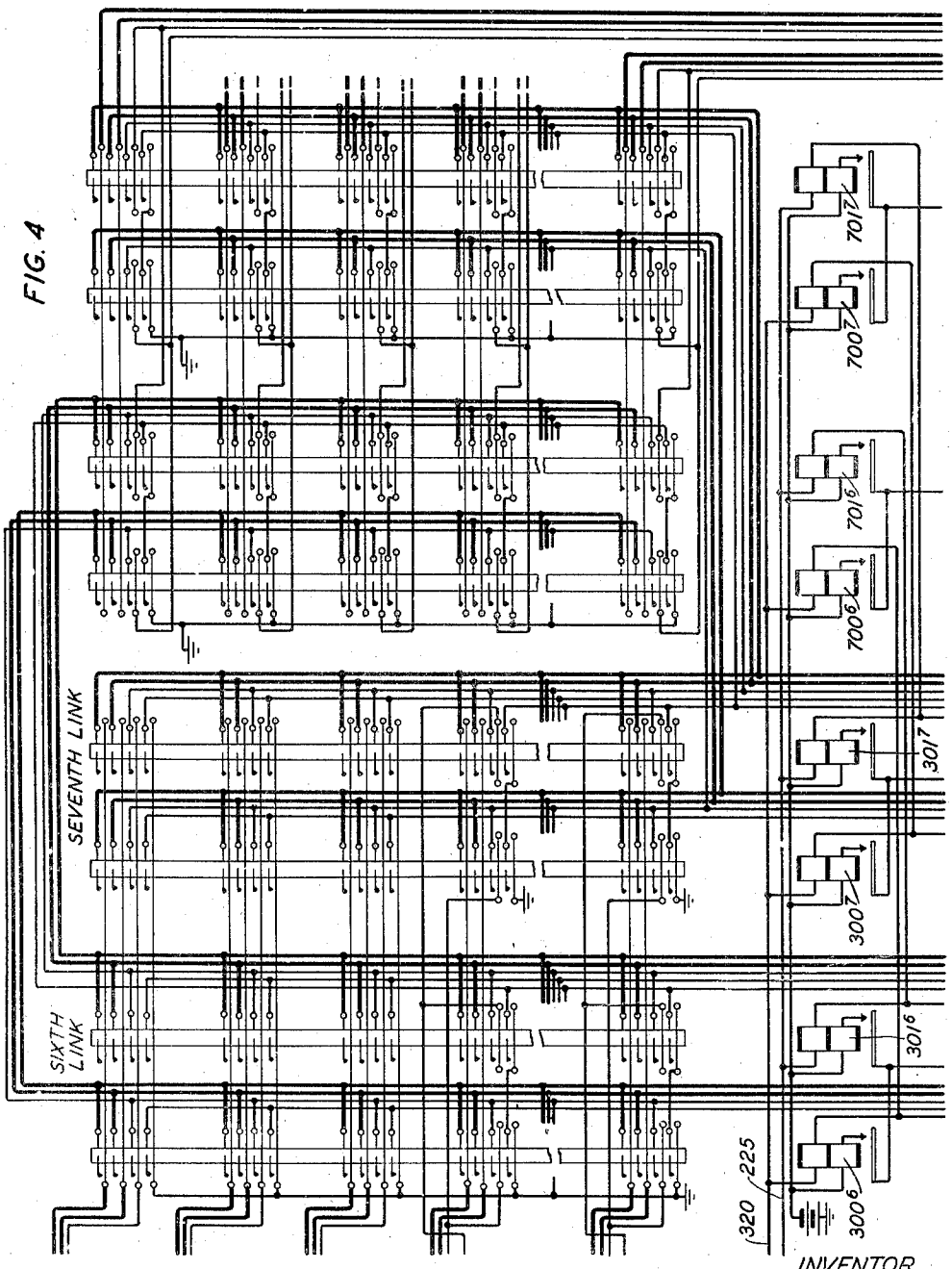
FIG. 4



INVENTOR
G. V. KING

BY
P. C. Smith

ATTORNEY

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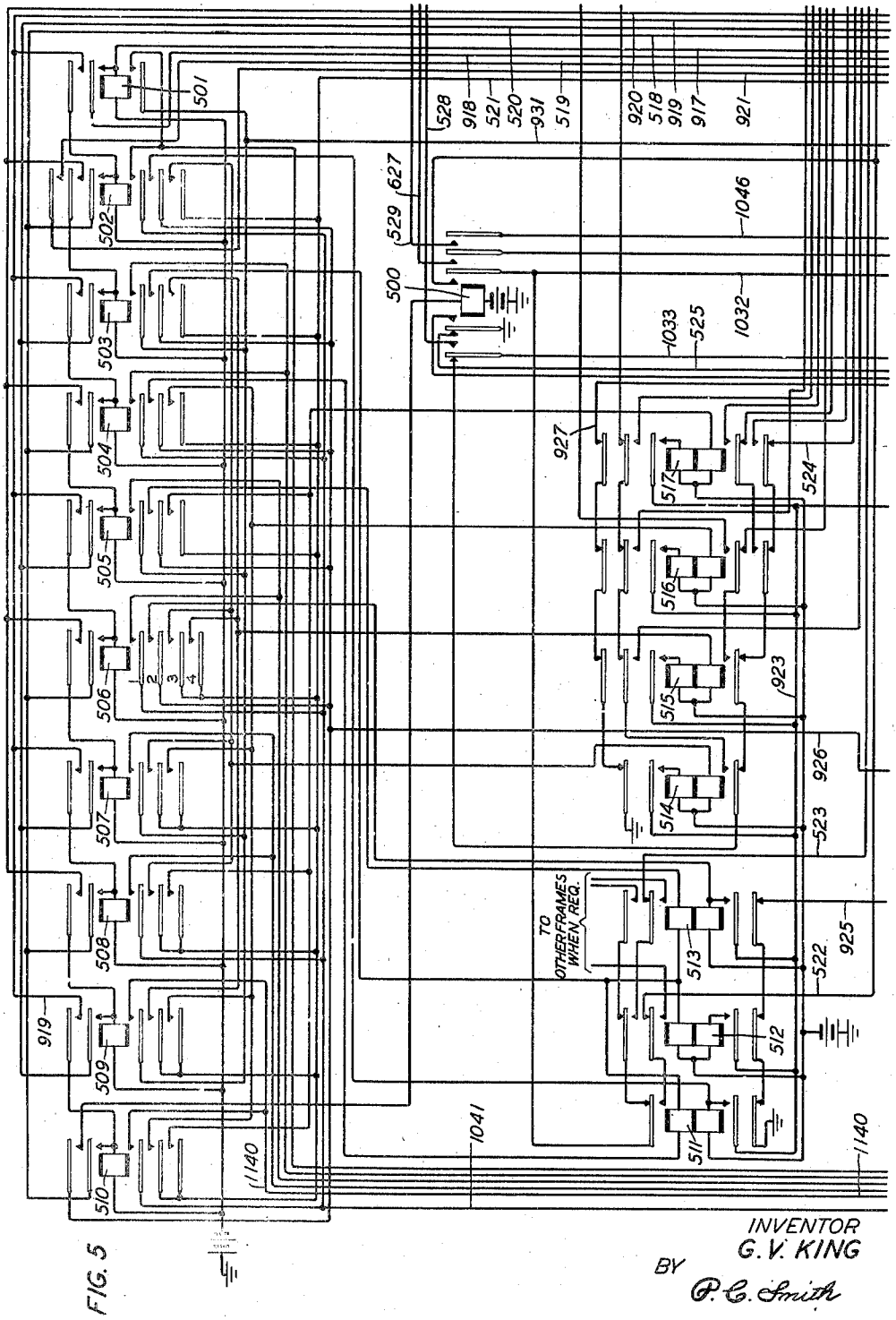

FIG. 5

INVENTOR
G. V. KING

BY
P. C. Smith

ATTORNEY

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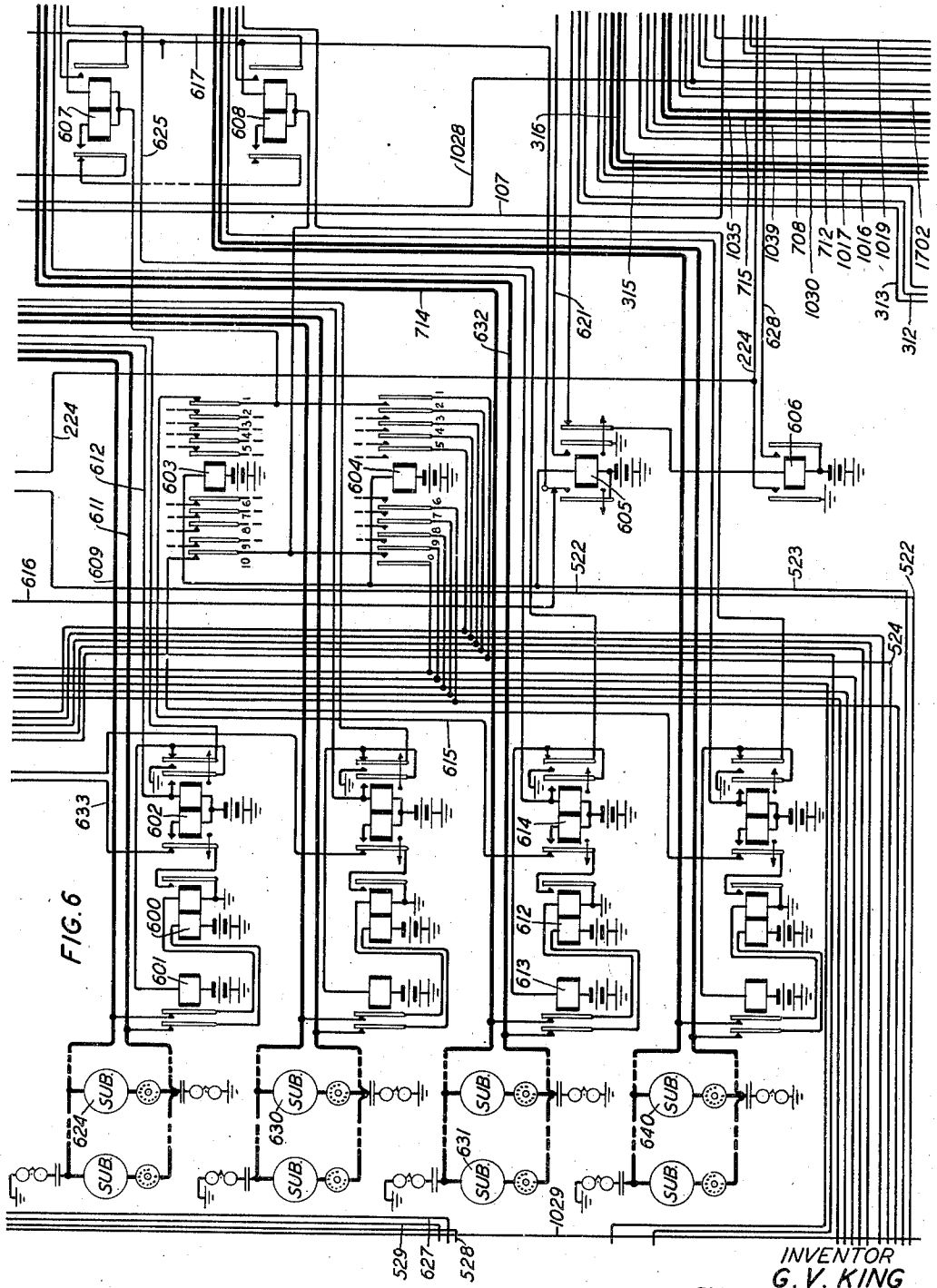

FIG. 6

INVENTOR
G. V. KING

BY
P. C. Smith

ATTORNEY

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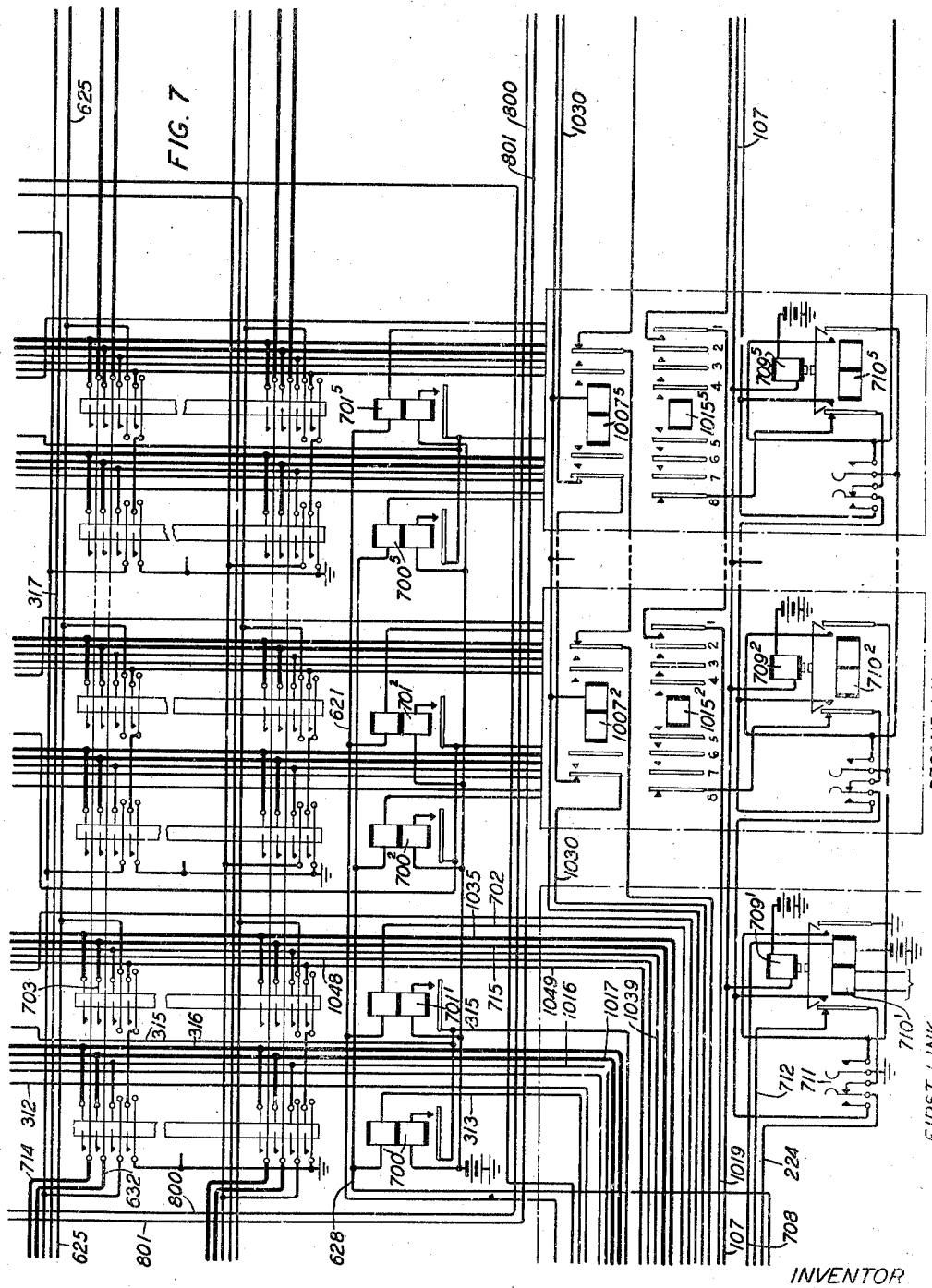
FIG. 7



INVENTOR
G. V. KING
BY
P. C. Smith
ATTORNEY

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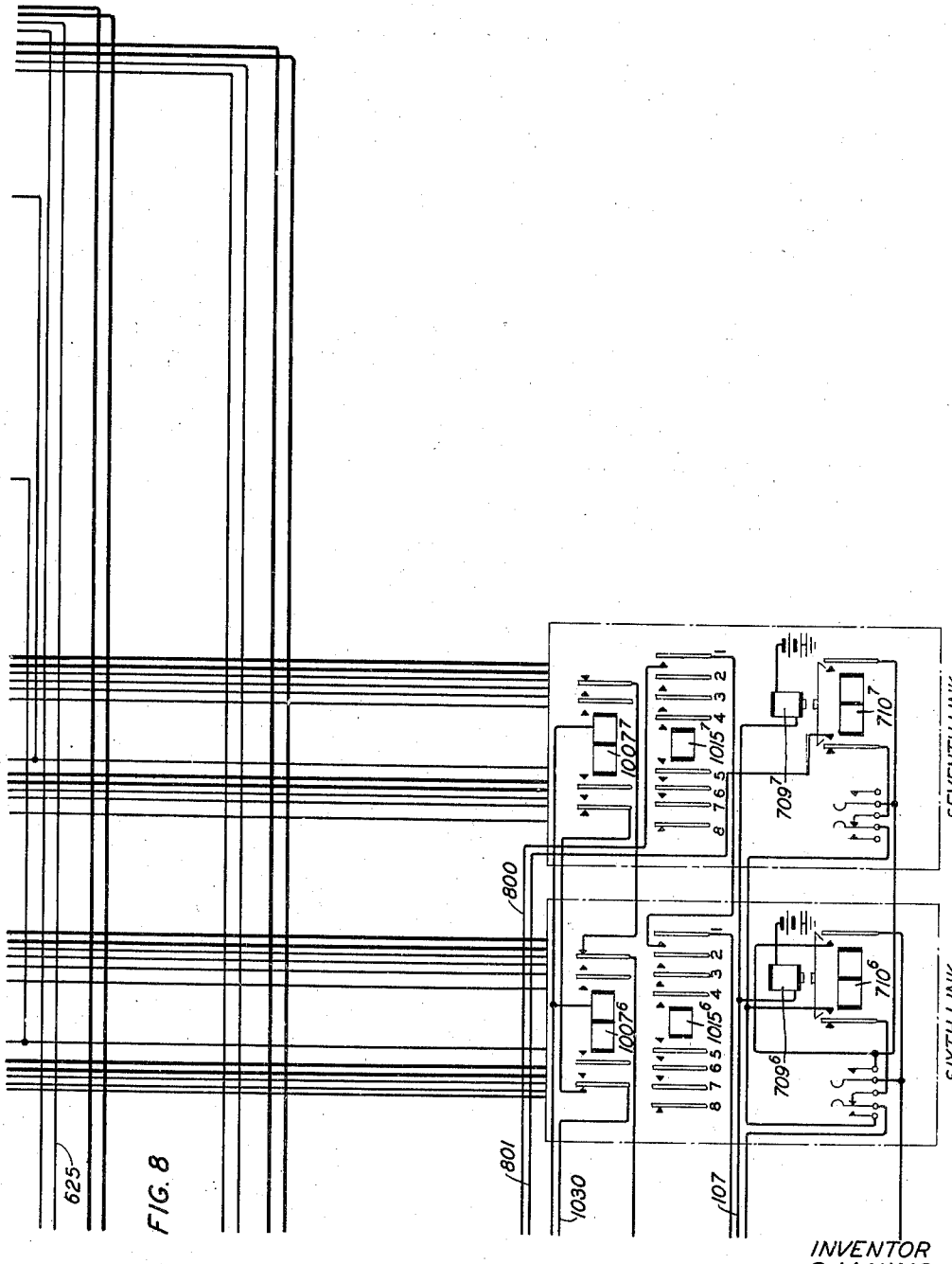

FIG. 8

INVENTOR
G. V. KING

BY
P. C. Smith

ATTORNEY

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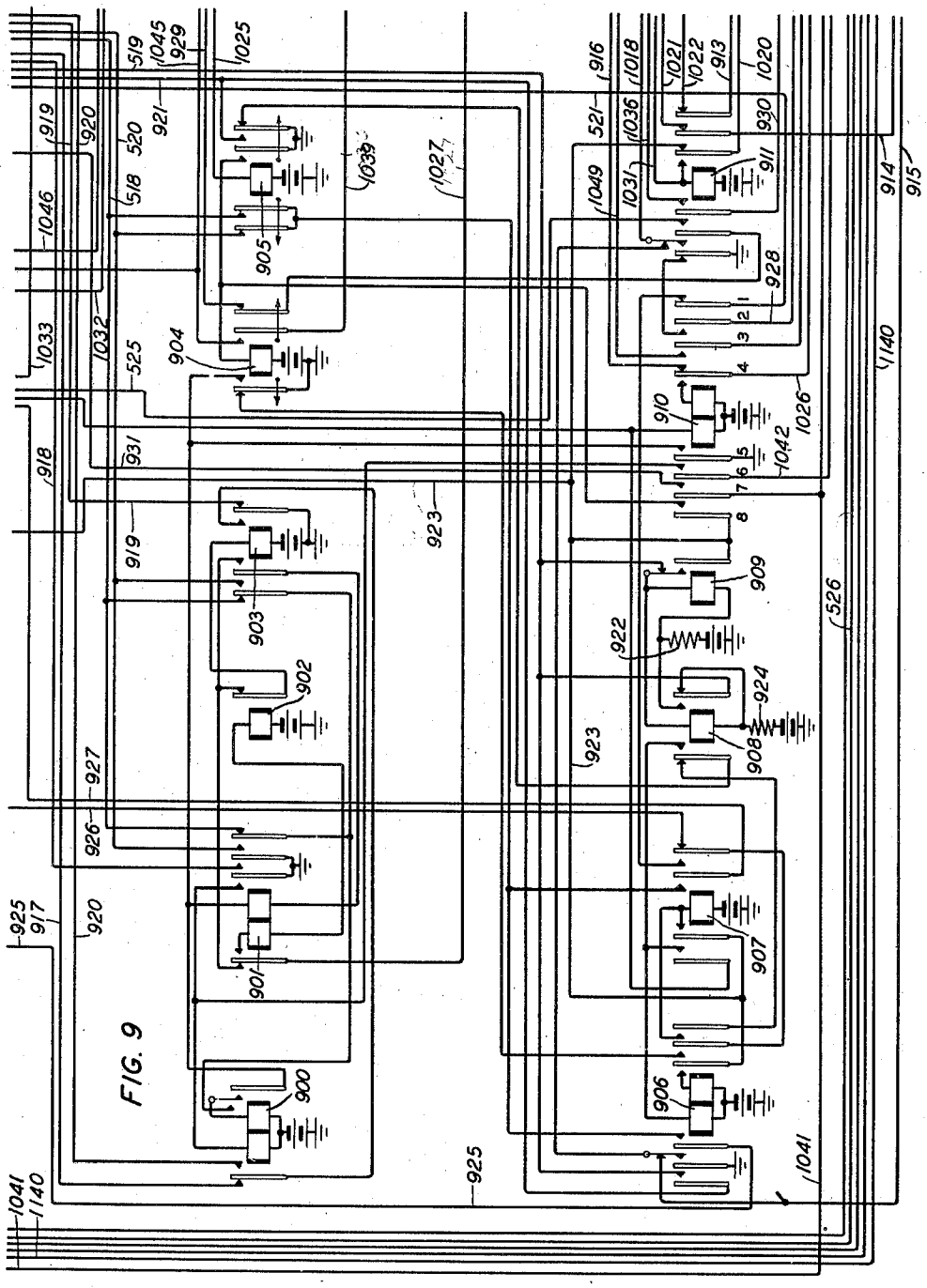

FIG. 9

INVENTOR
G. V. KING
BY
P. C. Smith
ATTORNEY

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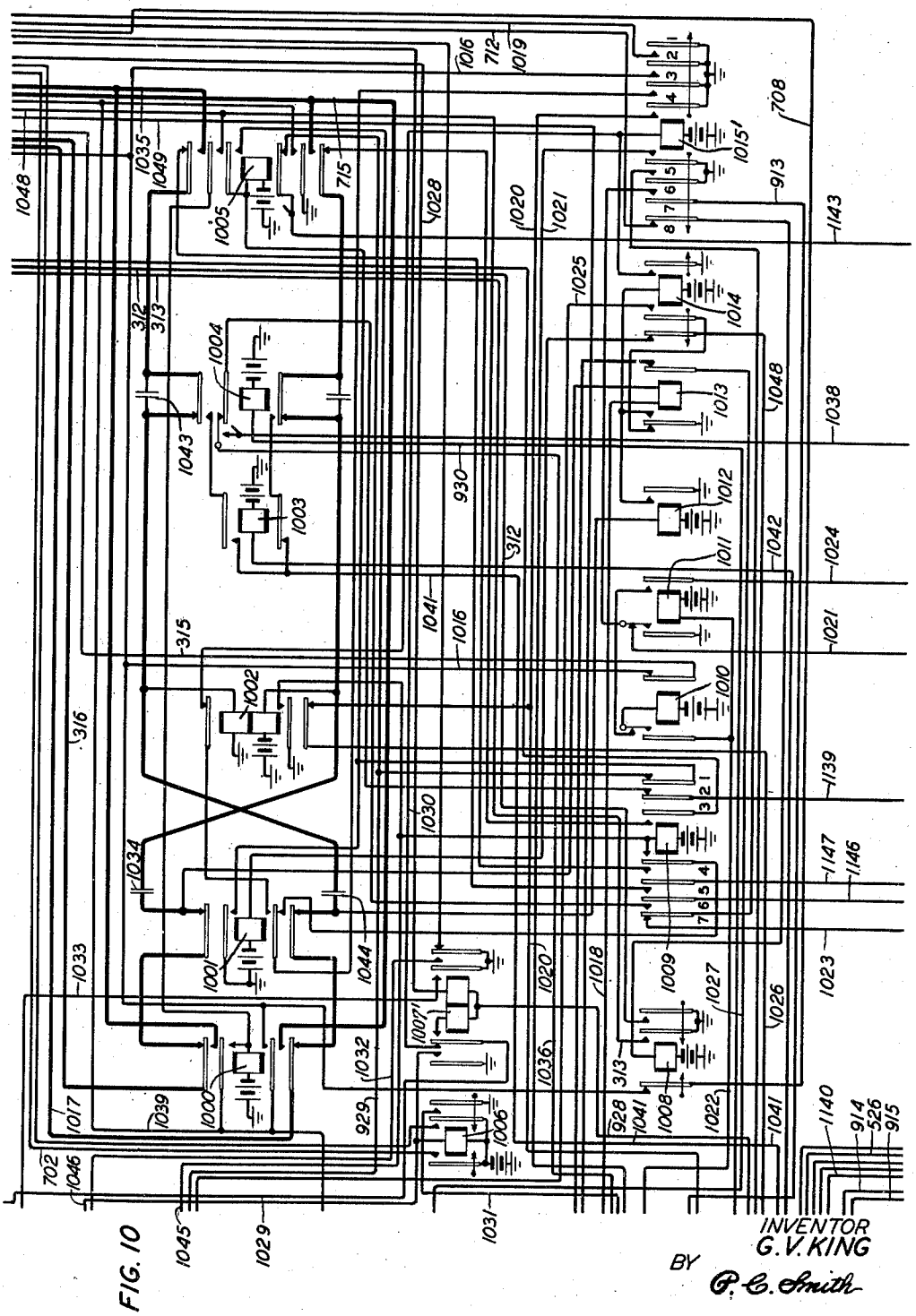

FIG. 10

INVENTOR
G. V. KING

BY
P. C. Smith

ATTORNEY

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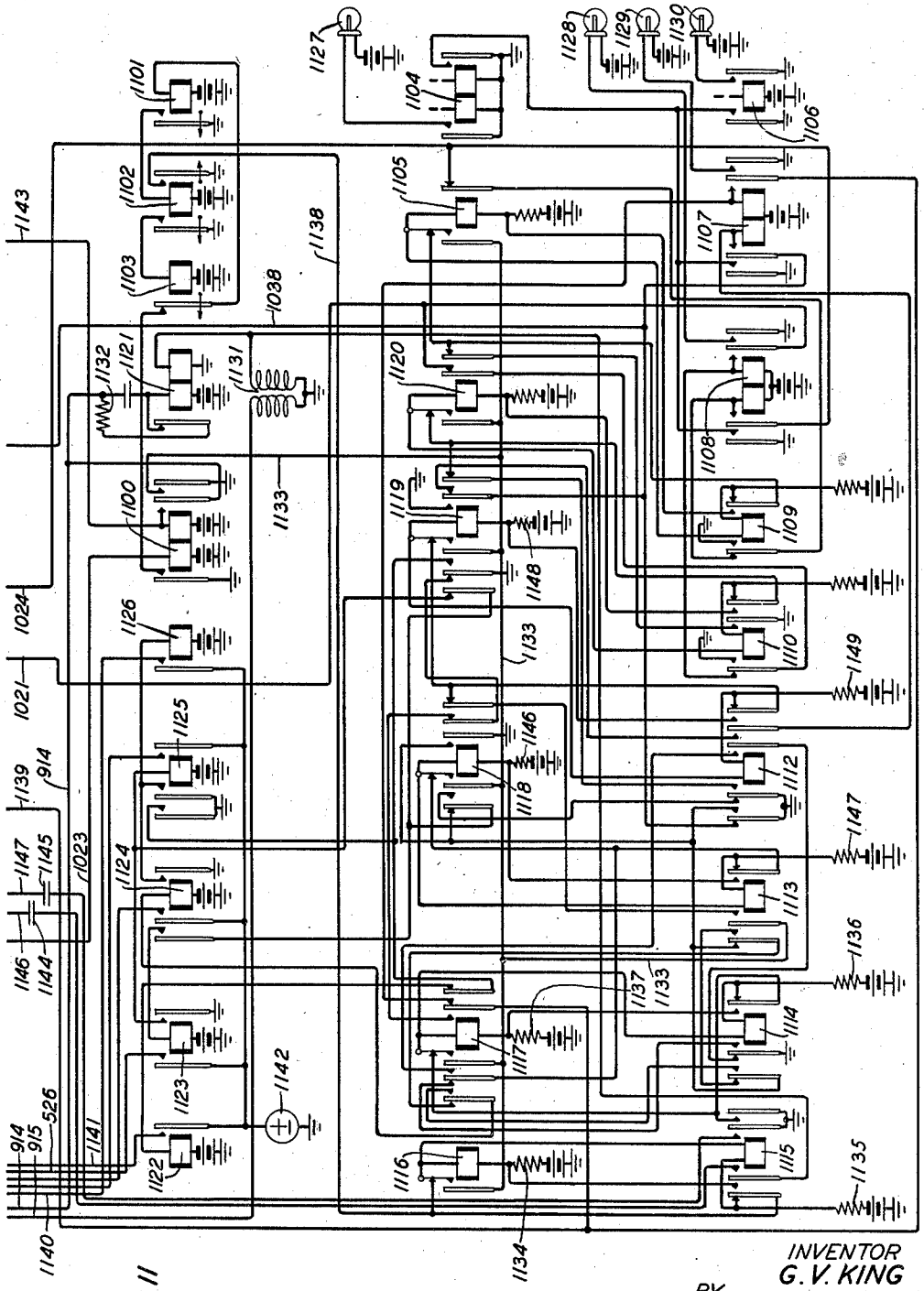

FIG. 11

INVENTOR
G. V. KING

BY
P. C. Smith

ATTORNEY

Patented Nov. 15, 1938 2,136,620

UNITED STATES PATENT OFFICE

2,136,620

TELEPHONE SYSTEM

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

Application June 21, 1935, Serial No. 27,675

9 Claims. (Cl. 179—18)

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

The object of the invention is to improve small automatic telephone systems, such as satellite systems, by performing the various local and interoffice switching connections with a unitary and compact arrangement of switch structure and circuits.

A feature of the invention is the use of a cross-bar switch unit per group of local lines which combines in a single structure the functions of a line finder and a connector in relation to a group of links common to all switching units. Each switch unit is provided with horizontal line contacts and vertical link contacts coordinated in relation to each other into one cross-point whereby the operation of one horizontal and one vertical magnet in the proper combination closes said contacts or cross-point of a calling line through an allotted link, and the operation of another horizontal and vertical magnet in proper combination closes the defining cross-point of the called line or outgoing trunk through said allotted link. All the lines in each switching unit are accessible to one end of all the common links when calling and all the lines and trunks are accessible to the other end of said links when said lines or trunks are called.

Another feature of the invention resides in the allocation of a plurality of cross-points on one or more of said switch units for the use of outgoing trunks which may extend to a main central office and which may be reached by a calling subscriber by dialing a predetermined digit which serves to extend his connection to the trunk cross-point level and to the operated cross-points of an idle trunk in that level.

The nature of the invention will be more clearly understood from the following description of one embodiment thereof and of possible modifications thereto with reference to the accompanying drawings in which;

Figs. 1 to 10, inclusive, when arranged as shown in Fig. 13, disclose a number of link circuits accessible to groups of subscribers' lines and trunks shown in Figs. 2 and 6 for the purpose of completing connections between said lines or between said lines and trunks;

Fig. 11, arranged below Fig. 10, as shown in Fig. 13, is the timing, ringing and alarm circuit which serves all links;

Fig. 12 is a diagrammatic presentation of the arrangement between lines, links, and switching units contemplated by the invention.

Before discussing the details of operation, attention is directed to Fig. 12. In this layout of three cross-bar switching units, identified as frames 1, 2 and 3, twenty lines are shown, ten on frame 1 and ten on frame 2. Ordinarily, each frame is capable of holding five links, each of which can be connected to any two lines on different horizontal levels through the appropriate cross-points. On the other hand, if the capacity of the exchange is greater than ten lines, say twenty lines, and the traffic originating from said lines does not warrant the use of more than five links, the additional ten lines can be located on a second frame, as for instance on frame 2, and the five links accessible to frame 1 can be extended so as to be available to the additional ten lines on frame 2. In this manner, the number of lines which can be included in one exchange unit limited to five links can be extended, in groups of ten, almost indefinitely, although the circuits of the present invention, being designed primarily for application in rural districts, limits the total number of lines to a maximum of fifty lines, that is five switching units of ten lines each.

Moreover, while the number of lines can be increased with respect to a definite number of links, conversely, my invention makes it possible to increase the number of links with respect to a definite number of lines. If, for instance, the quantity of traffic which originates in an exchange of twenty lines is greater than that which can be handled successfully by five links and two additional links are needed, said links may be accommodated on a separate or third switching unit to one half of whose horizontal cross-points may be multipled the lines from the first switching unit and to the other half the lines from the second switching unit with the two links extending to both halves of the third switching unit. In Fig. 12, an exchange of twenty lines is illustrated as needing seven links to handle the traffic successfully. Consequently a third switching unit is supplied, frame 3, to the left half of whose horizontal cross-points the lines appearing on frame 1 are extended and to the right half of whose horizontal cross-points the lines appearing on frame 2 are extended and the two additional links, namely, links 6 and 7 are extended to both halves of frame 3. Obviously, if ten links were needed to serve the twenty lines, then a fourth switching unit would be required and the third and fourth switching units could be arranged so that the lines appearing on frame 1 would ex-

tend clear across frame 3 and the lines appearing on frame 2 would extend clear across frame 4 with the five additional links accessible to each of the twenty lines through frames 3 and 4.

Inasmuch as the preferred embodiment of this invention is disclosed with respect to its application to a rural telephone system in which a plurality of telephone stations may be located in the same pair of line conductors, as for instance, five stations on the tip and five stations on the ring, and which makes it necessary to provide "code" ringing to identify each station and to make it possible for one station to call another station on the same line, the more detailed description of this invention will include the operations required to (1) establish a connection between a station on one line and a station on another line, (2) a connection between two stations on the same line and (3) a connection between a station and an outgoing trunk, three of which occupy the first three horizontal cross-points, respectively, on frame 1 and the left half of frame 3.

It must be understood, however, that the invention herein set forth and claimed is not limited to any such arrangement but can be readily applied by any one skilled in the art to an exchange having individual lines or to any other arrangement of lines and stations that suggest themselves by the character of the service to be rendered as, for instance, two or four party line service or single party service.

When any one of the group of subscribers in the group shown in Fig. 6, say subscriber **624**, initiates a call, line relay **600** is operated over a circuit extending from grounded battery through the left winding of said relay, outer contacts of cut-off relay **601**, the subscriber's line loop, inner contacts of relay **601**, right winding of relay **600** to ground. Relay **600** operates and completes a circuit for selective magnet **212** which extends from ground through the contacts of relay **600**, left back contacts of relay **602**, conductor **633**, upper No. **4** contact-set of relay **206**, conductor **214**, right winding of selective magnet **212**, conductor **215**, lower normal contacts of relay **208**, conductor **216**, left contacts of relay **102**, right outer contacts of relay **103**, right contacts of relay **101**, to battery and ground. Magnet **212** operates and locks in a circuit completed from operating ground as traced to its left winding, through its left front contacts, left back contacts of selective magnets **211**, **210** and **209**, conductor **217**, winding of relay **102**, right inner contacts of relay **103**, right contacts of relay **101**, to battery and ground. Relay **102** operates in the locking circuit of magnet **212**, closes an obvious circuit for slow-operate relay **104** over its right front contacts and opens the operating circuit of magnet **212** at its left contacts.

In the usual construction of the cross-bar switch, the so-called "100 point" switch preferably has one selecting magnet for ten horizontal cross-points, thus making it possible to provide five links to the frame, each link having one "calling" cross-point and one "called" cross-point; that is, one set of contacts through which the link gains access to the calling line and another set of contacts through which it gains access to the called line. However, where the link capacity is greater than five, and other switch frames have to be provided to accommodate additional links, the number of frames is, of course, determined by the number of links. Where, as in the case being illustrated according to Fig. 12, seven links are provided for twenty lines, an additional frame (frame 3) is split in two and the two additional links accommodated thereon as already described. Under such circumstances, when a subscriber, such as subscriber **624**, initiates a call and the selecting magnet **212**, on the main frame for the horizontal level of the calling line is operated, it also becomes necessary to operate the selecting magnet for the same level on the additional frame since the idle link to be selected and attached to the calling line may be either in the main frame or the auxiliary frame. In the drawings, Fig. 4 represents the auxiliary frame, while its selecting magnets **306** to **310** are shown on Fig. 3 and of which selecting magnet **309** controls the continuation, on the auxiliary frame, of the level controlled by selecting magnet **212** on the main frame. Consequently when relay **104** operates, it completes a circuit which extends from ground through its contacts, conductor **106**, conductor **617** right contacts of magnet **212**, conductor **218**, right winding of selective magnet **309** to battery and ground. Magnet **309** operates and then extends its operating ground through its right contacts, conductor **311**, top outer contacts of relay **208**, winding of relay **219** to battery and ground. Relay **219** operates and completes a circuit for relay **1008**, which circuit extends from ground on the left contacts of relay **219**, conductor **224**, left normal contacts of link make-busy key **711**, left back contacts of relay 710^1, (if the first link is idle), conductor **712**, No. **8** contact-set of relay 1015^1, winding of relay **1008**, to battery and ground. Relay **1008** operates and, through its right sets of contacts, connects ground to conductors **312** and **313** respectively, the former of which extends to the operating winding of the holding magnet 300^1 on the cross-bar frame 1 while the latter extends to the operating winding of the holding magnet 700^1 on the lower cross-bar frame 2. Inasmuch as the calling line **624** appears in the upper frame and the origination of the call therefrom has resulted in the operation of relay **219**, the circuit of holding magnet 300^1 of the first link, if idle, is completed over conductor **312**, winding of magnet 300^1, conductor **320**, right contacts of relay **219** to battery and ground. Magnet 300^1 operates, locks from battery through its lower winding and contacts, conductor **315**, right back contact of relay **1010**, conductor **1016** to ground over the No. **2** contacts of relay **1015'** and, since horizontal selecting magnet **212** is also operated, the combination of the operated selecting magnet **212** and the operated holding magnet 300^1 serves to operate contact-set **314** on the first link and thereby extend conductors **609**, **611** and **612** of the calling line **624** to the first link. As soon as cross-point **314** is operated, then, by virtue of succeeding operations in the link which result in the operation of relay 1015^1, as described hereinafter, a circuit is completed for relay **602** which extends from ground and battery, through the right winding of said relay, conductor **612**, third set of contacts on cross-point **314**, conductor **1016**, to ground on the No. **2** contact-set of relay 1015^1. Relay **602** operates and performs functions described hereinafter.

If the calling line had been located on frame 2, and in the corresponding fourth horizontal position on the frame as line **624** is located on frame 1, say line **634** (not shown), with its extension to the fourth horizontal position on the right of frame 3, then after the operation of the proper selecting magnet on frame 2, instead of closing

the circuit of holding magnet 300[1], the circuit of holding magnet 700[1] on frame 2 would have been completed from ground and battery through the right contacts of relay 606, conductor 628, upper winding of holding magnet 700[1], conductor 313, right inner contacts of relay 1008 to ground. In this way, only the holding magnet of the chosen link in the frame in which the calling line belongs is operated.

Before proceeding with the further operations which follow the connection of a link to the calling line, it is necessary to observe those circuit operations which, prior to this connection, take place to insure that, in the event that more than one line calls at the same time, links, if available, are connected to each of said lines in a definite order of preference and only after each link has been connected to a line.

Suppose that subscriber 624, whose line according to Fig. 12, is located on cross-bar frame 1 and on the fourth level thereof and that subscriber 631, whose line appears on cross-bar frame 2 and on the first level thereof, simultaneously initiate calls by removing their respective receivers off their hooks, line 624 will cause the operation of line relay 600 as already described while line 631 will cause the operation of line relay 612 by the closure of an obvious circuit similar to that for line relay 600.

It will be recalled that the operation of relay 600 resulted in the operation of horizontal selecting magnets 212 and 309 controlling those cross-points on the link frames to which the line 624 is extended. In a similar manner, the operation of relay 612 causes the operation of horizontal selecting magnets 607 and 306 of those cross-points in the link frames to which line 631 extends. Accordingly, when relay 612 operates, a circuit is completed which extends from ground on the contacts of relay 612, left normal contacts of relay 614, conductor 615, No. 1 contact set of relay 603, right winding of selective magnet 607, left normal contacts of relay 605, conductor 616, conductor 216, left contacts of relay 102, right outer contacts of relay 103, right contacts of relay 101, to battery and ground. It will be recalled that the circuit of horizontal selecting magnet 212 was similarly completed to conductor 216 and thence to battery and ground on the back contacts of relay 101. Assuming that the circuit of each of the selective magnets 212 and 607 is closed simultaneously then, when magnet 607 operates, a circuit path is partially completed for selective magnet 306 which extends from ground and battery through its left winding, conductor 317, right contacts of magnet 607, conductor 617, conductor 106, to the contact of relay 104. However, each of the selecting magnets 212 and 607, on operating, closes a locking path through their respective left windings and front contacts, the left back contacts of the selecting magnet immediately ahead of them in preference, to conductor 217 and thence to battery and ground on the back contacts of relay 101 through the winding of relay 102. Inasmuch as the operation of magnet 212, which is ahead of magnet 607, by opening its back contacts breaks the locking path of magnet 607, only magnet 212 whose locking path is not broken, can lock. Hence, when relay 102 operates as before described, the operating circuit of magnets 607 and 212 is opened at its back contacts and since magnet 212 is now locked and magnet 607 is not, magnet 607 releases and further opens the previously described path for magnet 306. In virtue of the operations already described, the first link, if idle, becomes attached, therefore, to line 624.

Should the first link be busy, this condition causes the mechanical locking of relay 710[1] in the manner described hereinafter, and the ground connected to conductor 224 is advanced over the left front contact of relay 710[1], back contact of relay 710[2] of the second link, if idle, the No. 8 contact-set of relay 1015[2] of said link, to the winding of the start relay corresponding to relay 1008 in said second link. Further, if the second link is also busy and, therefore, relay 710[2] is mechanically locked in an operated position, the ground on conductor 224 is advanced over the left front contact of relay 710[2] to the armature of relay 710[3] (not shown) in the third link and from thence either over the back contact of this relay, if the link is idle or over the front contact if the link is busy, to the contacts of relay 710[4] (not shown) of the fourth link; the circuit path being extended over an operated relay 710 in each busy link until an idle one is found, after which operations will take place similar to those already described. Should all links be busy at the time a subscriber initiates a call, relay 710 in each link will be locked in an operated position, whereupon a circuit is completed which extends from ground on the right front contacts of each relay 710 up to and including relay 710[7] of the seventh link, conductor 801, winding of relay 100, to ground and battery. Relay 100 operates and closes an obvious circuit for relay 101 which operates and opens the battery connection to the operating circuits of the horizontal selecting magnets, thus making it impossible to operate any of them if no link is available. Relay 101 further completes a circuit which extends from ground through its left contacts, conductor 107, winding of magnets 709[1]–709[7] in parallel, to battery and ground. Each of these magnets operates and unlocks its companion relay 710[1]–709[7]. So long as each of the links is busy, then, inasmuch as relay 1008 in each of said links releases immediately after the horizontal selecting magnets are operated, as more completely described hereinafter, each of the separate make-busy relays 710[1]–710[7] will remain operated over a path which, for relay 710[1], extends from ground and battery through its right winding, conductor 708, left contacts of relay 1008, No. 2 contact-set of relay 1015[1] to ground; relay 1015[1] in each of the busy links having been operated as described hereinafter. On the other hand, as soon as a link becomes idle, relay 1015[1] releases, the corresponding make-busy relay 710[1] releases and the link is made available for service. Also, when a link becomes idle and its make-busy relay 710 releases, the circuit of relay 100 is broken, causing the release of relay 101, the consequent release of all locking magnets 709[1]–709[7] and the restoration of battery to the start circuit of the horizontal selecting magnets.

Returning, now, to the allotment of an idle link to the subscriber on line 631 on the assumption that said subscriber has started the call at the same time as the subscriber on line 624, and assuming that, due to the preferential arrangement of line 624 ahead of line 631, a link has been connected to line 624, it will be recalled that the horizontal selecting magnets 607 and 306, corresponding to the position of line 631 on the link frames, could not remain operated once the locking circuit of magnet 607 was opened by the operation of magnet 312. However, as soon as the link is allotted to line 624 and relay 602 has

operated, cut-off relay 601 operates over a circuit completed through the right locking contact of relay 602 to a previously traced ground on conductor 612, whereupon line relay 600 releases and opens the locking circuit of horizontal selecting magnet 212 the release of which, in turn, opens the locking circuit of the corresponding selecting magnet 309 on the third link frame. Once the locking circuit of the horizontal magnet 212 is opened, relay 102 releases and restores the operating and locking battery for all of the horizontal selecting magnets. The horizontal magnet 607 and also consequently, horizontal magnet 306 can now operate and lock and cause the allotment of an idle link to line 631.

Having shown how each one of two idle links may be connected to each one of two calling lines on which calls are initiated simultaneously, the operations which follow the connection of the first link to a line on which a subscriber's station, say station 624, is located, will now be described. It will be assumed that the subscriber 624 wishes to establish a connection with another subscriber's station, say station 631 whose line, according to Fig. 12, is located on the first horizontal level of frame 2 and that, in order to establish said connection, subscriber 624 dials the number 319. The first two digits of this number identify the position of the line on the frame on which it is located while the last digit identifies the ringing code assigned to station 631.

When the cross-point 314 is closed, a circuit is completed for relays 1012, 1013 and 1014 over the line loop which may be traced from ground and battery through the winding of relay 1012, bottom outer back contacts of relay 1001, bottom outer contacts of relay 1000, conductor 1017, second contact from the top of cross-point 314, conductor 611, loop of subscriber's line 624, conductor 609, top contact of cross-point 314, conductor 316, top outer back contacts of relay 1000, top outer contacts of relay 1001, winding of relay 1013, conductor 1018, left normal contacts of relay 911, left normal contacts of relay 906, conductor 915, left winding of transformer 1131 to ground. Relays 1012 and 1013 operate closing obvious parallel circuits to the winding of relay 1014 which operates. Relay 1014 causes the operation of relay 1015^1 which, on operating connects: (1) ground through its No. 1 contact-set to conductor 1019 which extends to the No. 1 contact-set of relay 1015^2 of the second link and from thence through corresponding contact sets of relay 1015^3–1015^7 of all the seven links, from the last relay of which, that is relay 1015^7, it extends by way of conductor 800, to the winding of register 105 which, on the other side of its winding, is connected to battery and ground. If, when the first link is taken into use, as above-described, and relay 1015^1 operates, the remaining six links are busy, each of their corresponding relays 1015 is operated and the circuit to register 105 is completed to indicate an all-busy condition of the links; (2) through its No. 2 contact-set, relay 1015^1 connects ground to conductor 1016 which completes previously described circuits to the right winding of relay 602 and to the locking winding of holding magnet 300^1; (3) over its No. 3 contact-set relay 1015^1 extends ground through the bottom inner back contacts of relay 1001 and thence to the No. 4 contact of relay 1009; (4) over its No. 4 contact-set ground is connected to conductor 1020 and, through the bottom outer contacts of relay 1002, to conductor 1026, both of which conductors provide locking paths to the various relays shown in Figs. 5 and 9, as explained hereinafter; (5) over its No. 5 contact-set, ground is connected to conductor 1021 which, over the right middle contacts of relay 911, extends as conductor 914 to resistance 1132, contacts of relay 1121, left winding of relay 1121 to battery and ground. Relay 1121 operates over this self-interrupted circuit and induces currents at each interruption in the closed inductive path extending from ground through the right winding of relay 1121, right winding of coil 1131 to ground. Inasmuch as the left winding of said coil comprises an element in the circuit of relays 1012 and 1013, which circuit extends over the subscriber's loop, said interruptions are repeated over said loop as "dial tone" which is heard by the subscriber as an instruction that he may proceed to dial the wanted number; (6) over the No. 6 contact-set of relay 1015^1 a circuit is completed over the left outer contacts of relay 1009 and conductor 1023 through the left winding of relay 1100 to battery and ground, which relay functions are described hereinafter; (7) over its No. 7 contact-set, relay 1015^1 closes a partial path for relay 1011 which extends from battery through the winding of said relay, conductor 1022, right outer contacts of relay 911, conductor 913, No. 7 contact-set of relay 1015^1, normal contacts of relay 1011 to conductor 1021. The manner in which conductor 1021 is completed to ground will become evident hereinafter from a consideration of the operation of the miscellaneous signaling circuits in Fig. 11, which begins to function as soon as relay 1100 operates at the time ground is connected to conductor 1023; (8) over its No. 8 contact-set, relay 1015^1 opens the previously described circuit of relay 1008, causing said relay to release. In releasing, relay 1008 disconnects ground from conductors 312 and 313 and, since the holding magnet 300^1 is now locked through its lower winding, ground on these respective conductors is no longer necessary while over its left contacts relay 1008 completes a circuit for the link make-busy relay 710^1 which extends from grounded battery through the right winding of said relay, conductor 708, left contacts of relay 1008, No. 2 contact-set of relay 1015^1 to ground. Relay 710^1 is now held operated as long as the link is busy.

Relay 1100, on operating, locks over the right winding and right inner contacts to ground on conductor 914, causes ground to be connected to locking conductor 1133 which extends to various parts of the circuit of Fig. 11, and further completes a circuit for relay 1101 which extends from ground on the left outer contacts of relay 1100, contacts of relay 1103, winding of relay 1101 to battery and ground. Relay 1101 operates and closes an obvious circuit for relay 1102 which causes it to operate and to further close an obvious circuit for relay 1103. Relay 1102 further completes a circuit for relay 1116 extending from ground through its right contacts, conductor 1138, normal contacts of relay 1116, winding of relay 1116, resistance 1134 to battery and, in parallel therewith through the left outer back contacts of relay 1115, resistance 1135 to battery. It will be observed that the winding of relay 1115 is short-circuited by the operating ground for relay 1116 by the connection of said ground to one side of its winding at its left outer back contacts and to the other side of its winding at the normal contacts of relay 1116. Relay 1116 operates, locks to ground on conductor 1133

and maintains the short circuit for the winding of relay 1115 through its front contacts.

In the meanwhile, the operation of relay 1103 opens the circuit of relay 1101 which, after an interval, releases, in turn opening the circuit of relay 1102 which releases after an interval and in turn, opening the circuit of relay 1103 which also releases after an interval and reestablishes the circuit for relay 1101 to repeat the cycle of operations of relays 1101, 1102 and 1103. Relay 1102, on releasing, further disconnects ground from the left terminal of relay 1115 at the left outer back contact of said relay, after which said relay operates in a circuit which extends from ground and battery, resistance 1135, winding of relay 1115, front contacts of relay 1116 to ground on conductor 1133. Relay 1115 operates and establishes a circuit for relay 1117 extending from ground on its right outer contacts, left inner normal contacts of relay 1117, winding of relay 1117, resistance 1137 to battery and ground. Relay 1117 operates and establishes a short circuit for the winding of relay 1114 by connecting ground on conductor 1133 through its left inner contacts to the left terminal of the winding of said relay, ground having been already connected to its other terminal in a path extending from ground on the right outer contacts of relay 1115, right outer back contacts of relay 1114 to the right side of its winding.

On the next operation of relay 1102 ground is again connected to conductor 1138 and since relay 1115 is operated, said ground is extended to resistance 1134 thereby short-circuiting relay 1116 and causing it to release. Relay 1115, however, does not release since it is now held in an operated position by the ground on conductor 1138 extended through the normal contacts of relay 1116. On the subsequent release of relay 1102 and the removal of ground from conductor 1138, relay 1115 releases, the short-circuiting ground for relay 1114 is disconnected and this relay now operates in a circuit extending from ground and battery through resistance 1136, winding of relay 1114, left inner contacts of relay 1117 to ground on conductor 1133.

Upon the next operation of relay 1102, relay 1116 operates again over a previously described path, locks as before and again short-circuits the winding of relay 1115. When relay 1102 releases, relay 1115 operates in parallel with relay 1116 and establishes a short circuit for relay 1117 which circuit may be traced from ground on the right outer contacts of relay 1115, right front contacts of relay 1114, resistance 1137. Relay 1117 releases and completes a circuit for relay 1118 which may be traced from ground and battery, resistance 1146, winding of relay 1118, left inner normal contacts of relay 1118, left middle contacts of relay 1117, left inner front contacts of relay 1114 to ground. Relay 1118 operates and establishes a short circuit for relay 113 by connecting ground on conductor 1133 through its left inner front contacts to the left terminal of the winding of relay 1113 while ground is connected to the right terminal of its winding through its own right back contacts, through the left middle contacts of relay 1117 as already traced.

When relay 1102 operates again, relay 1116 releases in the manner already described and, when it releases, relay 1115 also releases. Inasmuch as relay 1114 is held through the normal contacts of relay 1117 and the right outer contacts of relay 1115, then, with the release of relay 1115, relay 1114 releases. Further, since the winding of relay 1113 is held short-circuited by ground through its right back contact and extending over a previously traced path to the left inner front contacts of relay 1114, then, when said relay releases, the short circuit is removed and relay 1113 operates over a circuit which extends from grounded battery, resistance 1147, left inner front contacts of relay 1118 to ground on conductor 1133.

Thus, after relay 1102 has operated and released four consecutive times, relays 1113 and 1118 are operated and locked while the two previous pairs of counting relays, namely 1115 and 1116, 1114 and 1117 are released.

In the same way it can be shown that after eight consecutive operations and releases of relay 1102, relays 1112 and 1119 will be operated and locked; that after twelve consecutive operations, relays 1110 and 1120 will be operated and locked, that after twenty-four consecutive operations, relays 1109 and 1105 will be operated and locked, and that after forty-eight consecutive operations relays 1109 and 1105 will be released. In all cases, all preceding pairs of counting relays will be released.

Thus in the circuit of Fig. 11, six pairs of counting relays are provided which function to count time through the operating cycle of relays 1101, 1102 and 1103, which cycle can be made as long or as short as desired by appropriate means. During the interval that a link is connected to the calling line the counting relay circuit of Fig. 11 provides the proper intervals for giving the appropriate signals usually given when calls are not completed in a given length of time and further provides for operating the five ringing relays 1122–1126, inclusive, in the proper interval called for by the ringing code of each of five stations located on each of the line conductors. Inasmuch as code ringing is well established in the art and can be carried out by any well-known means which provides for the closure of the ringing circuit path in accordance with the code called for by the wanted station, it is not thought necessary to unduly lengthen this specification by the detailed description of all the functions of the circuit shown in Fig. 11 except in so far as they are necessary to a complete disclosure and understanding of the operation of the link circuit and the manner in which it is used to establish a talking connection between two stations.

Returning, now, to the operation of the link circuit and the fact that the calling station has been given dial tone, let it be assumed that the subscriber does not dial for the time interval measured from the instant relay 1102 operates to the time that relay 1110 operates. If the link has not released during this interval, which means among other things, that the subscriber has not dialed, a circuit is completed over a previously described path to conductor 1021 and thence over the inner right back contact of relay 1120 and the left front contact of relay 1110 as soon as the timing circuit has advanced to operate relay 1110. Relay 1011 operates, locks over conductor 1022, outer back contact of relay 911, conductor 913, No. 7 contacts of relay 1015[1] to ground at its left front contacts and, over its right contacts, extends the winding of relay 1010 to conductor 1024. When the timing circuit has advanced, in the manner previously described, to the point where relay 1109 is operated and relay 1105 is released, ground is connected to conductor 1024 over a path which extends through the

left front contacts of relay 1109 and right contacts of relay 1105, causing the operation of relay 1010 which locks to ground over conductor 1022, right outer contacts of relay 911, conductor 913, No. 7 contact-set of relay 1015[1], left contacts of relay 1011, ground. Relay 1010 disconnects ground from conductor 315 over which holding magnet 300[1] has locked. Magnet 300[1] releases and frees the subscriber's line at the cross-bar contact-set 314. The restoration of the link equipment to normal thereafter is the same as that which will be described subsequently for the disconnection of a completed connection.

Now if the subscriber 624 still has his receiver off the hook after the link is freed, or if the line is crossed, the line relay 600 will reoperate over the line loop since, with the release of the cross-bar point, ground is disconnected from conductor 612 causing the cut-off relay 601 to release, thereby again connecting relay 600 over the line. Relay 602 being slow-release, does not release immediately and before it can release, the reoperation of relay 600 will cause it to remain locked, which condition will prevent the reconnection of the ground to conductor 609 and thereby prevent the seizure of another link during the time that the line is locked out of service.

Assuming, however, that the subscriber does not delay dialing until the operation of relay 1010 but that, on hearing dial tone, proceeds to dial the tens digit 3, then on the interruption of the line which follows the first pulse, relays 1012 and 1013 release, but relay 1014, being slow to release, remains operated during pulse interruptions. A circuit, therefore, is completed which extends from ground on the left back contacts of relay 1013, left inner contacts of relay 1014, conductor 1025, winding of relay 905 to battery and ground. Relay 905 operates and closes an obvious circuit for relay 904 which also operates. Another circuit is also completed which extends from ground through the No. 4 contact-set of relay 1015[1], conductor 1020, lower back contacts of relay 1002, conductor 1026, back contact of No. 4 contact-set of relay 910, conductor 916, right back contacts of relay 1013, conductor 1027, left back contacts of relay 901, contacts of relay 902, winding of relay 903 to battery and ground. Relay 903 operates and the ground through the left back contacts of relay 901 is now extended through the left inner contacts of relay 903 to one side of the right winding of relay 901, the other side of which is also connected to ground through the left front contacts of relay 904. Relay 903 further completes a circuit for relay 501 which extends from ground through the right front contacts of relay 903, left back contacts of relay 900, conductor 917, winding of relay 501 to battery and ground. Relay 501 operates but performs no useful function at this time.

When relay 1013 reoperates on the closure of the line after the interruption thereof by the first pulse, the circuit which caused the operation of relay 903 is opened while neither relays 905 nor 904 release during the pulse interruption since both of them have slow releasing characteristics. Moreover, and due to the fact that relay 904 does not release, relay 903 does not release either, but holds in a circuit which extends from ground through the left front contacts of relay 904, right winding of relay 901, left inner contacts of relay 903, contacts of relay 902, winding of relay 903 to battery and ground. Relay 901 operates in this locking circuit and, on operating, extends ground to conductor 918 which locks relay 501 through its top inner contacts, closes an obvious circuit for relay 900 through the left winding of said relay, causing the operation of said relay which further locks over its right winding and right outer contact to ground on the left front contacts of relay 904.

When the line is opened again by the interruption of the second pulse and relay 1013 consequently releases, the ground previously traced through the right back contacts of relay 1013, left armature of relay 901 to conductor 1027, is now extended over the left front contacts and left winding of relay 901, winding of relay 902 to battery and ground, causing relay 902 to operate, whereupon relay 903 releases and relays 901 and 902 hold in the circuit of relay 902 just traced. With relay 903 released, a circuit is completed for relay 502 which extends from ground on the right back contacts of relay 903, conductor 919, top outer contacts of relay 501, winding of relay 502 to battery and ground. Relay 502 operates and completes a circuit which extends from ground through the right outer front contacts of relay 905, conductor 921, top outer contacts of relay 502, conductor 519, normal contacts of relay 909, winding of relay 909, resistance 922, to battery and ground. Relay 909 operates while relay 908 remains short-circuited by ground on the battery side of its winding extended thereto over conductor 519. On the reoperation of relay 1013 following the closure of the line on the termination of the second pulse, the holding circuit for relays 901 and 902 is opened causing said relays to release, but relay 900 being locked to ground on the contacts of relay 904, which relay does not release during the transmission of the pulses of a digit, remains locked, whereupon relay 501 is released by the opening of the contacts of relay 901 and relay 502 is locked in a circuit which extends from ground and battery through the winding of relay 502, top inner contacts of said relay, conductor 518, left outer back contacts of relay 903, right inner contacts of relay 900 to ground on the left front contacts of relay 904.

On the release of relay 1013 when the line is opened by the interruption of the third pulse, relay 903 operates again as it did for the interruption of the first pulse, and since relay 900 is operated at this time, a circuit is completed for relay 503 which extends from ground through the right front contacts of relay 903, left front contacts of relay 900, conductor 920, top middle contacts of relay 502, winding of relay 503 to battery and ground. Relay 503 operates. On the reoperation of the relay 1013 when the line is closed after the third pulse, relay 901 operates while relay 902 does not as before described. However, since the third pulse is the last of the series of pulses for the first digit 3, no more pulses will be forthcoming for the interval required by the subscriber to wind up the dial, an interval sufficiently long to cause the release of relays 904 and 905. However, due to the operation of relay 901 prior to the release of relays 905 and 904, relay 502 is released, whereupon the short circuit to the battery side of the winding of relay 908 is removed and this relay now operates in parallel with relay 909 in a circuit which extends from ground and battery through resistance 924, winding of relay 908, front contacts of relay 909, to ground on conductor 923. When relay 908 operates and, as soon thereafter as relay 905 releases, a circuit is completed for relay 906 which extends from ground and battery through the left winding of relay 906, left front contacts of relay 908 to ground on the right

outer back contacts of relay 905. Relay 906 operates and locks over its right winding and right inner contacts to ground on conductor 923. Now, due to the operation of relay 906 and the prior release of relay 905, relay 503 does not release because of a holding circuit which extends from battery through its winding and top inner contacts, conductor 520, left outer contacts of relay 905, left inner contacts of relay 906, conductor 925, bottom outer contacts of each of the relays 513, 512 and 511, to ground. A circuit is now completed for relay 512 which extends from ground on the left back contacts of relay 904, right middle contacts of relay 906, right outer back contacts of relay 907, conductor 926, bottom middle contacts of relay 503, top winding of relay 512, to battery and ground. Relay 512 operates over its top winding and locks over its lower winding and bottom inner contacts to ground on conductor 923. The operation of relay 512 registers the tens digit 3 and unlocks relay 503 which releases.

The subscriber now dials the second or units digit which, under our assumption is the digit 1. When relay 1013 releases on the line interruption, relays 904 and 905 operate as before described and the previously traced pulsing ground causes the operation of relay 903, after which a previously described circuit path is completed for operating relay 501 which further locks over conductor 918 to ground on the right middle contacts of relay 901. When relay 905 operates at the beginning of the pulse a shunting circuit is completed for relay 909 which extends from ground on the right outer front contacts of relay 905, left outer contacts of relay 906, right front contacts of relay 908, to resistance 922. Relay 909 releases but relay 908 continues to hold through the right normal contacts of relay 909 to ground, as traced, on the right outer front contacts of relay 905. On the reoperation of relay 1013, at the termination of the pulse, relay 901 operates in series with relay 903 followed by the operation of relay 900 and, after an interval, relays 905 and 904 release, causing the release of relays 901 and 903 after which relay 501 releases. Further, with the release of relay 905, the holding circuit for relay 908 is broken and this relay releases. Thereupon, a circuit is completed for relay 907 which extends from ground and battery through the winding of said relay, right outer contacts of relay 906, left back contacts of relay 908, right outer back contacts of relay 905 to ground. Relay 907 operates and locks to ground on conductor 923.

Now if the units digit of the wanted subscriber's number had been any other digit than the digit 1, say the digit 6, then six pulses would have been dialed and would have resulted in the operation of relay 506 by circuit operations similar to those described for the hundreds digit 3. When, in this assumed series of six pulses, relay 502 operates on the second pulse, ground is connected to resistance 922 over a path extending from the right outer front contacts of relay 905, conductor 921, top outer contacts of relay 502, conductor 519, right front contacts of relay 908 to resistance 922. This causes relay 909 to be shunted and released, causing relay 908 to be held locally so long as relay 905 remains operated; that is, until all the six pulses of the digit are received, at which time it releases and completes the operating circuit of relay 907, already described. A circuit is now completed for relay 514 which extends from ground and battery through the lower winding of relay 514, No. 3 contact-set of relay 506, conductor 521, No. 1 contact-set of relay 910, right outer front contacts of relay 907, right middle contacts of relay 906 to ground on the left back contacts of relay 904. Another circuit is also completed for relay 515 which extends from ground and battery through the lower winding of relay 515, No. 4 contact-set of relay 506 to ground as traced on conductor 521. Both of these relays operate and then lock over their respective top windings and top inner contacts to ground on conductor 923.

The reason why, in the case of any units digit higher than 1, it is necessary to operate one or more of the four relays 514–517 is the fact that, for each digit including 1, a record of the digit must be preserved for the future operation of the proper selecting magnet in the link for reaching the wanted line. Each of the first two digits of the wanted number represents a specific function which must be performed to reach the wanted line. Referring to Fig. 12, it is evident that the first, or tens digit, represents the particular link frame on which the wanted line terminates. Since the invention can accommodate a maximum of fifty lines with ten lines to the frame, it is obvious that the lines on the first frame will have a tens digit which will identify the frame, and inasmuch as the digit 1 is not used as the tens digit, all the lines located on the first frame will have a digit 2 for the tens digit while those on the second frame will have a digit 3. I have chosen to illustrate my invention as adapted to twenty lines, spread over two frames with an additional "split" frame to accommodate two more links that could not be accommodated on the first two frames, so that the lines terminating on the first frame all have a 2 as a tens digit and those terminating on the second frame have a 3 as a tens digit. In other groups of ten lines each were to be added to the office up to a maximum of fifty lines, then each of these groups would have a 4, a 5 and a 6, respectively, as the tens digit.

Hence, so far as the operation of the invention is concerned, the tens digit is used to identify the frame on which the wanted line is located, and this fact is recorded on the operation of one or more of the three relays 511 to 513, inclusive, by the connection of ground to one of the five conductors that identify each of the frames accommodating a group of ten lines. Since the illustration of the operation of the invention has been limited to twenty lines, ten on each frame, only two of these conductors, namely 522 and 523, are used and connected to such parts of the circuit as are controlled over these conductors; the remaining three being bracketed and labeled "to other frames as required." Since, in the call being illustrated, the wanted subscriber is located on the second frame and therefore involves the digit 3 as the first digit, the relay operated on the tens digit 3 was relay 512 to make conductor 523 effective at the proper time.

The relationship between the operation of the relays 511—512 and each of the tens digit which may be used in an exchange having fifty lines, ten lines to the frame is as follows:

Digit	Relays operated
2	511
3	512
4	511, 512
5	512, 513
6	513

The seconds or units digit of the subscriber's line is that which identifies the horizontal level in the frame on which the line terminates, and this fact is recorded in the four register relays 514 to 517, inclusive, in order to eventually prepare a circuit for operating the horizontal magnet involved for reaching the wanted line. These relays are operated or non-operated in particular combinations by the operated relay in the group of relays 501 to 510 which is responsive to the digit dialed. In the case of the call being used to illustrate the operation of the invention and which has the digit 1 as its units digit, none of these relays was operated following the operation of relay 501. If the wanted line had had the digit 6, as assumed for detailing the function of relays 514 to 517, then relays 514 and 515 would have been operated as described. The relationship between the units digit dialed and the relays operated is as follows:

Digit	Relays operated
1	None
2	514
3	515
4	516
5	517
6	514, 515
7	514, 516
8	514, 517
9	515, 516
0	516, 517

Returning, now, to the number being dialed by station 624; that is number 319, and remembering that the dialing of the units digit 1 resulted in the non-operation of the relays 514 to 517, as well as the release of relays 908 and 909 and also the release of relay 501, the subscriber is now ready to dial the last or the ringing digit 9. Each of the pulses of the digit causes the operation of relays 900, 901, 902 and 903 in the manner described, followed by the successive operation and release of relays 501–509. It will be recalled, however, that during the dialing of the units digit and as a result of the operation of relay 905 at the beginning of the digit and its release at the end of the digit, relays 908 and 909 were released. However, when the second pulse has been received and relay 502 has operated in consequence, a previously described circuit path is closed for relay 909, causing said relay to operate. When relay 502 releases, relay 908 is operated in parallel with relay 909, as before described. On the ninth or last pulse, relay 509 is operated and held over its locking contacts to ground on conductor 520 so long as the pulsing relay 903 remains operated. However, at termination of the pulse, the release of relay 905 causes a circuit to be closed extending from ground through the right outer back contacts of relay 905, left front contacts of relay 908, left outer contacts of relay 907, left winding of relay 910 to battery and ground. Relay 910 operates, locks over its right winding and No. 4 front contacts, conductor 1026, bottom outer contacts of relay 1002 to ground on the No. 4 contact-set of relay 1015^1, and extends ground over its No. 5 contacts to the right winding of relay 901, causing the pulsing relays 900, 901, 902 and 903 to hold after the release of relay 904 following the termination of the last pulse of the ringing digit. With relays 903 and 900 remaining operated, relay 509, instead of releasing as it would have done if it had operated on a 9 units digit, remains locked to ground on the No. 5 contacts of relay 910. Relay 910 further causes relay 904 to be held over its No. 8 contact-set to ground on conductor 923 in preparation for making the busy test of the wanted line as explained hereinafter.

The operation of relay 910 further causes a circuit to be completed which extends from ground on the left outer back contacts of relay 911, No 2 contacts of relay 910, conductor 928, right winding of relay 1007^1, conductor 1028, left contacts of relay 103, right back contacts of relay 102, battery and ground. Relay 1007^1 operates and completes a locking path extending from ground on conductor 928, left winding of relay 1007^1 and left inner front contacts, conductor 1029, winding of relay 103, right back contacts of relay 102, to battery and ground. Relay 103 operates in this locking circuit, opens the operating circuit of relay 1007^1 at the left contacts of relay 103 and also the operating circuit of relay 1007 in every link. The locking circuit of each of said relays is likewise opened by the operation of relay 1007^1 since said locking circuit is controlled over conductor 1030 which extends over the back contacts of each of relays 1007 in a chain arrangement, so that once relay 1007 of one link is locked, corresponding relays in other links cannot operate, thereby locking out other links which may be seeking access to the frame containing the wanted line.

Relay 1007^1, on operating, closes an obvious circuit for relay 1006 which, on operating, causes a circuit to be completed for relay 911 extending from ground through the right outer contacts of relay 1006, conductor 1031, winding of relay 911, to battery and ground. Relay 911 operates and locks over its right inner front contacts to ground on conductor 1020. In the meanwhile, the operation of relay 1007^1 causes the connection of ground to conductor 1032 which extends to the top armature of relay 511. Inasmuch as relay 512 has been operated for the tens digit 3, said ground is extended to complete a circuit over the top back contact of relay 511, top outer front contacts of relay 512, top inner back contacts of relay 513, conductor 523, winding of relay 605 to battery and ground; winding of relay 604 to battery and ground and winding of relay 603 to battery and ground. Relay 603 operates and opens the path of each horizontal selecting magnet on the second frame, each of which extends back to a corresponding line relay of a subscriber's line on this frame; relay 604 operates and extends the operating winding of each of said magnets to each of the ten conductors extending to the contacts of relays 514–517, while relay 605, over its left front contacts, connects ground and battery to each of the operating windings of said horizontal magnets while over its right inner contacts it extends ground to conductor 621 which is connected to the operating windings of all link holding magnets 701^1–707^1.

Since the units digit of the wanted subscriber's number is 1, and since the impulse of this digit resulted in the operation and locking of none of the relays in the group of relays 514–517 inclusive, a circuit is completed which extends from ground on the right inner contacts of relay 1007^1, conductor 1033, left outer contacts of relay 500, bottom outer back contacts of relays 514–517 inclusive, conductor 524, No. 1 contacts of relay 604, right winding of horizontal selecting magnet 607, left contacts of relay 605, to battery and ground. Magnet 607 operates and prepares the horizontal cross-points for contact with the vertical at the link attached to the cross-point of the calling line. In the meanwhile, the ground connected to conductor 621 completes a

circuit through the top winding of holding magnet 701[1] of the first link, conductor 702, left contacts of relay 1006 to battery and ground. Holding magnet 701[1] operates over its top winding and then locks over its lower winding and contacts in a previously described circuit. Since the circuit of horizontal selecting magnet 607 was closed ahead of that of holding magnet 701[1] by the fact that the former circuit is completed by relay 1007[1] and that of the latter by relay 1006 which is slow-operate, the cross-point contacts controlled by magnet 607 are set for locking under control of magnet 701[1] in advance of the operation of said magnet, as required for the proper operation of a cross-bar switch.

When relay 911 operates, it opens the circuit of relay 1007[1] which, on releasing, further releases relay 1006 disconnects ground from conductor 923 which latter causes the release of all relays locked to said conductor including relay 904, connects ground to conductor 1018 which extends to the winding of relay 1013 to replace ground supplied from conductor 915, and if the wanted line is idle after testing it in the manner to be described hereinafter, completes a circuit which extends from ground through the left inner back contacts of relay 500, conductor 525, left middle contacts of relay 911, right outer contacts of relay 904, conductor 929, right outer contacts of relay 1009, winding of relay 1005, to battery and ground.

If the wanted line is busy, relay 614 of said line is operated and as soon as cross-point 703 is operated and before relay 911 shall have had time to operate and, therefore, remove ground from conductor 923, a path is completed for relay 1009 which extends from ground and battery through the winding of said relay, conductor 1045, right inner contacts of relay 904, conductor 1039, third contact of cross-point 703, conductor 625, right outer front contacts of relay 614 to ground. Relay 1009 operates, locks to ground on the No. 3 contact-set of relay 1015[1] under the control of the bottom inner back contacts of relay 1001, cuts off the operating circuit of relay 1005, opens the circuit of relay 1100 which, however, does not release at this time because it is held up over another ground to its right winding extending over conductor 1143, bottom inner contacts of relay 1005, No. 7 front contacts of relay 1009, to ground through the No. 6 contacts of relay 1015[1], and completes a busy tone circuit for the calling line which extends from ground through the right winding of induction coil 1131, left inner front contacts of relay 1115, condenser 1144, conductor 1146, No. 6 contacts of relay 1009, top outer back contacts of relay 1005, top outer back contacts of relay 1004, upper winding of relay 1002, to ground and, in parallel therewith through condenser 1044, bottom outer contacts of relay 1001, bottom outer back contacts of relay 1000, conductor 1017, second contact of cross-point 314, conductor 611, subscriber's loop 624, conductor 609, first contact of cross-point 314, conductor 316, top outer back contacts of relay 1000, top outer contacts of relay 1001, condenser 1034, lower winding of relay 1002 to battery and ground and, in parallel therewith, bottom back contacts of relay 1004, bottom outer back contacts of relay 1005, No. 5 contacts of relay 1009, conductor 1147, condenser 1145, right inner contacts of relay 1115 to ground. The subscriber hears the tone which is interrupted at regular intervals by the operation and release of relay 1115 as before described. He is by this means notified that the called line is busy and restores his receiver to the switchhook.

If the wanted line is not busy, relay 614 is normal, relay 1009 does not operate and the circuit of relay 1005 is completed as before described. Relay 1005 operates and locks over its operating path to ground on conductor 929. It further completes a circuit for operating the called line cut-off relay 613 which extends from ground through the bottom middle contacts of relay 1005, conductor 1039, fourth contact of cross-point 703, conductor 625, right outer back contacts of relay 614, winding of cut-off relay 613 to battery and ground. Relay 613 operates, removes the line relay 612 from the line and prevents the subscriber from initiating a call.

As soon as relay 1005 is operated, the wanted line is cut through to the calling line preparatory to the closure of the ringing circuit over a path hereinafter described.

It will be recalled that, when the link is seized, the alarm circuit shown in Fig. 11 begins to function as soon as ground is connected to conductor 1023, and that the pairs of counting relays like relay 1115 and 1116 operate and release to count off time in the manner described. As soon as relay 1117 operates, ground is connected to conductor 1139 through the left middle back contacts of relay 1119, right middle back contacts of relay 1118, right inner front contacts of relay 1117 to conductor 1139 which further extends through the right middle back contacts of relay 1009, top inner continuity contacts of relay 1004, conductor 1036, left inner contacts of relay 911, conductor 930, conductor 1037, winding of relay 1004 to battery and ground. Relay 1004 operates and locks over its top inner front contacts, conductor 1038, to ground through the left outer back contacts of relay 1112 which is normal at this time.

During the period in which relay 1004 is operated, the called subscriber's station is being rung, and this period is measured from the first release of relay 1102 to the operation of relay 1112 on the eighth consecutive release of relay 1102, as already described.

The operation of relay 1004 completes the ringing circuit to the called subscriber's line and in the proper ringing code combination determined by the last digit of the wanted number which, in this case, is determined by the digit 9 and, therefore, by the operation of relay 509. Inasmuch as the operation of the invention is being disclosed with respect to a rural exchange having five stations on the tip conductor of the line and five stations on the ring conductor, the different stations must be rung by a code individual to each station although the invention is not limited to a plurality of stations on one line or even to a single station. Under these circumstances, relays 1123 to 1126 each provide a different ringing code for each of the five stations on one of the line conductors and the circuit for operating each of said relays is controlled in the appropriate order and for the required length of time by the pairs of counting relays shown in Fig. 11. Inasmuch as this part of the circuit is ancillary to the operation of the invention in that ringing code relays and the manner of their control are well established in the art, it is not deemed necessary to describe the various operating circuits for the relays 1123 to 1126 except to mention the fact that relay 1122 provides a code of two medium rings per cycle; relay 1123 three short rings; relay 1124 four short rings; relay

1125, one long and one short ring; and relay 1126 one long and two short rings. When these relays operate in the appropriate order called for by the operation of the counting relays, ringing current is transmitted to one of the line conductors depending on which of the relays in the group of relays 501 to 510 has been operated by the ringing digit, while the same thing is true of the stations on the other line conductor, the discrimination between whether ringing current is applied to one or the other conductor being determined by the ringing digit which causes the operation or non-operation of relay 1003 as explained hereinafter.

Remembering that if the ringing digit is an odd digit, which means that the called station is on the tip conductor of the line, relay 900 does not release on the termination of the pulse, a circuit is completed from ground and battery through the winding of relay 1003, conductor 1042, No. 6 contact-set of relay 910, to ground on the right inner contacts of relay 901. With relay 509 operated, a ringing circuit is now completed which extends from ground through the ringing generator 1142, contacts of relay 1126, conductor 1140, bottom inner contacts of relay 509, conductor 931, No. 7 contacts of relay 910, conductor 1041, top front contacts of relay 1003, top outer contacts of relay 1004, top outer front contacts of relay 1005, conductor 1035, top contacts of cross-point 703, conductor 714 to ground through all the ringing circuits in parallel of all the stations, including station 631, located on the tip side of the line. Since relay 1126 operates from the counting relays in a manner such as to provide one long interval followed by two short intervals of operation, one long and two short ringing signals are transmitted which will be recognized by the subscriber of station 631 as a call for that station.

If a wanted subscriber's station is located on the ring side, its ringing digit would be even in consequence of which relay 901 would be released at the termination of the digit, relay 1003 would not be operated, and the ringing circuit would be closed to the ring conductor of the line, ringing all the stations on said conductor according to the code determined by the relay in the group of relays 501 to 510 which was operated by the ringing digit.

During the time that ringing current is connected to the calling station, ringing tone is induced over the calling line loop in a circuit which extends from the ringing current circuit traced to the top outer contacts of relay 1004, condenser 1043, condenser 1044, lower outer back contacts of relay 1001, lower outer back contacts of relay 1000, conductor 1017, second contact of cross-point 314, conductor 611, subscriber's loop 624, conductor 609, first contact of cross-point 314, conductor 316, top outer back contacts of relay 1000, top outer back contacts of relay 1001, condenser 1034, lower winding of relay 1002 to battery and ground. This tone circuit enables the calling subscriber to hear the ringing of the wanted station.

When the called station 631 answers during a silent interval, relay 1002 operates over the circuit path previously traced for the ringing current, except that a part of the path is traced, in this case, through the transmitter and receiver of the station that is bridged across both conductors of the line. Relay 1002, on operating, unlocks relay 910, which on releasing, unlocks the pulsing relays 900, 901 and 902 and also the ringing digit relay 509. Relay 1002 further closes an obvious circuit for relay 1009 which locks over a previously traced circuit to ground on the No. 3 contact-set of relay 1015^1, opens conductor 1023 and since, at this time, relay 1005 is also operated, conductor 1143 is also opened, causing the release of relay 1100 and the consequent restoration of the timing relays to normal, accompanied by the release of relay 1126 and the prevention of any further ringing.

The talking circuit between the two lines is now complete, with relay 1002 holding over the called line loop and relays 1012 and 1013 holding over the calling line loop.

When the calling line restores, the path which holds relays 1013 and 1012 operated is broken at the subscriber's station and said relays release, causing in turn, the release of relay 1014 which, in turn, causes the release of relay 1015^1. The release of relay 1015^1 unlocks relays 911 and 1009 and the holding magnets 300^1 and 701^1, thus freeing the cross-points 314 and 703, respectively. The release of relay 911 unlocks relay 1005 which then causes the release of relay 1002 and the link is thus restored to normal. With the opening of the link cross-point 703, cut-off relay 613 of line 631 is released and the line is restored to normal while, with the release of cross-point 314, relay 602 is released, in turn releasing cut-off relay 601 and restoring line 624 to normal.

Should the subscriber 624 call a station located on his own line he will, of course, dial the tens and units digit of his own number followed by the appropriate ringing code digit which may also be the same as his own if the station called is on the other line conductor and assigned to the same ringing code. The subscriber, after dialing, restores and waits for an interval during which the called station is being rung and then again removes his receiver to ascertain whether the called station has answered, in which case conversation between the two stations will ensue. When the calling subscriber has dialed his own number, the link will test the called line which, being the calling line in this case, will find it busy, whereupon relay 1009 operates in the manner described. When the calling station restores, relays 1012, 1013 and 1014 release, but before relay 1015^1 releases, a circuit is completed for relay 1001 which extends from ground and battery through the winding of said relay, left outer contacts of relay 1014, conductor 1048, No. 3 contacts of relay 910, conductor 1049, fourth contact of cross-point 319, fourth contact of cross-point 314 to ground. Relay 1001 operates, closes an obvious circuit for relay 1005, closes a locking circuit for relay 1015^1 over the top contacts of relay 1002, bottom inner front contacts of relay 1001, No. 3 contacts of relay 1015^1 to ground. By the holding of relay 1015^1 the link is prevented from disconnecting while, with the operation of relay 1005 the two stations are connected together, permitting ringing to be applied in the manner already described. The removal of the called subscriber's receiver then closes a circuit already traced for the back bridge relay 1002 the effect of which will be to cause a dismissal of the link as already described.

When the link is disconnected from the line, cut-off relay 601 releases and since both the calling and called stations have their receivers off the hooks, relay 600 is again operated which, in turn, holds relay 602 locked. Talking battery for the two lines is supplied through the windings of the line relay 600.

In order to enable a calling line to make a call

beyond the local area, trunks are provided which extend to a distant switching point, and an idle one of these trunks can be reached by the subscriber dialing the digit 0. In the present embodiment of this invention three such trunks are shown, namely, trunks 221, 222 and 223 which are connected, respectively, to the first three successive cross-points on link frame 1 and split link frame 3.

When a subscriber, such as 624 for instance, wishes to obtain an outside connection he removes his receiver and an idle link, such as link 1, is connected to the line by the operation of cross-point 314. Dial tone is then transmitted in the manner described. In consequence of dialing 0, which results in the generation of ten line pulses, relays 900, 901 and 902 respond to these pulses in the usual way and since, on the tenth pulse, it being an even pulse, relay 903 is released, a circuit is completed for relay 510 which extends from ground and battery through the winding of said relay, top outer contacts of relay 509, conductor 919, right back contacts of relay 903 to ground. Relay 510 operates and completes a circuit for relay 500 which extends from ground and battery through the winding of said relay, top outer contacts of relay 510, conductor 926, right outer back contacts of relay 907, right middle contacts of relay 906, left back contacts of relay 904 to ground. Relay 500 operates and, over its left inner front contacts, connects ground to the left winding of relay 910 which, on operating, causes the operation of relay 1007[1] in the manner already described and which, in turn, causes the operation of slow-operate relay 1006. Relay 1007[1], on operating, further connects ground to conductor 1033 which extends over the left outer front contacts of relay 500 to conductor 528 which, in turn, extends to the left inner armatures of the trunk cut-off relays 200, 202 and 204, and holds operated whatever cut-off relay is up at the time so as to prevent the release of a busy trunk should it become idle during the selection of an idle trunk. Relay 1007[1] further connects ground to conductor 1032 which, in this case, extends over the right inner contacts of relay 500 to conductor 522.

Inasmuch as the outgoing trunks are located on the first three levels of the first link frame, it becomes necessary to operate those relays which close through the circuits of the horizontal selecting magnets and holding magnets on this frame, that is, relays 207 and 208. For this reason the conductor which extends from the right outer contact of relay 500 is connected to conductor 522 which, it will be remembered, is the conductor that is grounded to operate relays 207 and 208 if a wanted line appears on the first frame for which the identifying tens digit is a 2 and results in the operation of relay 511. If the trunks had been located on the second frame, which can be reached by dialing the tens digit 3 and hence, by the operation of relay 512, the conductor extending from the right outer contact of relay 500 would have been joined to conductor 523 which, as previously described, would have caused the operation of relays 604 and 605 for operating the appropriate selecting magnet on the third frame. Hence, upon the operation of relay 500 and that of relay 1007[1], a circuit is completed extending from ground on conductor 1032, right inner contacts of relay 500, conductor 522, winding of relay 208 to battery and ground and, in parallel therewith, winding of relay 207 to battery and ground. Relay 208 operates, connects ground to conductor 225 which extends to the operating windings of all "called" holding magnets 301[1]–301[7], connects ground and battery to the operating windings of horizontal selecting magnets 209–213, and opens the circuit of relay 219. Relay 207, on operating, closes through the operating winding of each of the selecting magnets to the conductors extending to relays 514 to 517 inclusive, which are inactive at this time and also, in the case of the first three magnets 209, 210 and 211 to the respective right outer back contact of the cut-off relay of each of the three trunks served by each of these magnets. If all three trunks are idle at this time, then a circuit for selecting magnet 209 is completed which extends from ground through the left outer contacts of relay 1007[1], conductor 1046, right outer contacts of relay 500, conductor 529, right outer back contacts of relay 200, No. 1 contacts of relay 207, right winding of selective magnet 209, to battery on the bottom contacts of relay 208. Selective magnet 209 operates and, due to the fact that relay 1006 is caused to operate slightly ahead of selecting magnet 209 for reasons pointed out in connection with the operation of selecting magnet 607 and holding magnet 701[1], holding magnet 301[1] operates slightly after selecting magnet 209 and thereby operates cross-point 318 by which the calling line is extended to the trunk 221.

Should trunk 221 be busy at the time selection is being made, then relay 200 would be operated, the operating circuit of selective relay 209 would be cut off at its right outer back contact and a circuit for selecting relay 210 would be completed, if trunk 222 is idle, extending from ground and battery through the bottom contacts of relay 208, right winding of selecting magnet 210, No. 2 contacts of relay 207, right outer back contacts of relay 202, right outer front contacts of relay 200 to ground as traced on conductor 529. And in the same way, if trunks 221 and 222 were busy, the circuit of selecting magnet 211 would be completed over the back contacts of relay 204 and the front contacts of relays 201 and 200. Should all three trunks be busy, then a circuit would be completed for relay 1009 extending from ground on the right inner contacts of relay 200, right inner contacts of relays 202 and 204, conductor 627, right middle contacts of relay 500, conductor 1045, winding of relay 1009 to battery and ground. Relay 1009 would then operate and cause the transmission of busy tone to the calling line in the manner already described. Assuming, however, that trunk 221 is idle, then, when connection is established thereto, a circuit is completed for cut-off relay 200, conductor 226, third set of contacts on cross-point 318, conductor 1039, bottom middle contacts of relay 1005 to ground; relay 1005 operating in the same manner as before described. Relay 200 operates, locks over its left winding and left inner contacts, conductor 227, left outer front contacts of relay 500 to ground on conductor 1033 and removes the trunk relay 201 from the line. The connection of the calling line to the trunk now takes place over cross-points 314 and 318 over the same link path as previously described, except that the outward connection in this case is not through cross-point 703 but through cross-point 318.

In case the trunk circuits are of the kind that furnish their own talking battery the link circuit is provided with relay 1000 as shown. Upon the operation of relay 1005, a circuit is completed for relay 1000 which extends from ground and battery through the winding of relay 1000, top middle contacts of relay 1005, conductor 1048, to ground

on the fourth set of contacts on the appropriate trunk cross-point as, for instance, cross-point 318. Relay 1000 operates, locks to ground on the bottom middle contacts of relay 1005, and removes the battery bridge through relay 1002 from the talking conductors, thus extending the talking line straight metallic to the trunk over its top and bottom outer front contacts. The disconnection of the calling station from the trunk takes place in the manner described when the calling station restores.

What is claimed is:

1. In a telephone system, a plurality of groups of local subscribers' lines arranged to be interconnected, link circuits for extending connections between said lines and a single cross-bar switch for each of said groups of lines for effecting all of said connections, each of said switches having a plurality of bars temporarily operable to prepare a connection and other bars operable to maintain the connection after the release of the first mentioned bars.

2. In a telephone system, a plurality of cross-bar switching units, groups of subscribers' lines terminating respectively in said switching units, a plurality of link circuits common to all of said switching units and each having a calling branch and a called branch appearing in each of said switching units, and means for connecting a calling line to a called line through an idle one of said link circuits.

3. In a telephone system, a plurality of groups of subscribers' lines, a plurality of cross-bar switching units, each individual to one of said groups of lines and in which the lines of said group appear exclusively, a plurality of link circuits common to all of said switching units and each having a calling branch and a called branch appearing in each of said switching units, and means for connecting a calling line to a called line through an idle one of said link circuits.

4. In a telephone system, a unitary cross-bar switch consisting of coordinate rows of separately operable contacts and intersecting bars for operating said contacts, a plurality of local subscribers each of whose lines terminates in two separate sets of contacts on said switch, said lines being provided with impulse senders, outgoing trunks for extending connections from any of said lines, each of said trunks terminating on one row of separately operable contacts on said cross-bar switch, and a link circuit comprising means responsive to the initiation of a call by one of said lines for connecting said link to said calling line through one of the two sets of contacts of said calling line on said switch, means responsive to dial impulses from said line for connecting said link with a called line in said plurality of local subscribers' lines through the other of the two sets of contacts of said called line on said switch, and means responsive to the impulses of another digit for connecting said link to said row of separately operable contacts on said switch that extend to said outgoing trunks.

5. In a telephone system, a plurality of local subscribers' lines arranged to be interconnected, each of said lines being provided with an impulse sender, outgoing trunks for extending connections from any of said lines, a single cross-bar switch in the terminals of which said lines and said trunks terminate, said switch having a plurality of bars temporarily operable to prepare a connection and other bars operable to maintain the connection after the release of the first mentioned bars, and a link circuit for effecting all of said connections comprising means responsive to the initiation of a call for operating the terminals of said switch to which said calling line belongs and means responsive to a series of impulses transmitted from the dial of said calling line for operating one of said first mentioned bars, to a second series of impulses for operating one of said second mentioned bars for closing the terminals of the wanted line on said switch, and to a third series of impulses for closing a ringing circuit to said called line through the terminals of said line on said switch.

6. In a telephone system, a plurality of selective switches, lines incoming to each of said switches, a plurality of lines common to said switches and outgoing therefrom, an auxiliary switch having its terminals divided into sections, said sections serving respectively the different selective switches, outgoing lines appearing in common in the several sections of said auxiliary switch, and means for connecting a line incoming to one of said selective switches to any outgoing line appearing in such selective switch or to any outgoing line appearing in the corresponding section of said auxiliary switch.

7. In a telephone system, a plurality of first cross-bar switching units, an extension cross-bar switching unit having its field of circuit making contacts divided into a plurality of vertical sections, said sections being individual respectively to said first switching units, a plurality of lines incoming to each of said first switching units and to the respective sections of said extension switching unit, a plurality of lines common to said first switching units and outgoing therefrom, a plurality of lines common to the sections of said extension switching unit and outgoing therefrom, and conjointly operating members in each of said switching units for connecting a line incoming thereto to any line outgoing therefrom.

8. In a telephone system, a plurality of cross-bar switching units, groups of subscribers' lines terminating respectively in said switching units, a plurality of link circuits common to all of said cross-bar switching units for effecting connections between said lines and in which said lines terminate, a cross-bar switching unit common to said groups of lines, and a plurality of additional link circuits accessible from said common cross-bar switching unit for effecting connections between said lines.

9. In a telephone system, a plurality of cross-bar switching units, groups of subscribers' lines terminating respectively in said switching units, a plurality of link circuits common to all of said cross-bar switching units for effecting connections between said lines, a cross-bar switching unit common to said groups of said lines and in which said lines terminate, a plurality of additional link circuits accessible from said common cross-bar switching unit for effecting connections between said lines, and means for rendering an idle one of said additional link circuits available when all of said common link circuits are busy.

GERALD V. KING.