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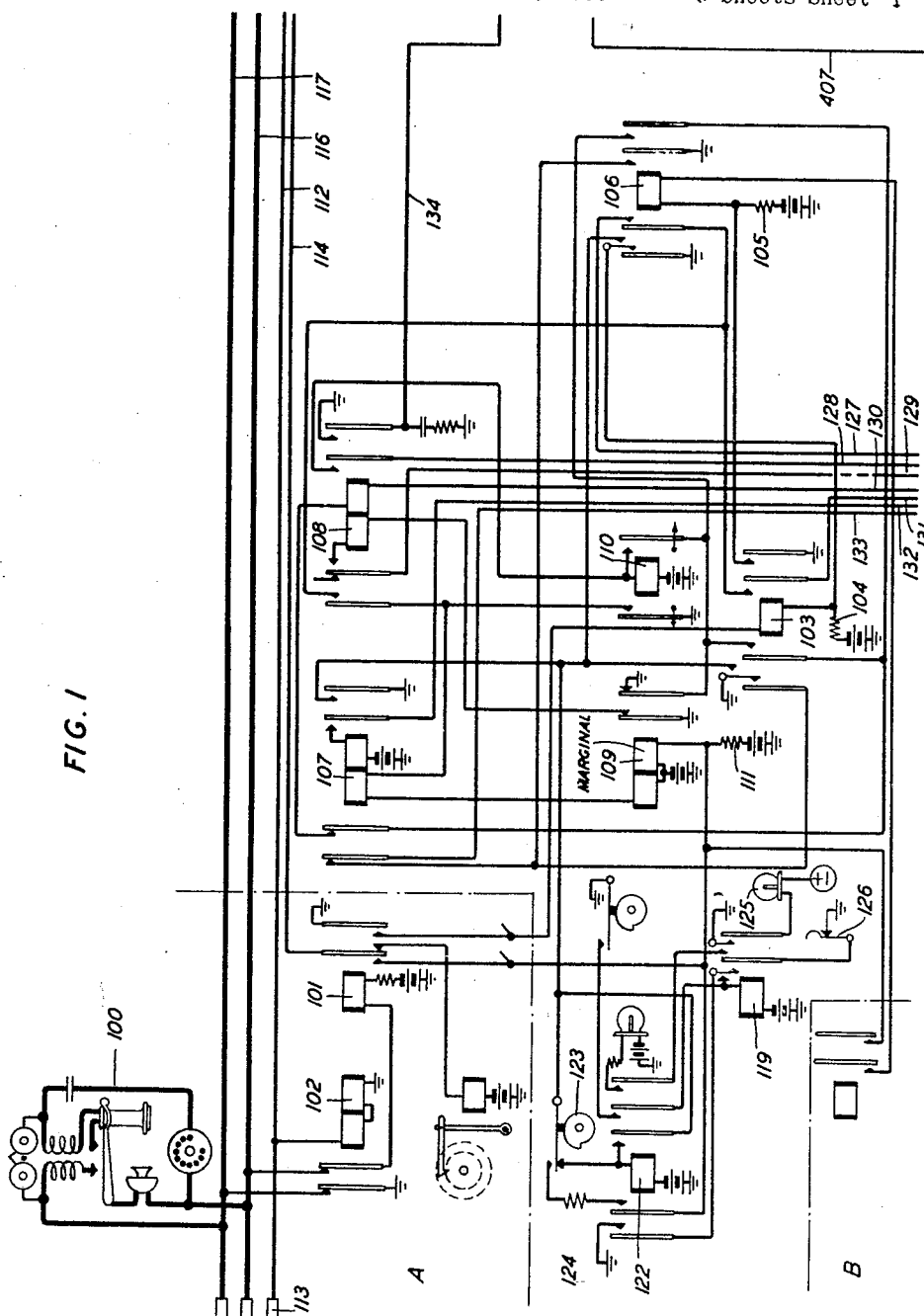
F. S. IRVINE

1,840,364

TELEPHONE DIAL SYSTEM

Filed Oct. 18, 1930

9 Sheets-Sheet 1



INVENTOR
F. S. IRVINE
BY *P. C. Smith*
ATTORNEY

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F. S. IRVINE

1,840,364

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9 Sheets-Sheet 2

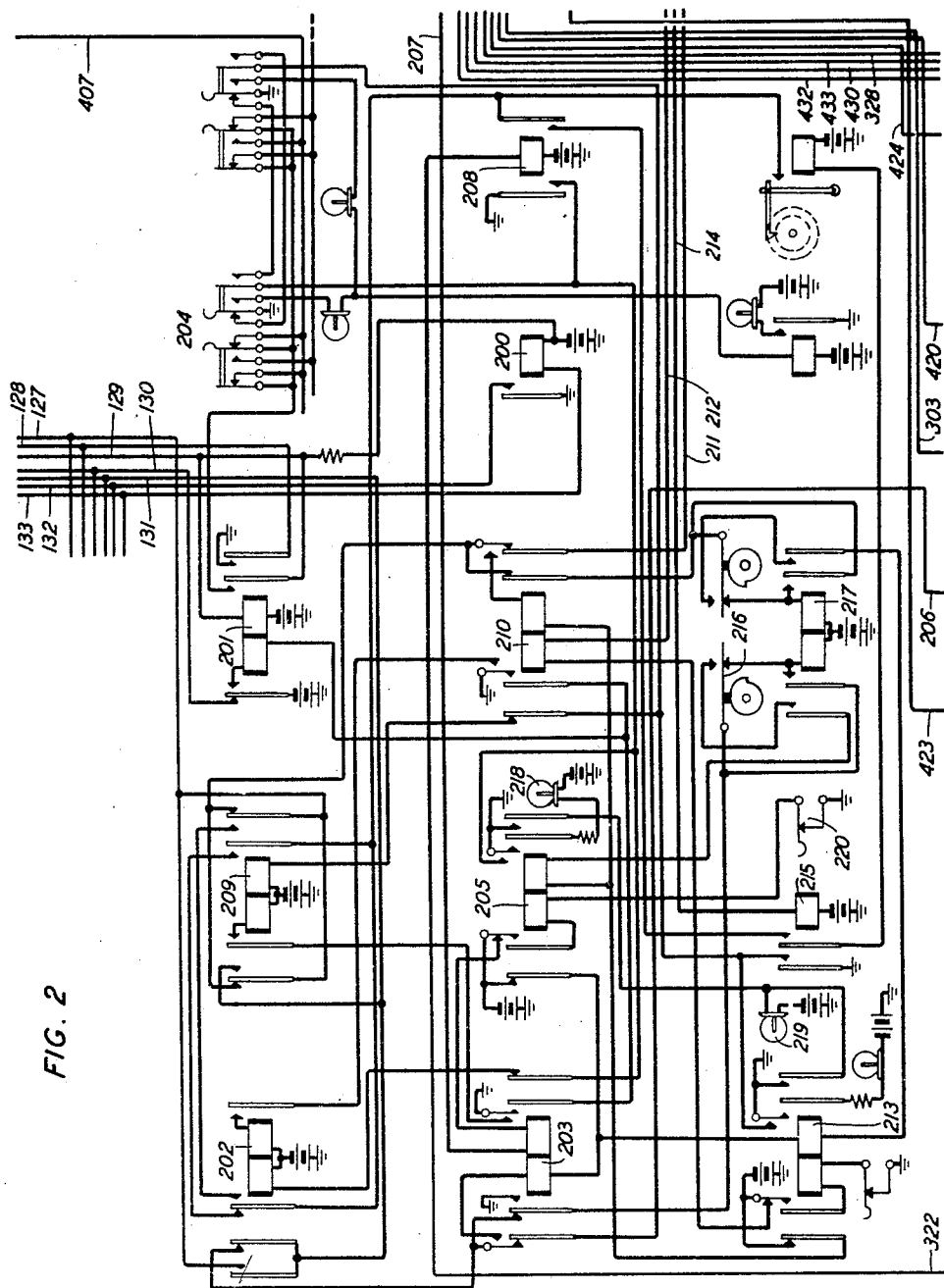


FIG. 2

INVENTOR
F. S. IRVINE
BY *P. C. Smith*

ATTORNEY

Jan. 12, 1932.

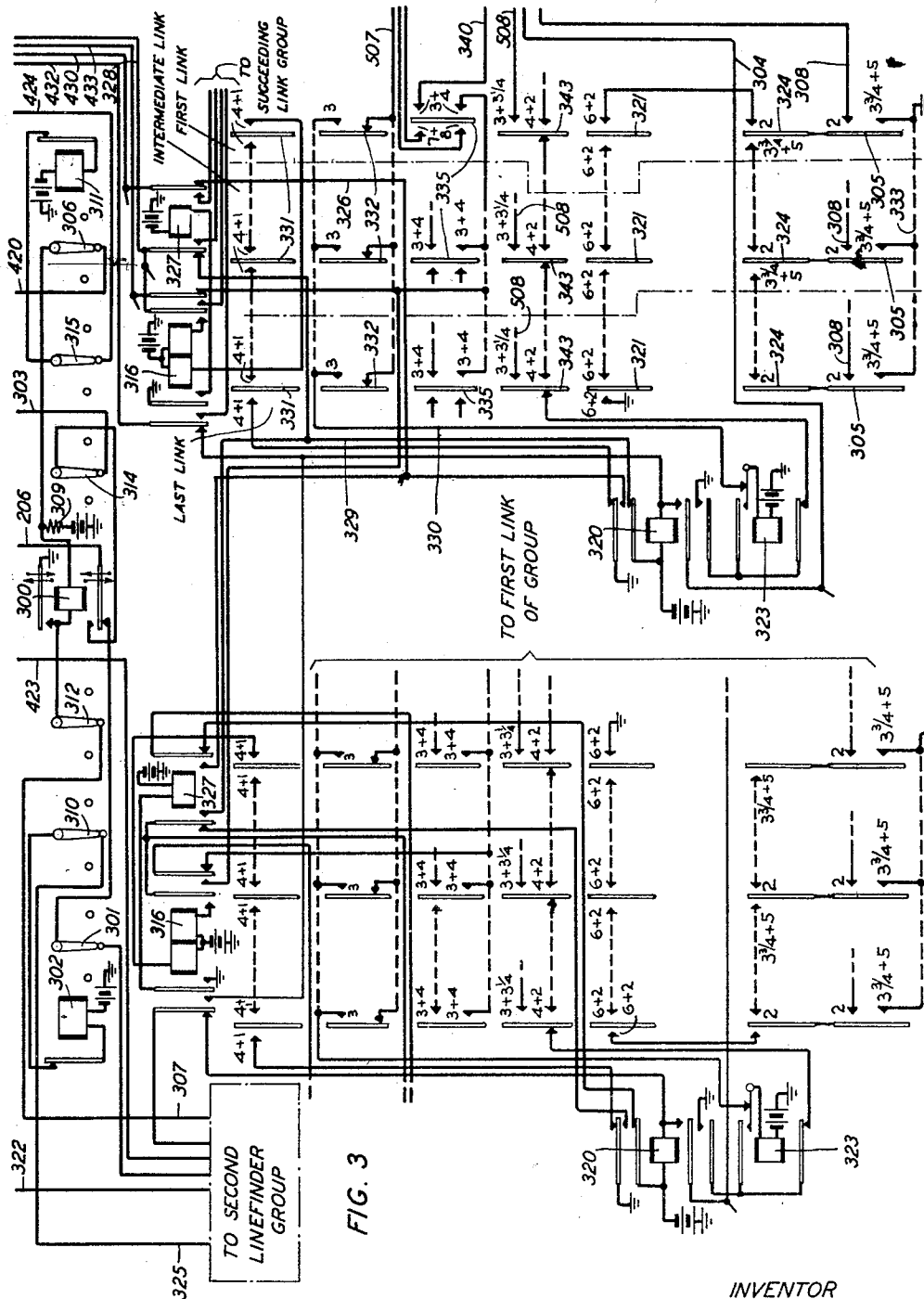
F. S. IRVINE

1,840,364

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Filed Oct. 18, 1930

9 Sheets-Sheet 3



INVENTOR
F.S. IRVINE
BY *P. C. Smith*

ATTORNEY

Jan. 12, 1932.

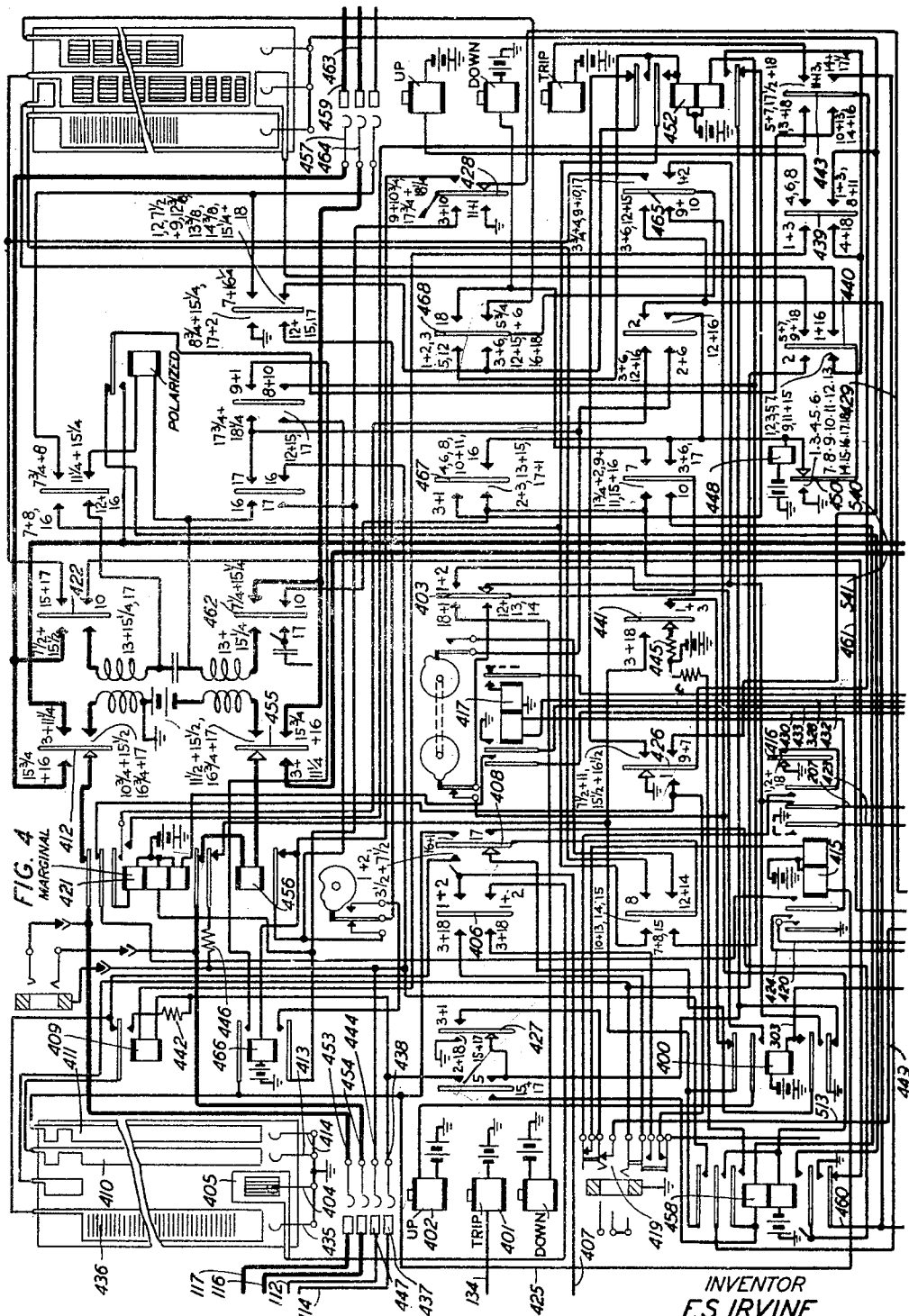
F. S. IRVINE

1,840,364

TELEPHONE DIAL SYSTEM

Filed Oct. 18, 1930

9 Sheets-Sheet 4



INVENTOR
F. S. IRVINE
BY *P. C. Smith*

ATTORNEY

Jan. 12, 1932.

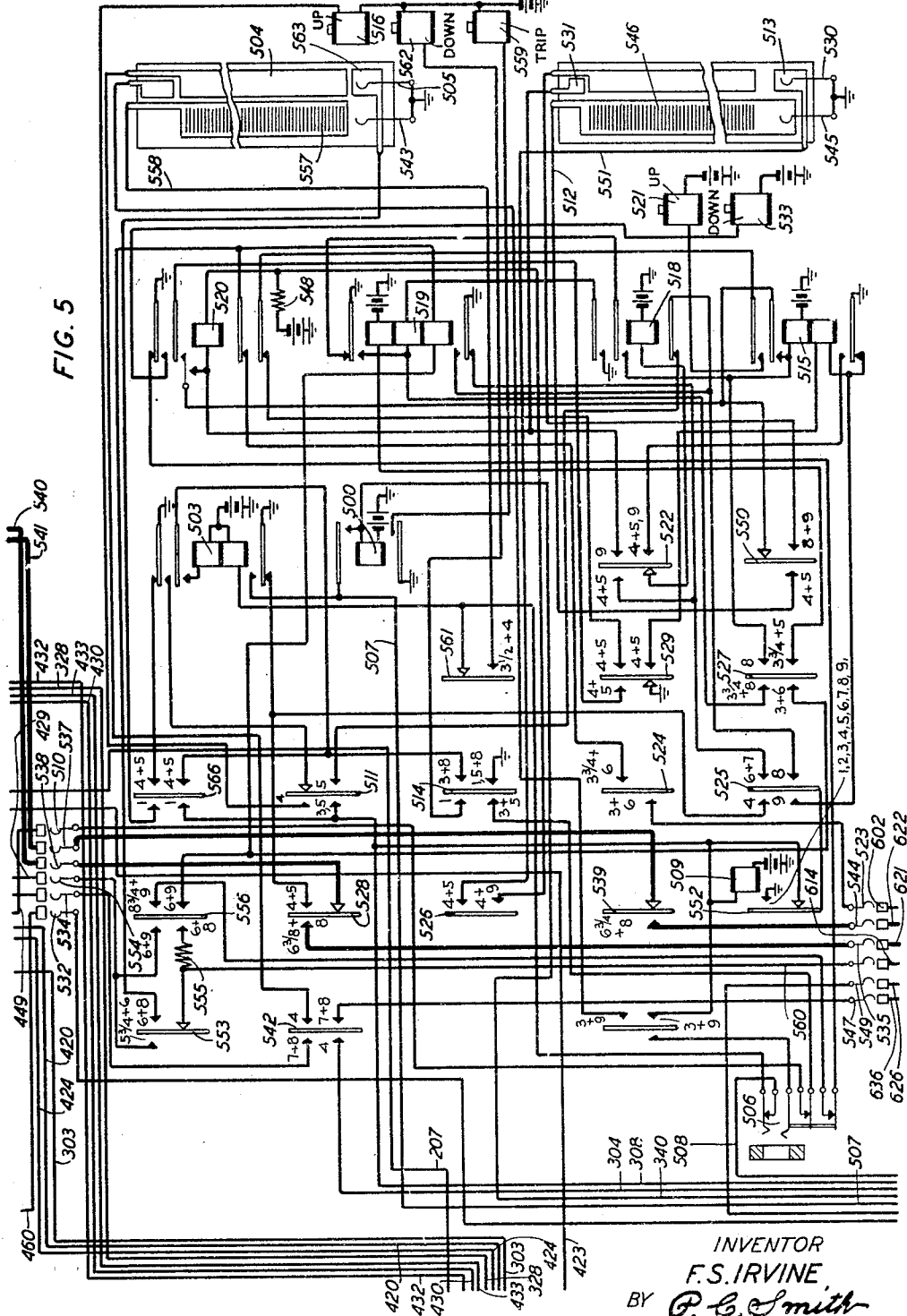
F. S. IRVINE

1,840,364

TELEPHONE DIAL SYSTEM

Filed Oct. 18, 1930

9 Sheets-Sheet 5



INVENTOR

F. S. IRVINE

BY *P. C. Smith*

ATTORNEY

Jan. 12, 1932.

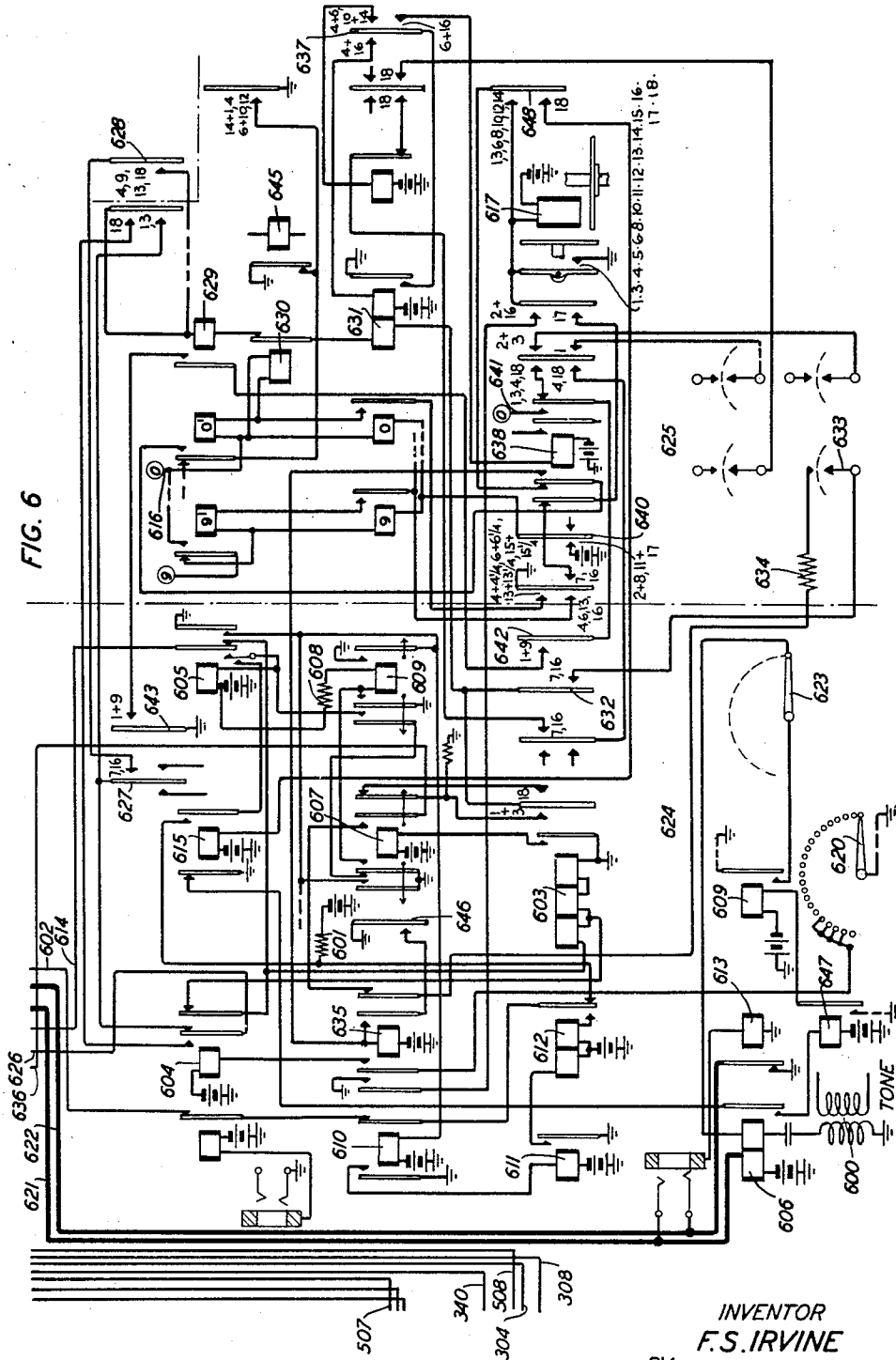
F. S. IRVINE

1,840,364

TELEPHONE DIAL SYSTEM

Filed Oct. 18, 1930

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Jan. 12, 1932.

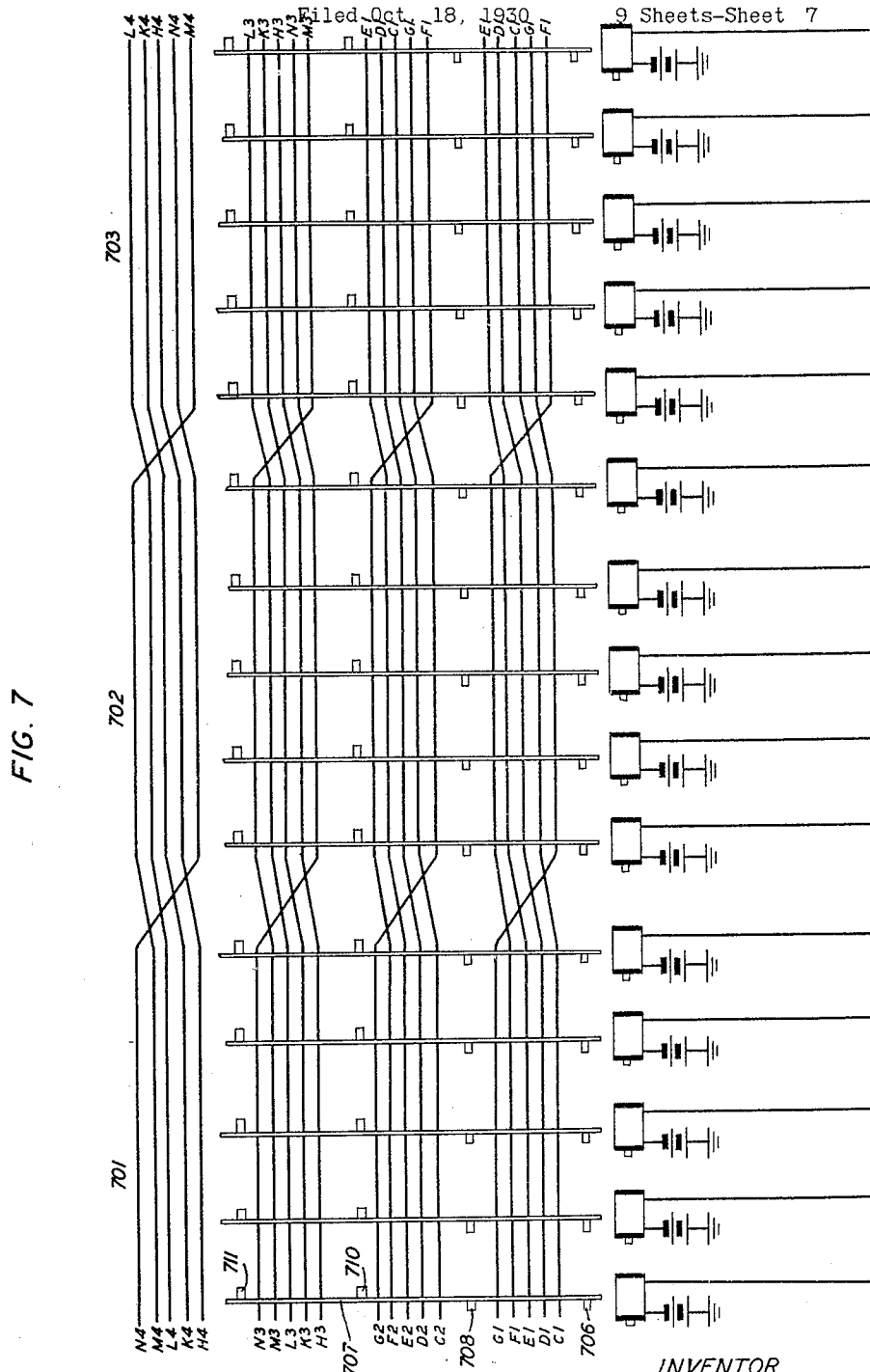
F. S. IRVINE

1,840,364

TELEPHONE DIAL SYSTEM

Filed Oct. 18, 1930

9 Sheets-Sheet 7



INVENTOR
F.S. IRVINE
BY *P. C. Smith*

ATTORNEY

Jan. 12, 1932.

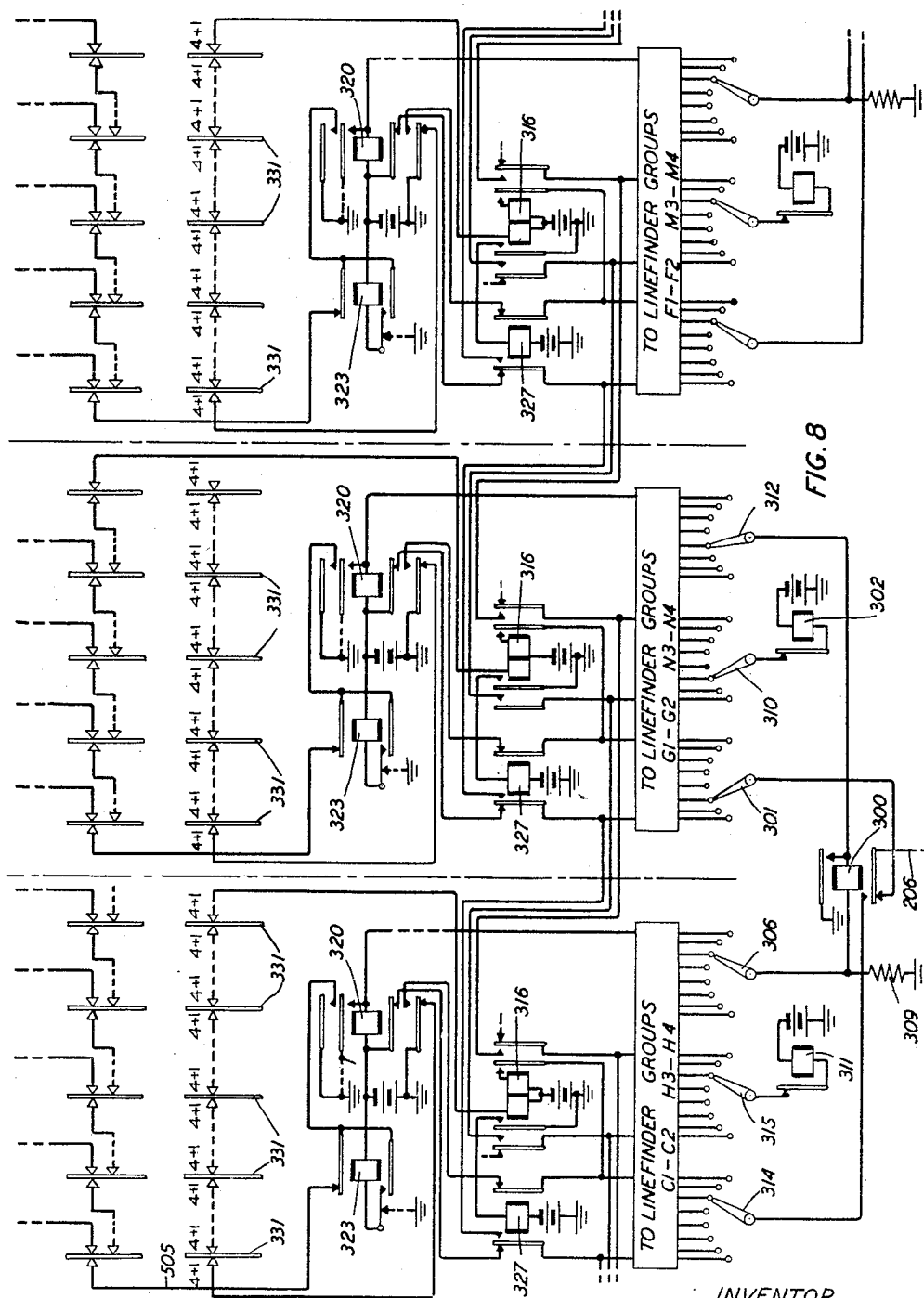
F. S. IRVINE

1,840,364

TELEPHONE DIAL SYSTEM

Filed Oct. 18, 1930

9 Sheets-Sheet 8



INVENTOR
F. S. IRVINE
BY *C. C. Smith*

ATTORNEY

Jan. 12, 1932.

F. S. IRVINE

1,840,364

TELEPHONE DIAL SYSTEM

Filed Oct. 18, 1930

9 Sheets-Sheet 9

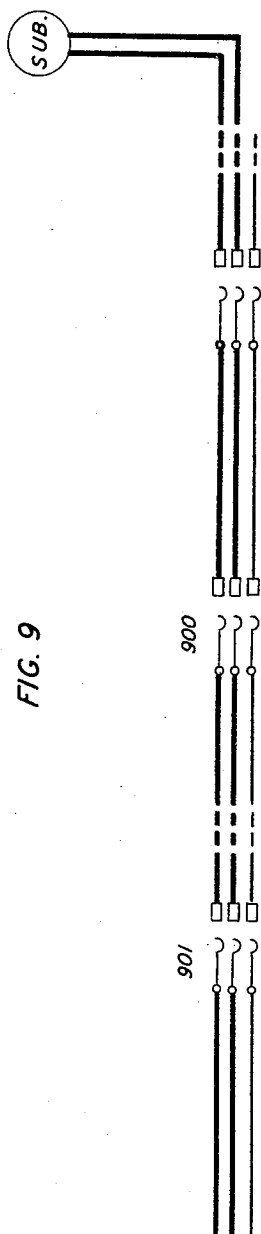


FIG. 9

FIG. 11

FIG. 7
FIG. 8

FIG. 10

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

INVENTOR
F.S. IRVINE
BY *P. C. Smith*

ATTORNEY

UNITED STATES PATENT OFFICE

FRANK S. IRVINE, OF GREENLAWN, NEW YORK, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

TELEPHONE DIAL SYSTEM

Application filed October 18, 1930. Serial No. 489,579.

This invention relates to automatic telephone exchange systems and more particularly to a system in which link circuits are used to connect line finders with idle senders. The object of the invention is the provision of means for increasing the efficiency of a group of links by providing them with accessibility to a larger number of line finders than heretofore.

The link circuit contemplated in this invention comprises a line finder selector and a sender selector for temporarily connecting a calling line finder with an idle sender during the time necessary for the sender to receive dial impulses from the calling subscriber and to thereafter set the train of selectors which connect the calling line with the called line. When the sender has completed this function, the line finder, link and sender are disconnected from each other; the last two returning to normal while the line finder remains operated as a part of the talking-circuit of the established connection. The link, therefore, being essentially a connecting circuit whose holding time is small compared to that of the line finder, is most efficiently used if, after completing one association between a calling line finder and a sender, is immediately taken into use again to establish, in succession, similar associations between other calling line finders and idle senders.

The determination of the most efficient size of a link group for a given number of line finders cannot be established with any degree of accuracy by the method of dividing the holding time of a link into that of a line finder chiefly because, in actual practice, the holding time of a line finder is different for each call and also because the rate of incoming calls is not uniformly distributed over a time period. The relationship between the efficient size of a link group to a given number of line finders must, therefore, be determined from observations of actual traffic conditions from which is ascertained the percentage of line finders calling for senders from a group of line finders in all stages of operation, including the idle condition. This percentage, again, while

furnishing the basic index for the number of links, nevertheless the actual number of links used is slightly larger as determined by an additional deviation figure which must be added, based upon the index determined according to traffic studies, to care for variations from the average in conversation holding time and incoming call rate, consistent with the grade of service the operating company expects to furnish its subscribers.

In a number of installations where links are used and where such studies have been made, it has been found that the efficiency curve of a link group is parabolic in form when plotted against the number of line finders accessible to the group. This indicates that the efficiency of the link group increases sharply at first with an increase in the number of line finders to which the group has access and then in smaller and smaller increments as the number of line finders greatly increases. In accordance with the present invention, therefore, it is proposed to take advantage of this relationship to increase the efficiency of the links by providing them with accessibility to larger groups of line finders, but not beyond the point where the number of line finders provided is disproportionately great to the percentage rise in efficiency of the link group. Specifically with panel systems it is proposed to increase the number of line finders from 80 to 200 and provide a link group which can efficiently serve the larger number of line finders.

While the invention hereinafter disclosed relates, as already mentioned, to panel systems, it is understood that it is not so limited and can be modified for adaptation to other well-known types of apparatus used in the telephone art.

In accordance with the invention, therefore, one specific embodiment of which is disclosed herein by way of illustration, this is accomplished in the following improved manner: The subscribers' lines in an office are divided into major groups suitable to the number which can be accommodated on a line finder frame or a group of line finder frames containing 160 line finders capable of han-

ding the traffic originated by the subscribers whose lines terminate on these frames. These groups are divided into smaller subgroups which are wired to the contacts of the finder banks, the subgroups being preferably limited to the number of superimposed contacts of a bank. It may further be considered that the line finder switches are provided with as many sets of brushes as there are contact banks in the frame and each set of brushes consequently having access to the subgroup of subscribers in the bank with which the brush in question can operatively cooperate. With the arrangement of tripping brushes used in line finder switches of this character, it is only necessary for the line finder to move a distance corresponding to a brush group of lines to seize and make contact with any calling line of the group. That is, when a subscriber initiates a call, the particular set of brushes of an idle line finder having access to the group containing his line, is tripped and moved over the terminals of the group in search of such a line. By dividing the total groups of lines into small brush groups, the time required for finding a calling line is materially reduced. In order to further decrease the hunting time of a line finder switch the brush group of lines are subdivided into smaller equal groups which, for convenience, will be designated hereafter as the A and B subgroups.

Conforming with the subdivision of a brush group of lines into A and B subgroups, the line finders serving the major group in a frame or a group of frames multiplied together are divided into groups designated as the A and B subgroups and containing an equal number of switches. In the embodiment of the invention herein described, it is assumed that the number of subscribers in a major group is such that 160 line finders will satisfactorily handle the volume of traffic originated by the major group. This number of line finders is subdivided into two groups of 80 line finders, one of which normally serves, as first choice, the A subgroup of lines, while the other normally serves, as first choice, the B subgroup of lines. In conformity, also, with well-known line finder operation, line finders of the B subgroup will be accessible to subscribers in the A subgroups as second choice whenever the line finders normally accessible to the A subgroups are all busy and vice versa.

Confining attention to the group of line finders normally serving the A subgroups of subscribers as first choice and remembering that the A and B subgroups are identical in this respect, the group of line finders serving the A subgroups of a major group of subscribers' lines are provided with two allotters, each having control of a subgroup of 40 line finders of the group of 80. These allotters are arranged to alternately start line finders

in the respective subgroups to which they have access and the line finder switches so assigned have access to contact banks in which the calling subscribers' lines appear as first choice, that is, in all the A subgroups. Each allotter comprises a self-stepping switch to the contact banks of which are wired the start circuits of the line finders to which the particular allotter switch has access. A relay, through whose contacts is extended the line finder start circuit, is common to both allotters and is under the control of the line finders allotted to both allotters, so that the start circuit is switched alternately from one allotter to the other as the line finders allotted to either allotter are taken into use. In this manner the starting point for allotting a line finder in either subgroup of 40 is shifted with each call thereby equalizing the distribution of wear amongst the line finders of the group. A similar pair of allotters with a common relay is provided for the group of 80 line finders serving the B subgroup of subscribers of the major group.

The link circuit proper consists of two switch elements, a selector finder and a sender selector. It also has a sequence switch and a group of relays. As more particularly described hereinafter the selector finder connects with a calling line finder while the sender selector connects with an idle sender; the two selectors becoming functionally related through the medium of the link relays and sequence switch so that circuits may be established between the sender and the line finder for the successful completion of the call.

The line finders in the subgroups mentioned above are terminal-ended on panel banks with which the link selector finders operatively connect. Four multiple banks are used, two for each 100 line finders, giving the link group an accessible capacity of 200 line finders. The connection between a calling line finder and sender through the medium of the connecting link requires the use of 6 leads, so that the line finder is wired to 6 contacts on the panel banks, 3 contacts on one bank and 3 corresponding contacts on the second bank. The selector finder is provided with 4 sets of brushes each brush set having access to 100 terminals of the bank with which the brush set can cooperate. Since each line finder appears on two banks two sets of brushes are tripped for each connection, either the lower two for connection to line finders wired to the lower banks, or the upper two for line finders wired to the two upper banks. A trip rod and trip magnet, individual to each selector finder is used and, when the trip magnet is normal, the trip rod trips the two lower brush sets, while when the trip magnet is energized, the two upper brushes are tripped.

It is apparent that before a calling sub-

scriber can proceed with dialing the wanted number, the line finder connected to his line must also be connected to an idle sender, which last function, in the proposed invention, takes place through the medium of a link. Since the link circuit is common to a group of line finders and a group of senders, it is necessary for the link, when taken into use, to find the calling line finder and seize an idle sender. The selector finder of the link taken into use must, therefore, hunt for the calling line finder and since the terminals of such a line finder may be anywhere in a set of 100 terminal contact banks to which the selector finder has access, considerable delay may result if, say, the selector finder must travel over 100 terminals before connecting with the calling line finder. Under such circumstances there is danger that the subscriber will begin to dial before the sender is ready to receive the pulses. It is therefore desirable to make this hunting time, on the average, as short as possible.

To materially reduce this hunting time to approximately the time that it takes a line finder to find a calling line in the subgroup of lines at the line finder frame, it is proposed to divide each group of 100 line finders accessible to a pair of brushes of the link selector finder into five groups of 20 line finders each and to divide the selector finder switches and associated links likewise into five groups and to connect the line finder subgroups of 20 to the terminal banks so that one group of 20 line finders appears as first choice to the brushes of the first link selector finder group, the next group of 20 as second choice, the third group of 20 as third choice, the fourth group of 20 as fourth choice and the fifth group of 20 as last choice. A similar division is made of the 100 line finders which terminate on the two upper contact banks of the selector finder frame. These groups are progressively slipped to the next section of the contact banks wherein appear the selector finder switches associated with the second group of links and the line finder groups are there connected to the terminals of the bank so that the group of line finders which was second choice to the first group of selector finders is now first choice to the second group. A similar progressive displacement of one subgroup of 20 line finders is made in each section so that this progressive slipping permits each group of 20 line finders to be first choice in one of the five sections of the bank. Normally, therefore, when a call originates in one of the line finder frames of the major group and a line finder is taken into use, regardless of whether it belongs to the A or B subgroups of line finders, a link is chosen, if one is available, from the group which is first choice to the subgroup of line finders containing the selected line finder. The associated selector finder is located in

that section of the contact banks where the subgroup of line finder terminals containing a line finder taken into use, appear as first choice. Should no link be available in the first choice groups of links, means are provided for switching to the second choice group. A similar operation takes place in switching to the next progressive choice should all the links of the previous choices be busy. If a first choice link is chosen the associated selector finder will then have to hunt only over a maximum of 20 terminals in order to locate the line finder taken into use by the calling subscriber. It is possible, however, that during heavy traffic when the links are busy, fifth choice links may be taken into use in which case the selector finder may have to hunt over a maximum of 100 terminals before locating the line finder associated with the calling subscriber's line.

In general, the system functions in the following manner: When a subscriber in any of the subgroups originates a call, the line finder start circuit, which is connected through the contacts of the allotter common relay to either one of the two allotters controlling the group of 40 line finders serving the subgroups as first choice causes the allotment of a line finder by that allotter switch to which the start circuit is connected at the time. The line finder starts hunting for the calling line and when it moves off normal, the common relay is either operated and locked or released depending upon which of the two allotters assigns the line finder, since the line finders connected to one of the allotters control the operation of this relay while the line finders of the second allotter control its release. This relay transfers the start circuit to the alternate allotter so that a subsequent calling line will have a line finder assigned from the group of 20 line finders controlled by the alternate allotter. At the same time the allotted line finder grounds its hunting terminal on the arc of its associated allotter switch and causes the switch to advance to the terminals of other line finders and stop on the first one which tests idle.

As already mentioned the entire group of links accessible to 200 line finders is divided into subgroups, each of which is first choice to two groups of 20 line finders each served by one of a pair of allotters that is, a group of 20 on the two lower banks and a group of 20 on the two upper banks. The link subgroups are arranged by means of the well-known paddle start circuit to be switched successively from one group of line finders to another, so that a calling line finder is caused to be connected either to a link of first choice, if one is available, or progressively to one in the second, third, fourth or fifth choices depending upon the busy or idle condition of the links in the subgroups of the prior choices. When a line finder is assigned and starts to hunt for

the calling line, the paddle start circuit associated with the particular group of line finders in cooperation with the line finders taken into use, functions to select the first idle link in the subgroup controlled by the paddle start circuit which is normally the first choice subgroup of links. Should all the links in the subgroup be busy, a series circuit through the busy links of the subgroup operates two relays of the paddle start circuit and transfers the allotted line finder to the link subgroup of the next paddle start circuit. This operation of advancing from one subgroup of links to the next continues until an idle link in one of the subgroups is found idle and taken into use, whereupon the associated selector finder will proceed to hunt for the allotted line finder in the first, second, third, fourth or fifth section of the contact banks, depending upon the subgroup to which the link taken into use belongs.

Each link is provided with a relay which controls the trip magnet of the selector finder and the operation or the non-operation of this relay determines which of the pair of brushes of the selector finder is to be tripped. This determination is made by grounding the contact of a relay in each of the line finders appearing in the two upper banks, while the relays of the line finders appearing in the lower banks are ungrounded. When a line finder is allotted and the relay containing the discriminating ground operates, a path is closed by way of the selected link which either results in the operation or non-operation of the relay in the link controlling the trip magnet of the selector finder depending upon whether the contacts of the line finder relay closing this path are grounded or not. The operation of the relay will cause the operation of the trip magnet which controls the rotation of the trip rod for tripping the two upper brush sets. If the relay does not operate, indicating that the allotted line finder is located in the two lower banks, the trip magnet, of course, is not operated and, according to the mechanical structure of the tripping mechanism, the two lower brush sets are tripped.

When a link is selected and connection is made with the allotted line finder, the link sequence switch is advanced to the next position where the link is set in operation for hunting and seizing an idle sender by a well-known means. With the link attached to both the calling line finder and an idle sender, the sequence switch is advanced to a cut-through position where paths are established through the link between the line finder and the sender for the operation and control of the various circuits necessary for the sender to properly guide the selectors to the called subscriber's line.

When this function is completed circuits are closed in the link from the line finder

which serve to disconnect the selector finder switch from the terminals of the line finder and cause it to return to normal. Similarly circuits are closed in the link from the sender, which causes the link to open the connecting leads between the link and the sender. The link circuit is thereafter restored to normal by advancing its sequence switch to a normal position after which it is advanced again to its reassignment position.

The above and other features of the invention will be apparent from a consideration of the following description in connection with the drawings and appended claims.

Referring to the drawings:

Fig. 1 shows one of a group of subscribers' lines together with a tripping circuit common to the group of lines;

Fig. 2 shows a start circuit serving a plurality of tripping circuits;

Fig. 3 shows two link allotters together with the cooperating parts of the links of two groups of link circuits controlled by said allotters;

Fig. 4 shows a line finder-district selector circuit for extending the line of Fig. 2 to succeeding selectors;

Fig. 5 shows one of a plurality of link circuits controlled by the allotters of Fig. 3 and having access to the line finder-district selector circuit of Fig. 4;

Fig. 6 shows a portion of a sender circuit adapted to be selected by the link circuit of Fig. 5;

Figs. 7 and 8, taken together and arranged in accordance with Fig. 11 show in a diagrammatic manner, the relationship between the arrangement and distribution of line finder circuits on a link finder frame, the cooperating link finders thereat and the cooperating link circuits;

Fig. 9 shows schematically the successive switching stages of one type of connection for which the present invention is adapted to operate in building up a telephone connection to a wanted subscriber;

Fig. 10 shows the manner in which Figs. 1 to 6 inclusive and Fig. 9 of the drawings should be arranged to disclose the invention completely; and

Fig. 11 shows the manner in which Figs. 7 and 8 should be arranged.

It is to be noted that Fig. 6 is a skeletonization of the sender shown in U. S. Patent 1,589,402 granted to O. H. Kopp, June 22, 1926.

When the subscriber at substation 100 removes his receiver from the switchhook a circuit is closed for line relay 101 extending from battery through that relay, inner contacts of relay 102 over the subscriber's loop to ground to the outer contacts of relay 102. Relay 101 operates and closes a circuit from battery, resistance 104 through the winding

of relay 103 to ground at the outer contacts of relay 101.

The operation of relay 103 closes a circuit from battery, resistance 105 to ground at the right outer contacts of relay 103. This circuit is in shunt to the winding of relay 106, which relay serves the second subgroup of lines of the group to which line relay 100 belongs, thus preventing the extension of a call from that subgroup, while the tripping circuit is in use with line 100. The operation of relay 103 also closes a circuit from battery through the winding of relay 200, conductor 133, left outer contacts of relay 107, left outermost contacts of relay 103 to ground.

Relay 200 operates and connects ground over its contacts and conductor 132 to the right inner armature of relay 107. When relay 107 operates, as described hereinafter, it locks to ground through its right winding and remains locked as long as relay 200 remains operated. With relay 107 operated, the operating circuit of relay 108 remains open and hence any other incoming calls in this group must await the release of relay 107 before they can be extended. Since relay 200 operates as soon as relay 103 or relay 106 operates, it will remain operated as long as a call awaits in any subgroup served by the start circuit of Fig. 2. The relay of each trip circuit corresponding to relay 107 operates as each call is served and locks to the contacts of relay 200. When all waiting calls have been served the circuit of relay 200 is opened and that relay releases, releasing the relay 107 to permit the extension of other calls. Since the circuit of relay 200 is extended over the back contacts of relay 107, should simultaneous calls exist in all the groups served by the start circuit of Fig. 2, when one call has been served in each group and relay 107 of the last trip circuit has been operated, no circuit would exist for holding relay 200 operated and that relay would release permitting the relays 107 to release and close over their back contacts circuits for again operating relay 200 should additional calls await attention.

In addition, relay 103 closes a circuit from battery, over the back contacts of relay 201, conductor 130, right winding of trip relay 108, left inner contacts of relay 107, left innermost contacts of relay 103, right outer contacts of relay 109 to ground. Relay 108 operates in this circuit and closes a locking circuit for itself from ground, right inner contacts of relay 109, left winding and left inner contacts of relay 108 over the left inner back contacts of the trip relays of the other groups of lines, conductor 129, right winding of start relay 201 to battery.

Relay 201 operates in this circuit. A circuit is now closed for relay 110 extending from battery through the winding of relay 110, right inner contacts of relay 108, conduc-

tor 128 to ground on the right outer contacts of relay 201. Relay 110 locks in a circuit to ground at the outer contacts of relay 109. Relay 108, together with relay 103, prepares a circuit from ground on the left contacts of relay 110, left outer contacts of relay 108, right inner contacts of relay 103, conductor 131, left middle back contacts of relay 202, left outer back contacts of relay 203, conductor 206, bottom front contacts of relay 300, which relay may be operated as more fully described hereinafter, brush 314 and associated contact of distributor switch 311, conductor 303, winding of relay 400 to battery. Relay 400 operates and performs functions hereinafter described.

The operation of relay 108 also closes a circuit from ground over its right outer contacts, conductor 134 through the winding of trip magnet 401 serving the group in which line 100 appears in the line finder frame, to battery. Relay 110, upon energizing, closes a circuit from battery through the left winding of relay 109, left winding of relay 107, left contacts of relay 110 to ground. Relay 107 operates and locks through its right winding and right inner contacts, conductor 132 to ground on the contacts of relay 200.

The operation of relay 400 closes a circuit from battery through the winding of up-drive magnet 402, top inner contacts of relay 400, right contacts of cam 403, bottom outer front contacts of relay 400 to ground. Under the control of up-drive magnet 402, the line finder shaft is moved upwards. Due to the operation of the trip magnet 401, the set of brushes serving the group of lines to which line 100 belongs is tripped. Relay 400, on operating, also closes a circuit from ground on its bottom front contacts, right lower contact and cam 465, cam 468 and left upper contact thereof, top winding of relay 452 to battery. Relay 452 operates in this circuit but performs no useful function at this time.

When the line finder shaft leaves the tripping zone a circuit is closed from ground over brush 404 through commutator segment 405, right contacts of cam 406, conductor 407, left outer normal contacts of key 204, right inner contacts and right winding of relay 201 to battery. Relay 201 is held operated in this circuit but the circuit through the locking winding of relay 108 is shunted and this relay releases, in turn releasing trip magnet 401. As soon as brush 404 leaves commutator segment 405 the circuit of relay 201 is opened and this relay releases, again connecting battery to the operating winding of relay 108 and the corresponding relays of other trip circuits so that subsequent calls may be served.

As soon as the elevator shaft moves off-normal relay 400 closes a locking circuit for itself over its bottom inner front contacts, left contacts of cam 408, back contacts of relay 409, commutator segment 410, brush 413

to ground. Relay 400 also closes a circuit from battery over the left inner contacts of relay 205, right winding of relay 203, conductor 207, right middle back contacts of relay 415 to ground on the bottom outer front contacts of relay 400. Relay 203 operates in this circuit and removes ground from conductor 206, thereby preventing the starting of another line finder until the brushes are tripped. Relay 203 locks in a circuit from battery over the left outer contacts of relay 205, left winding and left outer front contacts of relay 203, left back contacts of relay 202, conductor 131, right inner contacts of relay 103, left outer contacts of relay 108, left contacts of relay 110 to ground. The operation of relay 203 also closes a locking circuit for relay 201 from battery, left front contacts and left winding of relay 201, right inner contacts of relay 203 to ground. The circuits just traced are established before relay 108 is released by the shunting action of commutator segment 405. As soon, however, as relay 108 deenergizes, it opens the locking circuit of relay 203 restoring the start circuit to a condition to serve subsequent calls.

In the meanwhile when the line finder shaft has moved upwards to where brush 414 makes contact with commutator segment 411, a circuit is closed from ground on brush 414, segment 411, conductor 425, left winding of relay 415 to battery, operating this relay which then locks in a circuit from battery over its right winding, top outer contacts of jack 419, right outer contacts of relay 415, contacts of cam 416 to ground. Relay 415 closes ground on its left outer contacts, conductor 420, terminal on the arc of distributor switch 311 contacting with brush 306, winding of relay 300 to ground, resistance 309 to battery. Relay 415 also closes another circuit from ground on another of its left outer contacts, conductor 424, terminal on arc of distributor switch 311 contacting with brush 315, interrupter contacts of distributor magnet switch 311 to battery. Switch 311 operates and advances its associated switch brushes 314, 315 and 306 to the next set of contacts on the distributor switch arcs. Prior to the stepping of switch 311 to the succeeding terminals of the arcs, however, relay 300, which so far has been assumed to be locked to ground over its top contacts, releases by virtue of the ground on conductor 424 previously traced, shunting the locking battery through resistance 309. The operating and releasing characteristics of relay 300 are such as to make it both fast operate and fast release compared to the time of operation of each of the distributor switches 311 and 302 so that relay 300 always operates or releases before either distributor switch operates. The release of relay 300 transfers the start conductor 206 over its bottom back contacts to the arc of the distribu-

tor switch 302 associated with brushes 301, 310 and 312 and controlling the distribution of another group of line finders having access to the same group of subscribers' lines, as more clearly explained hereinafter. Should another call now be initiated by a subscriber belonging to the group having access to start conductor 206 then the start ground on this conductor will close a circuit for relay 400 in the line finder circuit of the second group of line finders controlled by distributor switch 302 and connected to the terminals of the arc on which the brushes of said switch 302 are standing but which line finder is not shown in the drawings. When relay 415 of this other line finder operates as a result of the associated line finder shaft moving upwards and has made contact with its associated commutator segment 411, a ground is connected to conductor 307 in the same manner as ground was connected to conductor 420 by relay 415 of the previous line finder under description. The ground on conductor 307 closes a circuit path by way of brush 312 through the winding of relay 300, resistance 309 to battery operating thereby relay 300. At the same time, another ground on conductor 325, connected thereto by an operated contact of this other relay 415 closes a circuit by way of brush 310, and associated contact on the arc, interrupter contacts of switch 302, winding of switch magnet 302 to battery. Switch 302 operates and advances brushes 301, 310 and 312 to the succeeding set of arc contacts connected with an idle line finder of the group. Conductor 206 is now transferred back to the contacts of the first distributor switch 311 by way of the bottom front contacts of relay 300. In this manner the allotment of line finders is alternated between the two groups of line finders controlled by each of the two distributor switches respectively, thereby reducing wear on line finders ordinarily first in preference and distributing the calling load evenly among all the line finders having accessibility to the group of subscribers on the line finder banks with which the line finders of both groups shown in Fig. 3 cooperate.

When all the line finders of both groups are taken into use a chain circuit is completed through the right innermost contacts of all the relays 415 beginning with a ground on the contacts of relay 415 of the first line finder in one of the two groups, through each of the chain of contacts on other relays 415 in series of the group, conductor 423, through the series chain of the second group of line finders, conductor 322, winding of relay 208 to battery. Relay 208 operates and closes a circuit from battery through the left winding of relay 202, right back contacts of relay 203, left contacts of relay 208 to ground. Relay 202 operates, disconnects conductor 131 from conductor 206 and transfers con-

ductor 131 over the left back contacts of relay 209, right outer back contacts of relay 210 to conductor 211 connecting with two other groups of line finder circuits second in preference to the group of subscribers having the two groups of line finders shown in Fig. 3 as first preference. When, now, the allotted line finder in one of these two other groups is started, relay 210 is operated in a circuit from ground over conductor 212 corresponding to conductor 207, left winding of relay 210, left inner back contacts of relay 213 to battery. Relay 210 closes a locking circuit for relay 202 from battery through the right winding and right contacts of relay 202, left inner front contacts of relay 210 to ground, preventing the release of relay 202 should a line finder circuit in the first two groups become free before the calling line has been found. Similarly, as all the line finder circuits in the latter two groups become busy, ground through all the line finder circuits in a chain through the contacts of their respective relay 415, conductor 214 will cause the operation of relay 215 which will, in turn, operate relay 209, disconnect conductor 127 from conductor 211 and transfer it to conductor 206 leading to the first two groups of line finders.

If for any reason a line finder fails to start within a predetermined time a circuit will be completed from ground on the left contacts of relay 110, left outer front contacts of relay 108, right inner contacts of relay 103, conductor 131, left inner back contacts of relay 202, left inner back contacts of relay 203, contacts of interrupter 216, left winding of relay 217 to battery. Relay 217 operates when the interrupter 216, closes its lower contacts and locks through its left inner contacts to the above traced circuit independent of the interrupter contacts. After an interval, when interrupter 216 closes its upper contacts, the above traced circuit is extended over top the interrupter contacts, left outer contacts of relay 217, right winding of relay 205, left back contacts of relay 213 to battery. Relay 205 operates and locks in a circuit from battery through its left inner front contacts and left winding of relay 205, key 220 to ground. The operation of relay 205 closes a circuit from battery through the left winding of relay 202, right outer contacts of relay 203, right inner contacts of relay 205 to ground, transferring calls from the first two groups of first preference to the second two groups of line finder circuits of second preference. Circuits are also closed for lamp 218 at the start circuit frame and lamp 219 at the trouble desk.

The operation of the link circuit, will now be described. The links are assigned one at a time after the line finders are taken into use in the manner previously described, position 2 of their respective sequence switches being the position in which all the links of the

group except one are resting when awaiting an assignment. In order to show clearly how the assignment takes place consideration is directed to Figs. 3 and 5, the latter figure disclosing in detail all the elements of the link circuit except such parts as cooperate with the distributor start circuit shown in Fig. 3 wherein such parts of the link circuit of the two groups of links cooperating with the corresponding two groups of line finders are shown. Referring to Fig. 3, when all the links are normal, that is, in position 2 and no call is initiated in the group of subscribers having accessibility to line finders controlling the start conductor 206, a chain circuit is closed from ground through the contacts of cam 321 of each link, beginning with the last in the group, cam 324 and contact thereof of the first link, cam 305 of the first link and top contact thereof, conductor 308, magnet 509 to battery. Magnet 509 operates and advances the sequence switch of the first link from position 2 to position 3. The remaining links of the group now remain in their respective positions, that is, the first link in position 3 and the others in position 2 and the link which is in position 3 will be the one first to be assigned when a call is initiated over conductor 206. When the call is initiated as already described and a line finder is taken into use in the group associated with distributor switch 311 and relay 415 operated in the assigned line finder as already described, a circuit is closed from ground on the left contacts of cam 426, top middle contacts of relay 421, left inner front contacts of relay 415, left winding of relay 417, conductor 328, left back contacts of relay 327, conductor 329, top inner back contacts of relay 320 to battery. Relay 417 operates and closes a holding circuit from ground through its right winding and right front contacts, conductor 432, left outer back contacts of relay 316, winding of relay 320 to battery. Relay 320 operates in series with the locking winding of relay 417, disconnects the operating battery from the left winding of relay 417 and establishes a locking circuit for itself over its bottom inner contacts, conductor 304 extending to the left lower and right top contacts of cam 542 of the assigned link when the said link advances to position 4 as described hereinafter. Relay 320 also connects ground over its bottom outer contacts to the bottom contacts of relay 323 and thereby closes a circuit for relay 503 of the allotted link from ground on the bottom outer contacts of relay 320, bottom contacts of relay 323 through cam 343 and lower contacts thereof of all the links in the group which are in position 2 and the left lower and right upper contacts of cam 343 of the assigned link in position 3, conductor 508, top outer make contacts of jack 506, bottom winding of relay 503 to battery. Relay 503

operates in this circuit and, through its bottom front contacts, connects ground to conductor 507, cam 332 and contacts thereof of the assigned link, conductor 330, normally made contacts and winding of relay 323 to battery thereby causing relay 323 to operate. Relay 323 locks over its top make contacts to ground on the bottom outer contacts of relay 320 and, at its bottom contacts, opens the operating circuit of relay 503. Relay 503, however, does not release when its operating circuit is opened because, when it operates, it closes a circuit for sequence switch magnet 509 from ground on its top outer front contacts, right upper and left lower contacts of cam 511, winding of magnet 509 to battery, advancing the sequence switch to position 4. In this position the top winding of relay 503 is connected over its top inner contacts, right upper and left lower contacts of cam 514, bottom middle contacts of jack 506, brush 510 of the link finder shaft which cooperates with the link finder banks on which the line finders are terminals-ended. Brush 510 makes contact with the test terminals of the line finders, and all the line finder circuits except the one which has been allotted and awaiting connection with a link have ground connected to their respective test terminal over conductor 449, top inner contacts of jack 419, right upper and left lower contacts of cam 427 to the bottom outer contacts of relay 400. Now any line finder is either in position 1 with relay 400 normal or with relay 400 operated, or it may be anywhere from position 2 to 18 in a condition of service with relay 400 either up or down. If the line finder is normal, that is, in position 1 and relay 400 is also normal, the path above traced connects ground to the corresponding test terminal associated with conductor 449 and holds relay 503 locked when the link tests the line finder in its hunt for the assigned line finder. If relay 400 is operated and the switch is in position 1, then the line finder is in an allotted condition whereupon ground is not connected to conductor 449 and when the link tests the line finder there is no holding circuit for relay 503 and this relay releases. If, on the other hand, the line finder is busy and the switch has passed position 1, then ground from the left upper contact of cam 427 is connected to conductor 449 thereby again supplying a ground on the associated test terminal on the link finder bank. Moreover the advance of sequence switch 509 to position 4 and the consequent upward movement of the link finder shaft to where brush 505 engages commutator segment 504, as more clearly explained hereinafter, provides a holding ground for relay 320 from ground on brush 505, commutator segment 504, right upper and left lower contacts of cam 542, conductor 304, bottom inner contacts of relay 320

to battery. Relay 320 remains locked and, in turn, keeps relay 323 locked by ground on its bottom outer contacts. Should, now, another line finder be taken into use by distributor switch 311, starting ground for assigning another link over the bottom back contacts of relay 323 will not be available to start the second link until the previous link assigned has hunted and found the calling line finder, which event takes place in position 4 of the first link. When the link has advanced out of position 4, the locking circuit of relay 320 is opened, thereby causing this relay to release and, in turn, releases relay 323 which, over its bottom contacts, reestablishes the start ground over the link conductor 508 of the next link of the group in position 3.

When relay 320 operates it connects ground over its top outer front contacts, right back contacts of relay 327, conductor 430, left outer contacts of relay 417, bottom winding of relay 421 to battery. Relay 421 is not marginal with respect to its bottom winding and when the circuit just traced is closed, it operates and locks over its top winding and top inner contacts, left upper contacts and cam 443, cam 426 to ground. Relay 421 by its operation opens its top middle contacts controlling the operating circuit of relay 417 previously described, leaving relay 417 locked through its right winding in series with the winding of relay 320 during the interval between the assignment of the link and the connection of ground to conductor 304 by the assigned link, at which time the locking winding of relay 417 is shunted and the relay releases.

Should it come to pass that another link finder of a link in the group controlled by one distributor switch is taken into use during the interval when an assigned link is hunting the line finder which caused its assignment, the fact that relay 320 operated prevents the operation of relay 417 of the subsequently allotted line finder, since the operating battery for all relays 417 of the group controlled by one distributor switch is supplied through the top inner back contacts of relay 320. An assignment of another link, therefore, is delayed until such a time when the previously assigned link has been allotted to and made connection with the line finder which caused its assignment. When this happens, the sequence switch of the assigned link is advanced to position 5, as more fully explained hereinafter. Relay 320 is released and the operating battery to the winding of relays 417 of the group of line finders is reconnected to conductor 328, whereupon relay 417 of the awaiting but allotted line finder will then operate and lock in the manner described and, by reoperation of relay 320, cause the assignment of a link for its use.

The locking contacts of relay 417 of each line finder in both groups, is controlled through a series back contact chain connecting all relays 417, so that in case of rapid allotment only one line finder at a time will be able to lock itself in series with the operating winding of relay 320 of the associated link group and, as each line finder assigns a link and the said link finds the line finder on the link finder frame, relay 417 releases and, through its back contacts, closes the locking circuit of relay 417 next in the preference of the series lockout circuit and consequently the operating circuit of relay 320 in series with it. In this manner an accumulation of allotted line finders have links assigned to them one at a time.

Since the assigned link has advanced to position 4, and recalling that all other idle links in the group are in the awaiting assignment position 2, the link next in succession for assignment is advanced to position 3. This is accomplished by a circuit over conductor 333, right lower contact and cam 305 of the link in position 4, cam 324 and left contact thereof, right contact and cam 324 of the next link in succession, cam 308 and upper contact thereof to conductor 308 of that link to the associated switch magnet 509 which, when a line finder is taken into use causes the subsequent advance of the link switch to position 4 as already described.

When all the links of the group are thus made busy a chain circuit is closed from ground on the top outer back contacts of relay 320, contacts of cam 331 of each link, left winding of relay 316 to battery. Relay 316 operates and closes an obvious circuit for relay 327 which also operates. The operation of these two relays causes the transfer, over their front contacts, of the link start conductors to the next group of links having accessibility to the same line finder frame as explained more fully below. Relay 316 is provided with a right locking winding to guard against the release of relays 316 and 327 when a line finder is taken into use and, at the same time, a link becomes available in the group controlling the operating circuit of relay 316. Under such circumstances the operating circuit of relay 316 will be opened at one of the cams 331 but a holding circuit from battery through its right winding, conductor 328 which is multiplied to the left winding of all relays 417 of the line finder group served by one group of links, left winding of relay 417 of the allotted line finder in position 1, left inner make contacts of relay 415, top middle contacts of relay 421, left contacts of cam 426 to ground. Relay 316 is thus prevented from releasing and is held until the allotted line finder has been advanced out of position 1, which event succeeds the assignment of a link for that line finder from the next succeeding link group

having an idle link to which the operated relays 316 and 327 have advanced the assigning conductors. A link will thus be assigned from the succeeding group even though a link in the previous group has become idle in the meanwhile.

Figs. 7 and 8 show the relationship, in a schematic manner, between distribution of the line finders on a part of the link frame shown in Fig. 7 with respect to the trip rods of the link finder shafts of three groups of links on one side of the frame and the co-operating link groups and start circuits as shown in Fig. 8 wherein identical reference characters are used for the same circuit and apparatus elements as are shown in the two similar start circuits in Fig. 3. Figs. 7 and 8, when considered in connection with Fig. 3, show clearly the manner in which the links are assigned and also the manner in which the line finder link start conductors are advanced from one group of links to another when all the links of the preceding group are busy.

In Fig. 7 three of the five vertical sections of the link finder banks of the frame are represented by 701, 702 and 703 and the line finder subgroups by the designations C1—C2, D1—D2, H3—H4, K3—K4, etc. The letter designation indicates the line finder subgroup while the numerical suffix therewith indicates the bank in which the group appears. Since each subgroup appears in either the two lower banks or the two upper ones, the letter designation is the same for each pair of banks.

Fig. 8 shows the manner in which the links, the link finders of the respective sections, and the link start circuits are inter-related. Each of the five sections of the link finder frame has its own group of links and each group of links has two switching relays, namely relays 316 and 327, for transferring a calling line finder to the succeeding group of links. It will be noted, also, that the line finder subgroups associated with a group of links appear as first choice in that section of the link finder frame where the link finder shafts of corresponding link groups are located. Thus, line finder subgroups C1—C2, H3—H4 are first choice to the link group having accessibility to section 701; the former subgroup being located in the two lower banks and the latter is located in the two upper banks. Similarly, line finder subgroups G1—G2 and N3—N4 are first choice to the link group having accessibility to section 702. It follows that since conductor 206 is the point of access connected through relay 300 to either of these four subgroups of line finders, the subscriber group on the line finder frame must have these four groups of line finders as first choice also. With such an arrangement, whenever a start ground is connected to conductor 206 it makes no difference from

which subgroup a line finder is chosen. The link associated with such line finder subgroup will be one for which the particular line finder group is first choice in the section of the link finder frame where the link finder of the assigned link appears. For example, referring to Figs. 7 and 8, assume that relay 300 is locked by the operation of a previous allotment, a subsequent call from the same group of subscribers will ground conductor 206 and, by means of the circuit operations already described, the ground on conductor 206 will be extended by way of brush 314 of switch 311 to a line finder in either group C1—C2 or H3—H4. If the line finder allotted belongs to group C1—C2, it will be terminal-ended on the two lower banks of the link finder frame; otherwise, it will belong to group H3—H4 and is terminal-ended on the two upper banks. When a line finder is assigned in the manner described ground will be connected to brush 306, relay 300 is released and switch 311 is advanced to the terminals of the next idle line finder of either group C1—C2 or H3—H4. By operations already described, relay 320 in the associated link start circuit connects ground to start conductor 505 and causes the assignment of the first link which is in position 3 of the group. It will be observed that these links appear in section 701 where the line finder subgroups C1—C2 and H3—H4 appear as first choice. On the other hand, if relay 300 is normal as a result of a previous allotment the start ground on conductor 206 and coming from the same group of subscribers as those which are accessible to line finder groups C1—C2 and H3—H4, is connected to brush 301 of the distributing switch 302 thereby causing the allotment of a line finder in either subgroup G1—G2 appearing in the two lower banks of section 702 or group N3—N4 appearing in the two upper banks of this section. Both of these two groups are first choice to a group of links and by an inspection of Figs. 7 and 8 it is apparent that this group of links is the one operatively associated with the line finder subgroups G1—G2 and N3—N4. In the same manner it can be shown that the subscriber's group associated with another starting conductor like conductor 206 and cooperating with a pair of distributor switches like 302 and 311 are similarly associated with line finder subgroups which are accessible to the said subscriber's group and which appear in such sections of the link finder frame as to be first choice to the link groups cooperating with the said sections.

When all the links of a group have been assigned, that is, when the sequence switch of each link is in any position between 4 and 1, a chain circuit is closed from the bottom outer back contacts of relay 320 through cam 331 and contacts thereof of each link switch,

left winding of relay 316 to battery as already described. Relay 316 operates relay 327. When, now, another call is initiated and a line finder is allotted from either group C1—C2 or H3—H4, and it is assumed that the link group cooperating with the section where they appear as first choice is busy, relays 316 and 327 transfer the link start conductors to the next succeeding group of links if relays 316 and 327 of the said next succeeding link start circuit are not operated; otherwise to the link group next in succession. With the selection of a link from the next link group, that is, from the group cooperating with section 702, it will be observed that the line finders of the two subgroups C1—C2 and H3—H4 are not first choice in this section but second choice, so that when the link shaft moves upwards it will have to travel over the first subgroup without hunting for the allotted line finder and into the second group, either in the lower banks or the two upper ones to locate the allotted line finder. In the same way if, at the time that the links of section 701 are busy those of the section 702 are likewise busy and a call originates in a subscriber's group having access to line finder subgroups C1—C2 or H3—H4, relays 327 and 316 of both link groups being operated, the calling line finder may be connected to a link in section 703 where line finder subgroups C1—C2 and H3—H4 are third choice, in which case the line finder of the allotted link will have to travel over the two lower groups and hunt in the third group to find the calling line finder. In the same manner a calling line finder may be advanced to the two remaining link groups of the frame, which are not shown in the drawings, wherein the preference is still more remote, that is, subgroups C1—C2 and H3—H4 will be fourth preference in the fourth section and fifth preference in the fifth section.

It is thus seen that when a link group of a section becomes busy, an allotted line finder which is first choice in that section is successively transferred to link groups of other sections to have assigned therefrom an idle link of the link group in that section but for which the calling line finder group is of a more remote preference.

Referring once again to Figs. 7 and 8, taken in connection with Figs. 3 and 4, and recalling that the line finder is terminal-ended on contact banks of the well-known panel type cooperating with the moving selectors of the same type wherein a set of brushes is provided for cooperation with each bank, it is evident that when a link is chosen for connecting an allotted line finder with a sender through the medium of the link, such a connection must take place through two brush sets on the link finder shaft each of which is adapted to engage the

three terminals of the line finder in each of the two banks where the line finder is terminal-ended. Since, in the present embodiment of the invention, there are four banks in all to a link finder frame each link finder shaft is provided with a tripping rod mechanism controlled by the operation of a trip magnet in the well-known manner and adapted to trip two brush sets for cooperation with the two lower contact banks and two other brush sets for cooperation with two upper banks. Thus trip rod 707 associated with the first link finder shaft for section 701 has trip fingers 706 and 708 which will trip the brush sets cooperating with the two lower banks of section 701 and trip fingers 710 and 711 which will trip the brush sets cooperating with the two upper banks of section 701. Now the tripping rod mechanism is so arranged that when the trip magnet is not operated, the trip rod is in such a position that trip fingers 706 and 708 trip the two lower brush sets and when the trip magnet is operated, the trip fingers 706 and 708 are cleared out of the tripping zone and the two upper trip fingers 710 and 711 are rotated into the tripping position for tripping the said two upper brush sets. Normally, therefore, when a line finder appearing in the two lower banks is allotted for a call no tripping magnet operation is required for engaging the terminals of the allotted line finder as the two lower brush sets will be tripped by the normal setting of the trip rod. However, when a line finder which appears in the two upper banks is taken into use the trip magnet of the associated line finder shaft of the link must be operated in order to set the two upper pairs of brushes for connection between the calling line finder and the link. However, since a calling subscriber's group has access to both groups of line finders, that is, a group in the two upper banks and a group in the two lower ones and since, also, line finders are allotted indiscriminately from either group by a distributor switch such as 302 or 311, the link, when assigned, must know whether or not the trip magnet of its associated link finder shaft is to be operated, that is, whether the two upper sets of brushes must be tripped or the two lower ones. For this purpose the link is adapted to respond to a signal controlled by the allotted line finder which signal determines the location of the calling line finder on the two pairs of banks in the link finder frame and hence controls also the operating circuit of the trip magnet of the link finder shaft of the associated link. Relay 417 of each line finder is provided with a pair of left inner contacts one of which is or is not connected to ground depending upon whether or not the line finder circuit of which relay 417 is a part, is terminal-ended on the two upper or two lower banks respectively of the

link finder frame. The other of the two contacts is connected to conductor 433 which is likewise multiplied to corresponding contacts of other relays 417 of the line finders cooperating with one group of links and the common multiple conductor is carried to the right outer armature of relay 316 of the associated link start circuit. When, therefore, a line finder is taken into use and relay 417 is operated as already described, conductor 433 is or is not grounded depending upon whether the line finder so allotted is associated with a group appearing in the two upper banks or one appearing in the two lower banks. If it is associated with a line finder appearing in the upper banks, the ground connected to conductor 433 closes a circuit through the right outer back contacts of relay 316 through cam 335 of the particular link which is in position 3, conductor 340, winding of relay 500 to battery, operating this relay. On the other hand if the assigned line finder belongs to the group appearing in the two lower banks of the link finder, relay 417 is operated but no ground is connected to the left inner contacts of relay 417 and consequently no ground will be present on conductor 340 and relay 500 will not operate. Relay 500 controls the operation of the trip magnet circuit of the assigned link as more fully described hereinafter.

Returning now to the operation of the allotted link and remembering that sequence switch 509 is in position 3 prior to its being taken in use by a calling line finder and assuming, further, that the allotted line finder belongs in a subgroup appearing in the two upper banks, then relay 500 operates over the aforetraced circuit and over its top contacts locks to ground on the bottom front contacts of relay 503 which is already operated over an aforetraced circuit to ground on the bottom outer contacts of relay 320 when the line finder is allotted. Relay 503, it will be recalled, operated and closed its top winding over its top inner contacts, right upper and left lower contacts of cam 514, bottom inner contacts of jack 506 to brush 510. Relay 503 also closed a circuit from ground over its bottom front contacts to conductor 507, supplying thereby a locking ground for relay 500 and also, by this same ground, operated relay 323 over a circuit previously described and preventing the extension of ground on the contacts of relay 320 over conductor 505 to any other link which may have been assigned just at this time, as already described. Relay 503 then closed an aforetraced circuit to advance switch 509 to position 4. In position 4, two things happen simultaneously, namely, the link finder shaft moves upwardly to find the calling line finder and the sender selector shaft proceeds to

hunt for an idle sender. Both of these operations are accomplished as follows:

In position 4 a circuit is closed for the link finder shaft updrive magnet 516 from battery, through the winding of magnet 516, upper contacts of cam 511 to ground on the top outer contacts of relay 503. The link finder shaft now proceeds upwardly with the top winding of relay 503 connected to brush 510 as a testing condition. Now the line finder which has been assigned and with which the link must establish contact is one in which its associated sequence switch is in position 1, so that the terminal to which its test conductor 449 is connected and with which brush 510 will make contact when it comes to it is open-circuited as already described. All other line finders hunting leads 449 will be grounded. Relay 503, therefore, will remain locked through its top winding over the test terminals of the line finders not awaiting connection with a link. The link finder shaft will continue its upward motion with relay 503 locked through its top winding to ground over brush 510 and cooperating terminals and to ground on brush 543 over centering commutator 557, conductor 558, contacts of cam 561, through the lower winding of relay 503 when the link shaft is between link terminals on the finder banks. When a terminal having no ground is encountered relay 503 releases, opens the circuit of magnet 516 and causes the link shaft elevator to come to rest on the terminals of the line finder. The release of relay 503 closes a circuit for magnet 509 from ground over the bottom back contacts of relay 503, top left contact and cam 525 contacts of cam 552 to magnet 509, advancing the sequence switch to position 5.

Simultaneously with the above described operation, that is, with switch 509 in position 4, a circuit is closed for relay 518 from ground over the bottom back contacts of relay 519, left contacts of cam 522, winding of relay 518 to battery. Relay 518 operates, closes ground on its top outer contacts to the middle winding of relay 519 and, over its top inner contacts, prepares a path to operate relay 515. Now an idle sender is characterized by the connection of battery through a 150 ohm resistance, such as resistance 601, to conductor 602 and its associated terminal of the set engaged by brush 523. If the sender selector shaft is resting on the terminals of such a sender, this battery circuit is completed over brush 523, contacts of cam 524, bottom inner contacts of relay 520, lower winding of relay 519, left contacts of cam 527, middle winding of relay 519 to ground on the top outer contacts of relay 518. Relay 519 operates very quickly and establishes a locking circuit for itself from battery through its top winding, right lower and left upper contacts of cam 527, top front con-

tacts of relay 519 to ground. When the bottom back contacts of relay 519 are opened, relay 518 releases and a circuit is then established from ground through the bottom front contacts of relay 519, bottom back contacts of relay 518, lower contacts of cam 511, winding of magnet 509 to battery, advancing the sequence switch out of position 5 into position 6.

If, however, when the switch is in position 4 the sender selector is resting on the terminals of a busy sender, relay 519 will not operate since a busy sender is characterized by the absence of battery on conductor 602. Under such circumstances a circuit is closed for relay 515 from battery through its top winding, top inner contacts of relay 518 to ground on the top back contacts of relay 519. Relay 515 operates and, over its top contacts, closes a circuit for sender selector updrive magnet 521 from ground on the left lower contact of cam 529 and right upper contact thereof, bottom outer contacts of relay 520, top outer contacts of relay 515, winding of magnet 521 to battery. Magnet 521 operates and drives the sender selector shaft over the terminals of the senders; relay 515 remaining locked to ground over brush 545, centering commutator 546, conductor 512, cam 550 and the left and right upper contacts thereof, top inner contacts and top winding of relay 515 when the shaft is between terminal positions, and to the top outer contacts of relay 519 when relay 519 is testing the terminals of the sender. As soon as an idle sender is encountered relay 519 operates in the manner already described releasing relay 515 and causing the sender selector shaft to stop on the terminals of the selected sender. Relay 518 will likewise release when relay 519 operates and if, at this time, the link finder shaft is already connected to the terminals of the calling line finder, sequence switch 509 will have advanced to position 5 as already described and thereafter to position 6. On the other hand, if a sender is selected before the link connects with the terminals of the calling line finder, nothing happens until such a connection is made, whereupon switch 509 is advanced to positions 5 and 6 successively as described.

If all the senders terminating in the upper portion of the sender selector bank are busy the sender selector shaft will continue to test the hunting terminals thereof until the shaft reaches the level where brush 530 engages commutator segment 531 whereupon a circuit is closed for relay 520 from battery through resistance 548, winding of relay 520, commutator segment 531, brush 530 to ground. Relay 520 operates and over its top outer front contacts closes a circuit for sender selector downdrive magnet 533, causing the sender selector to return to normal. When the shaft reaches its normal position and

brush 530 makes with commutator segment 513 a shunting ground is applied to conductor 551, contacts of cam 526 to the winding of relay 520 and resistance 548, shunting the winding of relay 520 and causing it to release. With the sender selector shaft normal and relay 520 released, the original circuit to operate relay 518 is again closed and the hunting circuit is again established for testing the terminals of the sender selector bank by the closure of the circuit for the updrive magnet 521 and the application of the windings of relay 519 to the test brush 523 in the manner described; the operation continuing until an idle sender is found whereupon the release of relay 519 advances sequence switch 509 to position 6, as already described.

When the sender selector has established connection with an idle sender and switch 509 has advanced to position 6, a circuit is closed to operate relay 603 extending from ground through the right and middle windings of relay 603, right outer back contacts of relay 604, right back contacts of relay 605, conductor 614 and associated terminal, conductor 560 and associated brush, right lower and left upper contacts of cam 553, brush 554, conductor 429 and associated terminal, right lower and left upper contacts of cam 428, middle winding of relay 421 to battery and another branch in parallel at the right upper contact of cam 428, winding of relay 466 to battery, which circuits are not completed until the district circuit reaches position 3.

In the meantime the line finder shaft of the allotted line finder continues to move upwardly until it reaches the terminals corresponding to the calling subscriber's line. When these terminals are encountered a circuit is completed from battery through the right winding of relay 109 and resistance 111 in parallel, inner front contacts of relay 101, conductor 114, terminal 437, brush 438, winding of relay 409, left upper and right lower contact of cam 439, right lower and left upper contacts of cam 426 to ground. Relay 409 operates and closes a circuit in shunt of its winding through resistance 442, front contact of relay 409, commutator segment 410, brush 413 to ground. Relay 109, which is marginal, is so adjusted as not to operate in the circuit previously traced in series with relay 107 or in the circuit traced through the winding of relay 409. With resistance 442 in parallel with relay 409, relay 109 operates and locks through its left winding, left winding of relay 107, left contacts of relay 110 to ground. The operation of relay 109 opens the locking circuit of relay 110 and relay 110 releases after an interval due to the fact that relay 110 is slow to release. Relay 409 opens the locking circuit of relay 400 and this relay releases as soon as brush 435 en-

counters an insulating segment in the centering commutator 436.

The release of relay 400 opens the circuit of the updrive magnet 402 and stops the line finder on the calling subscriber's line. It also connects battery through resistance 445, lower contacts of cam 441, top outer contacts of relay 400, bottom outer back contacts of relay 421, resistance 446, brush 444, terminal 447, conductor 112, winding of cut-off relay 102 to ground. Relay 102 operates and releases relay 101, thereby removing the calling condition from terminal 437. The operation of relay 102 also opens the circuit of relay 110 permitting its release.

The release of relay 101 permits relay 103 to release and also opens the circuit of relay 409. The connection of battery with terminal 447 marks terminal 113 and the other multiple terminals of calling line 100 in the terminal banks of the final selectors with reduced battery potential to render the line busy to such final selectors. The release of relay 400 also closes a circuit from battery through the winding of sequence switch magnet 448, cam 450 and contact thereof, cam 440 and left lower contact thereof, lower front contacts of relay 452, bottom outer back contact of relay 400 to ground. The sequence switch is advanced in this circuit from position 1 to position 3.

When the sequence switch leaves position 2 the circuit of relay 452 is opened and this relay releases. When the sequence switch reaches position 3, the previously traced circuit for relays 603 and 421 is completed. Relay 421, being marginal on its middle winding does not operate at this time. Relay 603 operates and closes an obvious circuit for relay 607 which, in turn, closes a circuit from battery through resistance 608, winding of relay 609, left inner front contact of relay 607 to ground. Relay 609 operates and locks over its left inner contacts. Relay 609 closes a circuit for relay 610 from battery, winding of relay 610 to ground on the right contacts of relay 609 which circuit it also closed at the left outer contacts of relay 607. It also starts the timing switch of which brush 620 forms a part, in the manner disclosed in the above identified patent to O. H. Kopp. The operation of relay 610 closes an obvious circuit for relay 611 which, in turn, closes a circuit through the left winding of relay 612.

The operation of relay 612 opens the circuit previously traced from battery through resistance 601 to relay 519 and this relay releases. The release of relay 519 closes a circuit from ground on the bottom back contacts of relay 519, cam 525 and right upper contact thereof, cam 552 and lower contact thereof, winding of sequence switch magnet 509 to battery. The link sequence switch is advanced to position 8.

In position 8 of the link sequence switch the dialing conductors and the fundamental circuit conductors are cut through directly from the district circuit to the sender circuit. The dialing circuit may be traced from battery through the left winding of relay 606, conductor 621, sender selector brush 535, left upper and right lower contacts of cam 528, district finder brush 538, conductor 540, and its associated terminal, right upper and left lower contacts of cam 412, top outermost contacts of relay 421, brush 453 and its associated terminal, conductor 117, through the subscriber's substation, conductor 116 and its associated terminal, brush 454, bottom inner contacts of relay 421, winding of relay 456, left contacts of cam 455, conductor 541 and its associated terminal, district finder brush 537, contacts of cam 539, sender selector brush 544, conductor 622 and its associated terminal, back contacts of relay 613 to ground. When the dialing circuit above traced is completed, relay 606 operates and closes a circuit from battery through the winding of relay 647, contacts of relay 606, left contact of relay 615 to ground. Relay 647 operates and closes a circuit from battery through the winding of relay 609, contact of relay 647 and thence to ground. As soon as relay 609 operates the dialing tone circuit is completed as follows: from source of tone 600, right winding of relay 606, normal terminal and brush 623 of register switch 624, contacts of relay 609 to ground.

Due to the closure of this circuit, a tone is induced in the left winding of relay 606 and over the dialing circuit to the receiver of the subscriber's telephone to indicate that dialing may be started. The subscriber now dials the number of the wanted subscriber.

The registers of the sender are positioned, the translator 625 operated and selections made under the control of the sender as described in the above identified patent to O. H. Kopp. After the completion of the final units selection with the district selector sequence switch 448 in position 10, sender control sequence switch, some of the cams of which are disclosed to the left of the vertical broken line and above the horizontal broken line of Fig. 6, in position 7 and sender sequence switch 617 in position 15, a fundamental circuit is completed from battery at the incoming selector 900 through the office selector 901, terminal 459, brush 457, left upper and right lower contacts of cam 422, bottom outer back contacts of relay 458, conductor 460 and associated terminal, brush 532, left contacts of cam 335, brush 549, conductor 626 and associated terminal, right inner back contacts of relay 604, cam 627 and right upper contact thereof, cam 628 and contact thereof of the class sequence switch, winding of relay 629, back contacts of relay 630, left winding of relay 631, cam 632 and contact thereof,

translator brush 633 compensating resistance 634, right outer back contacts of relay 635, right inner contacts of relay 607, conductor 636 and associated terminal, brush 547, right lower and left upper contacts of cam 542, brush 534, conductor 461 and associated terminal, right contacts of cam 462, brush 464, terminal 463, through office selector 901 to ground (not shown) at the incoming selector 900. Relays 629 and 631 operate and relay 631 locks through its right winding, cam 637 and left upper contact thereof to ground on the front contacts of relay 631. Relay 631 also closes a circuit from battery through the winding of relay 638, cam 637 and right lower contact thereof to ground at the contact of relay 631. The operation of relay 638 closes a circuit from battery through cam 640 and contact thereof, winding of No. 0 counting relay, conductor 616, conductor 641, right outer front contacts of relay 638, contact of cam 642, contacts of stepping relay 629, contact of cam 643 to ground. The No. 0 counting relay operates in this circuit and closes the usual locking circuit for itself through the winding of the No. 0' counting relay and relay 630. The incoming selector then opens the fundamental circuit, permitting the operation of the No. 0' counting relay and relay 630. The operation of the No. 0' counting relay closes a circuit from battery, winding of relay 635, left inner front contacts of relay 638, front contacts of the No. 0' counting relay to ground on the contact of relay 645. Relay 635 operates and locks over its right inner contacts to ground over the contact of cam 646. Relay 635, in operating, closes a circuit through the winding of relay 604, left inner contact of relay 635 No. 18 to 21 terminals and brush 620 of the time measure switch 624 to ground. Relay 635 opens the fundamental circuit and advances sequence switch 617 to position 17. When sequence switch 617 leaves position 16, the circuit of relays 631 and 638 is opened and these relays release. Relay 638 in releasing advances sequence switch 617 to position 18 in which position talking selection is made.

When relay 604 operated it opened the shunt around the left winding of relay 603 and the high resistance right winding is included in the circuit of relay 603 which circuit, it will be remembered, includes the middle winding of relay 421, and the winding of relay 466 in parallel. This increase in resistance decreases the current through relay 466 to such an extent that it deenergizes. The release of relay 466 in turn releases relay 452 which closes a circuit from battery through the winding of sequence switch magnet 448, right lower and left upper contact of cam 467, bottom back contact of relay 452, bottom outer back contact of relay 400 to ground. The district selector sequence switch is advanced to position 12 in this cir-

cuit. As soon as the sequence switch reaches position 10 $\frac{3}{4}$, conductor 429 is opened at cam 428, the circuit of relay 603 is opened and this relay releases. The release of relay 603 in turn releases relay 607 causing the operation of relay 605 and the release of 609 in turn. Talking selection now takes place as described in the above identified patent to O. H. Kopp.

At the completion of talking selection, the No. 0' counting relay is operated closing a circuit from ground at the contacts of relay 645, front contacts of the No. 0' counting relay, left inner back contact of relay 638, cam 648 and lower contact thereof, winding of relay 615 to battery.

The operation of relay 615 connects battery through resistance 601 and the right contacts of relay 615, over the right inner front contacts of relay 605 in parallel with battery through the winding of relay 605 to conductor 614, brush 560, right contacts of cam 553, lower winding of relay 519, right lower and left upper contact of cam 556, brush 554, conductor 429 and associated terminal, lower contact of cam 428 to ground. Relay 519 operates in this circuit and closes another circuit from ground on its bottom front contact, cam 525 and right lower contact thereof, cam 552 and lower contact thereof, winding of magnet 509 to battery. The link sequence switch advances to position 9 and in this position another circuit is closed from ground on the bottom back contacts of relay 515, cam 525 and left lower contacts thereof, cam 552 and left lower contact thereof to the winding of magnet 509, advancing the link sequence switch to position 10 where a ground on the upper contact of cam 552 advances it to position 1 in the well-known manner. In position 1 a circuit is closed for the link finder shaft down-drive magnet 562 from battery through the winding of magnet 562, left upper and right lower contacts of cam 514 to ground. The link finder shaft is then returned to normal. When the shaft reaches its normal position and brush 505 makes contact with commutator segment 563, a circuit is closed from ground on brush 505, commutator segment 563, left contacts of cam 536, cam 552 and lower contact thereof, winding of magnet 509 to battery. The link sequence switch is advanced to position 2 which is the assignment position for the link as already described.

When the link sequence switch advanced out of position 8 the circuit of relay 605 was opened and this relay released, which, by releasing caused the restoration of the sender to normal.

At the termination of the conversation, the selector switches are restored to normal as described in the above identified patent to O. H. Kopp. When the sequence switch associated with the district selector reaches posi-

tion 1 battery is disconnected from brush 444 and cut-off relay 102 releases, restoring the subscriber's line to normal in readiness for subsequent calls.

What is claimed is:

1. In a telephone exchange system, line finders arranged in groups, major subgroups and minor subgroups, a plurality of superposed contact banks divided into a plurality of sections, a group of links arranged for cooperation with each section, the various minor subgroups of line finders being so arranged in the various sections that a different subgroup appears as first choice to a link group in each of said sections, a pair of distributor switches responsive in alternation to the initiation of successive calls and capable of allotting line finders therefor, and means responsive to the operation of a line finder so allotted for a call for starting an idle one of the links which serves a section of said banks in which the minor subgroup containing the contact set of the said operated line finder appears as first choice.

2. In a telephone exchange system, line finders arranged in groups, major subgroups and minor subgroups, a plurality of superposed contact banks divided into a plurality of sections, a group of links arranged for cooperation with each of said sections, the various minor subgroups of line finders being so arranged in the various sections that a different subgroup appears as first choice in each of said sections, a pair of distributor switches each responsive to the initiation of a call and capable of allotting a line finder therefor, the said allotting switches operating in alternation for successive calls, means responsive to the operation of a line finder so allotted for a call for starting an idle one of the links which serves a section of the banks in which the minor subgroup containing the contact set of said operated line finders appears as first choice, and means operated when all links having first choice access thereto are busy for starting an idle one of the links of the next succeeding link group before which the minor subgroup containing the contact set of the said operated line finder appears as second choice.

3. In a telephone exchange system, line finders arranged in groups, major subgroups and minor subgroups, superposed contact banks divided into a plurality of sections, a group of links arranged for cooperation with each of said sections, the links of each group having first choice access to a plurality of minor subgroups of line finders in each of said sections, respectively, a pair of distributor switches for a plurality of line finders, each of said switches having access to line finder subgroups appearing as first choice in their respective sections, a start circuit for the said pair of distributor switches responsive to the initiation of a call, means con-

trolled by the said start circuit and one of said switches for allotting a line finder for said call, means responsive to the allotment of said line finder for operating said switch and advancing it to the terminals of an idle line finder, means responsive to the allotment of said line finder for preparing said start circuit to allot a line finder accessible over the said other switch on a subsequent call, and means responsive to the operation of said first allotted line finder for starting an idle one of the links which serve a section of said banks in which the minor subgroup containing the contact set of said operated line finder appears as first choice.

4. In a telephone exchange system, line finders arranged in groups and subgroups, a plurality of superposed contact banks divided into a plurality of sections, a group of links arranged for cooperation with each of said sections, each of said group of links being first choice for those subgroups of line finders appearing in the first position of each bank section which the link group serves, second and more remote choice for the second and other subgroups of the line finders appearing in the same section, respectively, a pair of distributor switches each alternately responsive to the initiation of successive calls and capable of allotting line finders therefor, a link finder for each link, brush sets for each link finder for cooperation with said banks respectively, means for operating each link finder in a brush selecting and terminal finding movement and a trip rod for each link finder having a brush tripping finger corresponding to each brush set, the trip fingers of all link finders being arranged to trip pairs of said brush sets for any given brush selecting movement.

5. In a telephone exchange system, line finders arranged in groups and subgroups, a plurality of superposed contact banks, said line finders terminating in corresponding contacts on each of a pair of contact banks, a link circuit comprising a link finder having a brush set for cooperation with each bank, a pair of distributor switches each alternately responsive to the initiation of successive calls and capable of allotting a line finder therefor, means in said link circuit responsive to the operation of an allotted line finder in a subgroup accessible to said link circuit for marking the location of said subgroup of line finders on the said contact banks and means responsive to the operation of said means for operating said link circuit in a brush selecting movement to select the pair of brush sets which cooperate with the pair of contact banks in which the said line finder subgroup containing the calling line finder appears.

6. In a telephone exchange system, a plurality of line finders arranged in groups, a plurality of superposed contact banks, a group of said plurality of line finders ter-

minating on corresponding contacts of two of said contact banks, a group of said line finders terminating on corresponding contacts of a pair of contact banks immediately above the said other pair, a plurality of links each having a finder switch with a plurality of brush sets arranged for cooperation with said banks respectively, means in each of said line finders for determining its location on the said pair of banks, means responsive to the operation of a line finder for starting a link finder in a brush selecting and terminal hunting movement, and means in said link responsive to the operation of said means in said line finder which determines its location on the said banks for selecting a pair of said plurality of brush sets for cooperation with the said pair of banks in which the said operated line finder is located.

7. In a telephone exchange system, a plurality of line finders arranged in groups, each of said groups being subdivided into two subgroups, a pair of distributor switches operatively associated with each of said subgroups of line finders, a plurality of superposed contact banks divided into a plurality of sections, said line finders of each of said subgroups terminating in contacts in the several sections of said banks so that a different subgroup appears as first choice in each of said sections, a plurality of links arranged in groups, each link having a link finder having access to said contact bank, means responsive to the operation of a line finder in a subgroup for associating said subgroup of line finders with a group of links as first choice and with other groups of links as subsequent choices, and means responsive to an all busy condition of a preferred group of links for transferring said group of line finders to successive groups of said links.

8. In a telephone exchange system, a plurality of line finders arranged in groups, each of said groups being subdivided into two subgroups, a plurality of register senders, a plurality of superposed contact banks divided in a plurality of sections, said line finders terminating in contacts in the several sections of said banks so that a different subgroup appears as first choice in each of said sections, a plurality of links each having a link finder arranged in groups, each of said groups being capable of cooperating with one of said sections, a plurality of pairs of distributor switches, each of said pairs being operatively associated with two subgroups of line finders, means associated with each of said distributor switches and responsive in alternation to the initiation of successive calls to allot a line finder therefor from the subgroup of line finders associated with the distributor switch so operated, means in said selected line finder for starting a link finder hunting for the said allotted line finder in the said banks, and means in

said link circuit for selecting an idle register sender.

9. In a telephone exchange system, a plurality of line finders arranged in groups, each of said groups being subdivided into two subgroups, two distributor switches each having cooperating brushes and contact banks, said subgroups of line finders terminating in the contact banks of said distributor switches respectively, a relay operatively associated with both of said distributor switches, a start circuit, the said start circuit extending through the contacts of said relay, said brushes and said contact banks of one or the other respectively of said distributor switches dependent upon the operated or non-operated condition of said relay, means for stepping each of said distributor switches from the terminals of busy line finders in their respective subgroups, means responsive to the operation of said start circuit to operate a line finder in either of said subgroup of line finders, and means responsive to the operation of the said line finder for controlling alternately the operation and release of said relay when said line finder is seized depending upon the subgroup of line finders to which the operated line finder belongs.

10. In a telephone exchange system, a plurality of subscribers' lines, a plurality of link circuits, a plurality of line finders, a plurality of register senders, a pair of distributor switches responsive in alternation to the initiation of successive calls and capable of allotting line finders therefor, means in said allotted line finder for assigning a link, and means in said link responsive to said assignment for causing the said link circuit to hunt for the said allotted line finder and also for causing said link circuit to hunt for an idle sender.

11. In a telephone exchange system, a plurality of subscribers' lines, a plurality of link circuits, a plurality of line finders, a plurality of register senders, a distributing device operatively connected to said plurality of subscribers' lines and to said plurality of line finders, means in said distributing device responsive to the initiation of a call for allotting a line finder therefor, means in said allotted line finder for assigning a link, means for causing said assigned link to hunt for the said allotted line finder, and means for simultaneously causing said link circuit to hunt for an idle sender.

12. In a telephone exchange system, a plurality of subscribers' lines, a plurality of link circuits, a plurality of line finders, a distributing device operatively connected to said plurality of subscribers' lines and to said plurality of line finders, means in said distributing device responsive to the initiation of a call for allotting a line finder therefor, means in said allotted line finder for assigning a link, the link so assigned being the one in the

said plurality of links which is in the assigned position, and means effective as soon as the said link is assigned for causing another link of the said plurality of links to advance to its assignment position.

13. In a telephone exchange system, a plurality of subscribers' lines, a plurality of link circuits, a plurality of line finders, a distributing device operatively connected to said plurality of subscribers' lines and to said plurality of line finders, means in said distributing device responsive to the initiation of successive calls for allotting a line finder for each of said calls and means in each line finder of said plurality of line finders responsive to the allotment thereof for assigning a link to each of said allotted line finders in a definite order or preference.

In witness whereof, I hereunto subscribe my name this 16th day of October, 1930.

FRANK S. IRVINE.