

April 4, 1939.

N. D. NEWBY

2,152,769

TELEPHONE SYSTEM

Filed Sept. 25, 1937

5 Sheets-Sheet 1

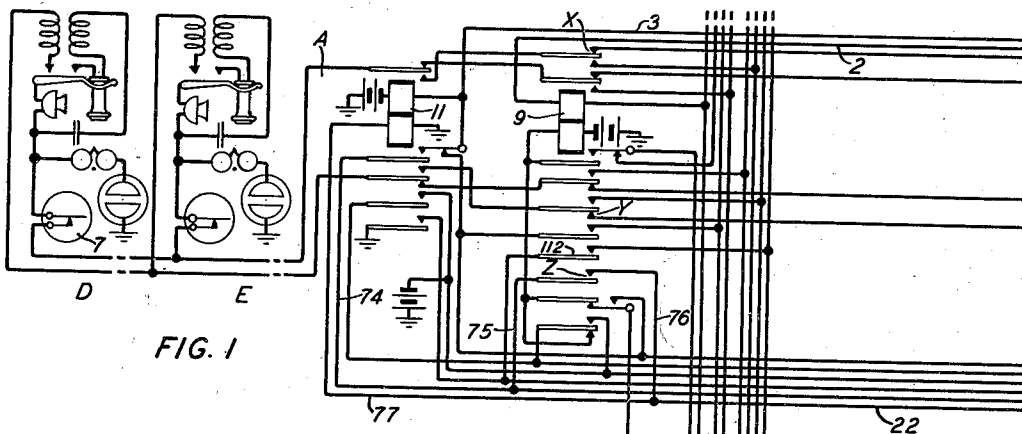


FIG. 1

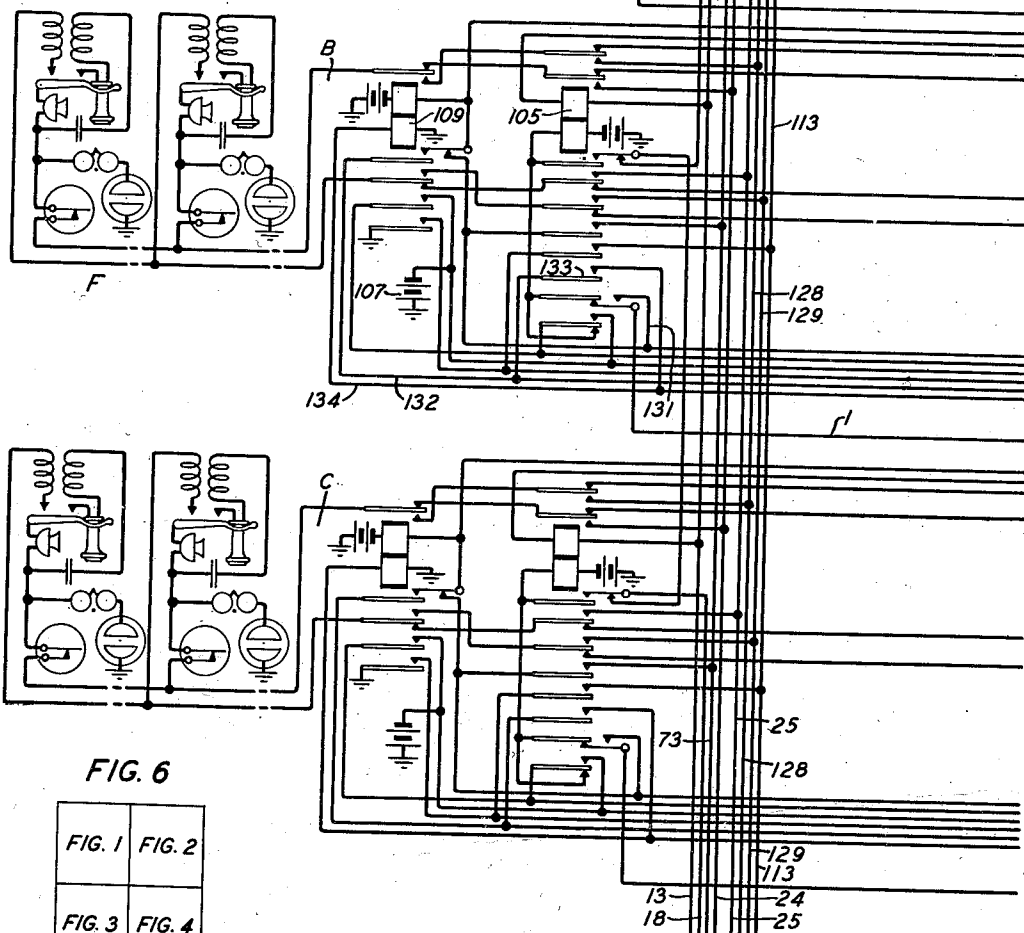


FIG. 6

FIG. 1	FIG. 2
FIG. 3	FIG. 4
FIG. 5	

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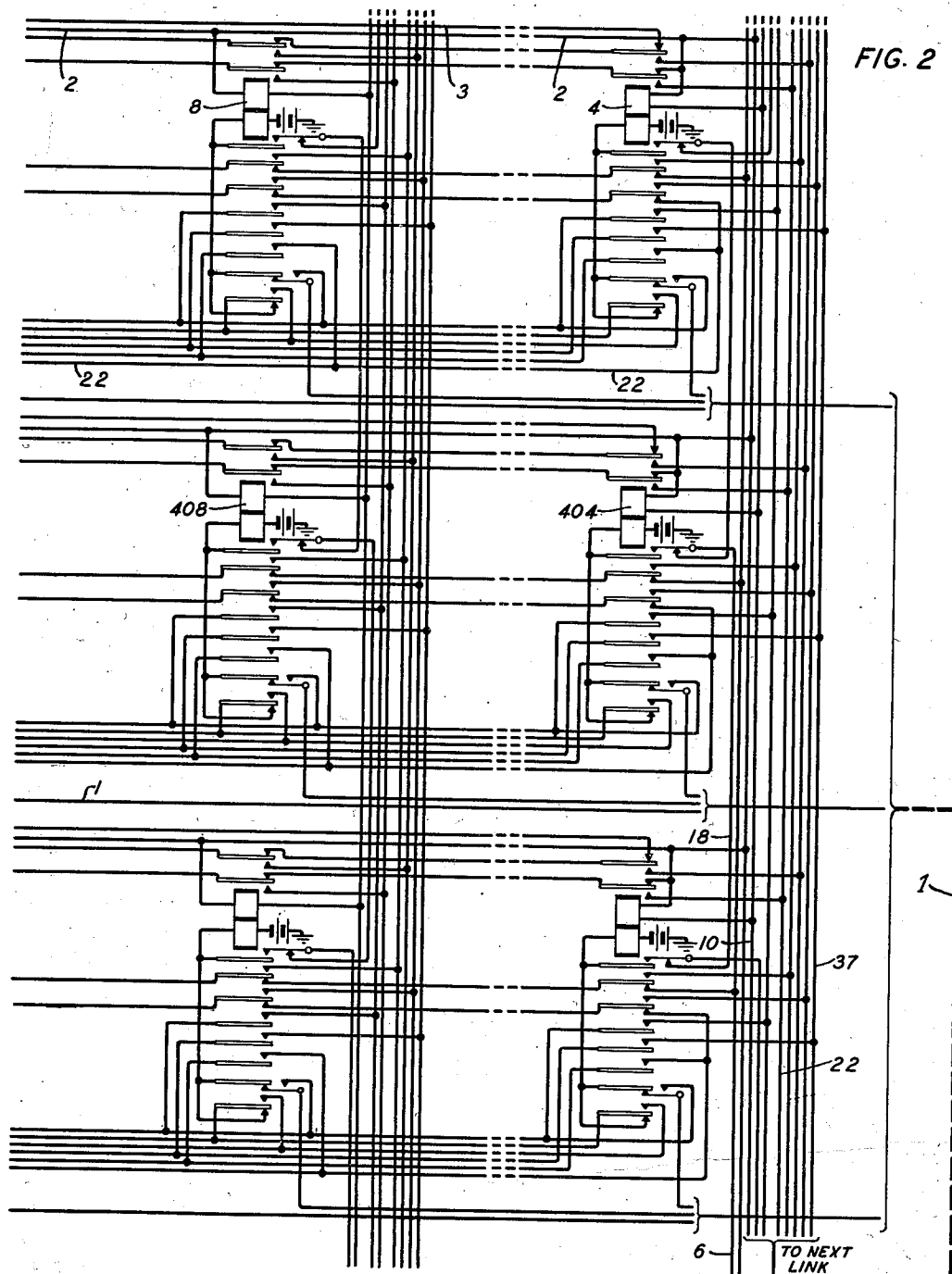
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TELEPHONE SYSTEM

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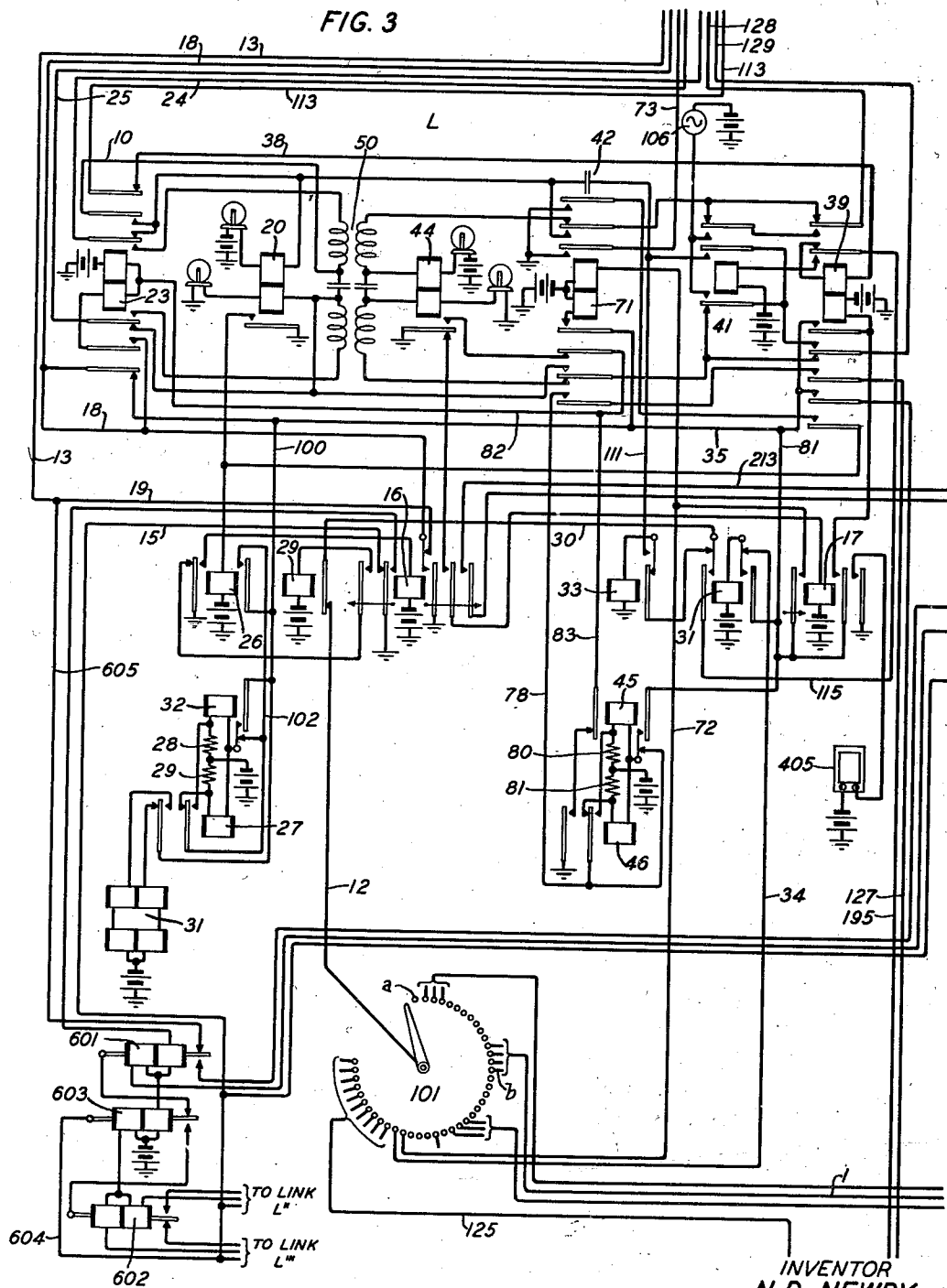
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FIG. 3



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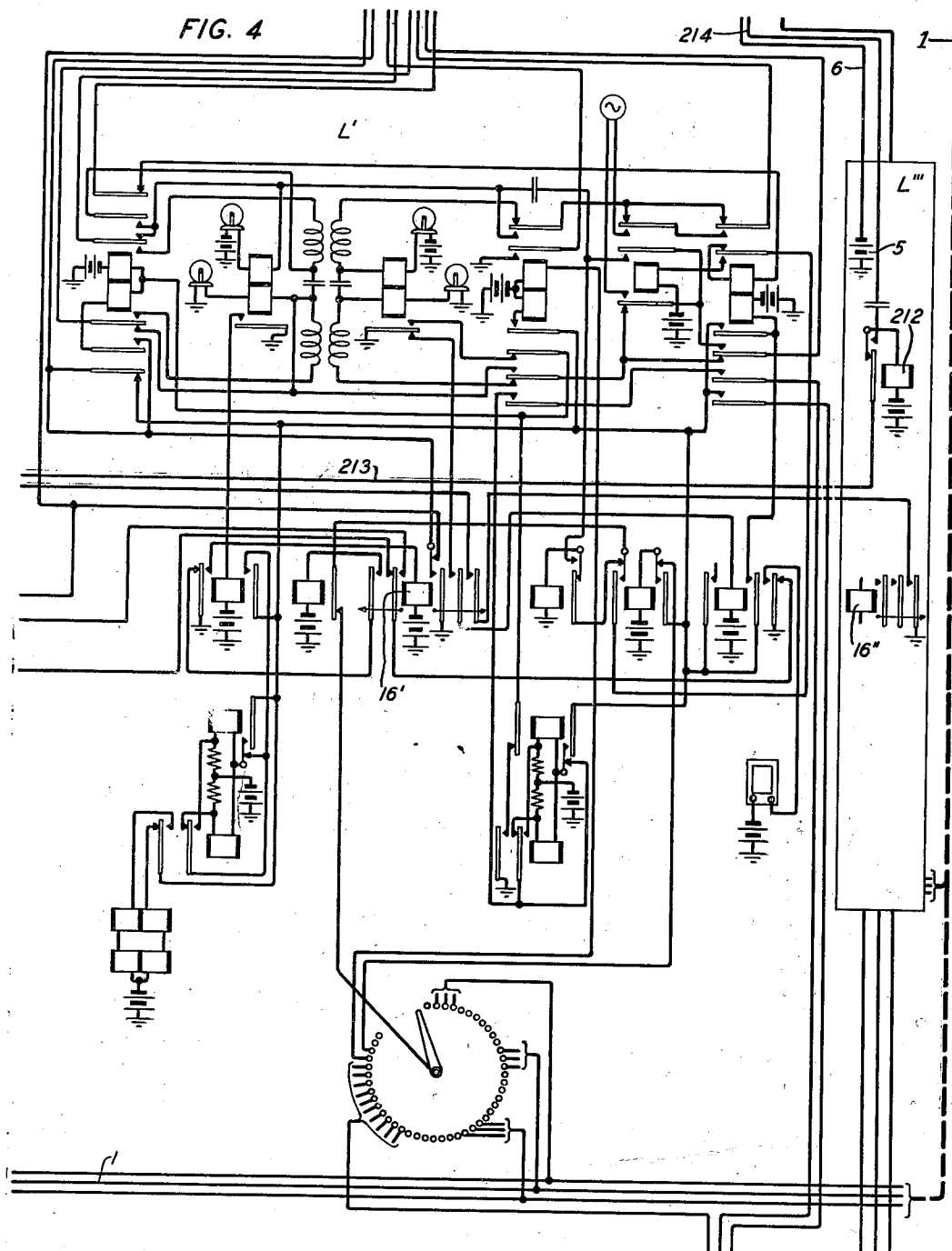
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TELEPHONE SYSTEM

2,152,769

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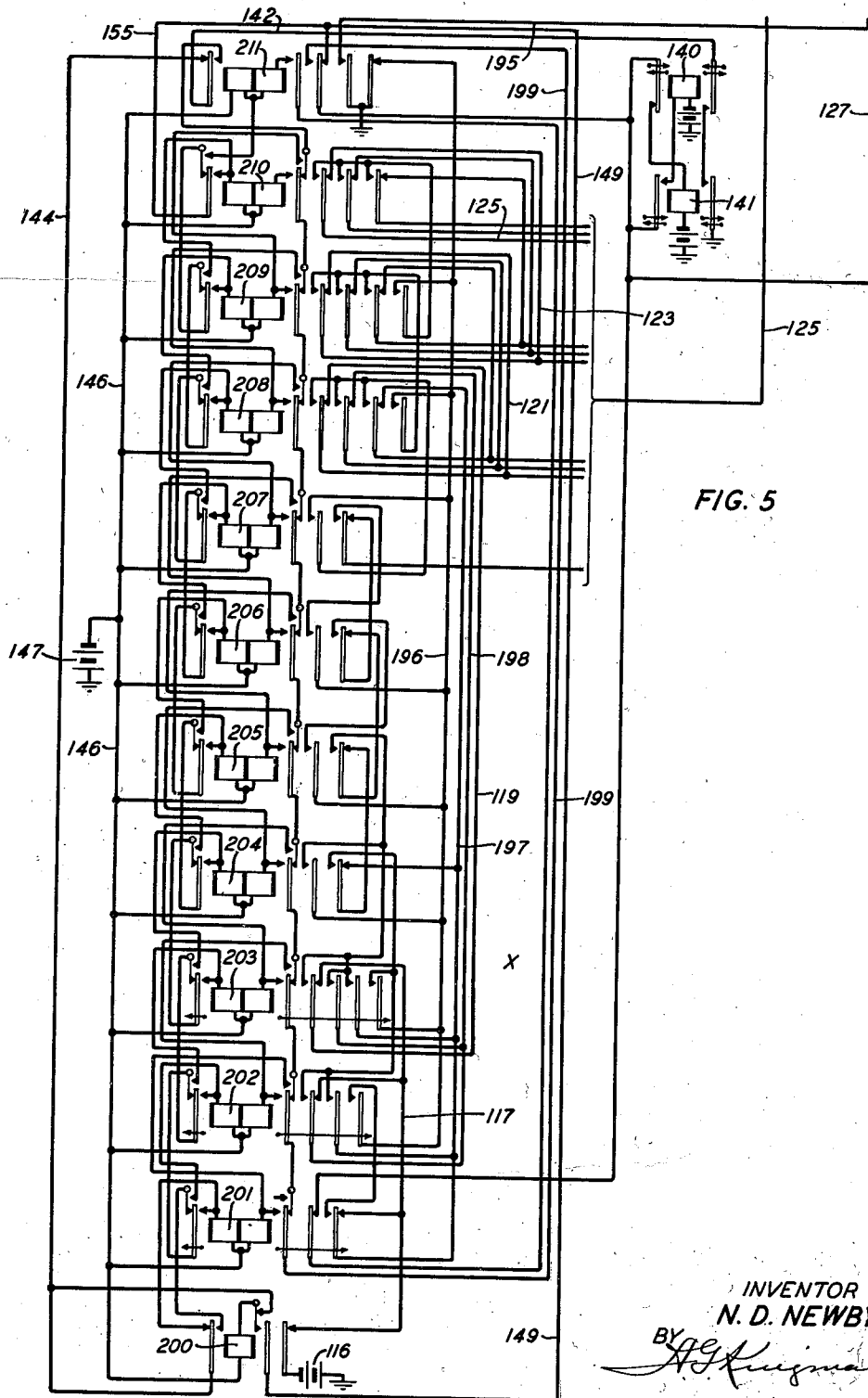
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5 Sheets-Sheet 5



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2,152,769

TELEPHONE SYSTEM

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Application September 25, 1937, Serial No. 165,607

11 Claims. (Cl. 179—17)

This invention relates to automatic telephone systems and particularly to communication facilities furnished by small community dial offices at which a plurality of party telephone lines terminate.

It is the object of this invention to simplify and improve the facilities of such offices and to facilitate the extension of connections between lines terminating thereat as well as between stations of the same line.

The invention is embodied in an organization of circuits and apparatus comprising a plurality of link circuits, each of which is accessible to any station on any of the party lines terminating at the central office, for the purpose of extending connections between calling and called lines and also between calling and called stations of the same line, and a selector switch, individual to each link, having certain terminals of a single bank of terminals allotted to the line circuits and which is controlled by the calling dial at the subscribers' stations.

In accordance with a feature of the invention, a single relay per line per link is used to perform the combined functions of the line, cut-off and cut-through relays heretofore relied upon in the establishment of automatic telephone connections. This relay, as a line relay, is normally connected to the line circuit and responds to receiver switchhook operations when a call is initiated; as a cut-off relay it cuts off the line circuit from the normal battery supply and associates it with the battery supply normally associated with the windings of the link calling supervisory relay and as a cut-through relay it operates on an incoming call to cut the link circuit through to the called line circuit.

Another feature of the invention resides in the use of a calling supervisory relay in the calling end of a link circuit which follows the interruptions of the dialing mechanism at a subscriber's station and controls the operation of a pulsing relay accordingly, and in the provision of means for transferring the calling supervisory relay from the calling end of the link circuit to the answering end thereof on reverteive calls, for the purpose of permitting ringing code impulses to be sent out over the calling line with which the called station is associated.

A further feature of the invention resides in the use of a timing relay in the link circuit which is controlled by the answering supervisory relay and functions, when a called party, on a non-revertive call, delays answering an incoming call for a predetermined interval of time, to release

the link circuit and place the call on a revertive basis. This feature renders it impossible for a link circuit to be unnecessarily tied up for too long a period of time and places a busy condition on the calling line.

A still further feature of the invention resides in the interposition of a relay chain circuit intermediate the link pulsing relay and a stepping magnet controlling the selector switch which serves to convert each combined open and closure of the line circuit effected by the actuation of the dial at a subscriber's station into a single controlling impulse. This halving of the transmitted pulses permits the use of all terminals on the selector switch, instead of alternate ones, for the line terminals and precludes the necessity for a special dial for controlling the stepping magnet.

These and other features of the invention will be readily understood from the following detailed description made with reference to the accompanying drawings, in which:

Figs. 1 and 2 placed side by side, with Fig. 1 to the left of Fig. 2, illustrate three groups of subscribers' stations and a line circuit per group, each line having access to each of a plurality of link circuits;

Figs. 3 and 4 each illustrates a link circuit and associated selector switch which are utilized to extend connections between the line circuits shown in Figs. 1 and 2;

Fig. 5 shows the code ringing circuit which controls the application of ringing current to a called line. A single code ringing circuit serves an office, and

Fig. 6 illustrates the manner in which the several figures are to be associated to effect a complete system.

It is believed that the invention will be best understood from a detailed description of the operation of the system disclosed and to this end the following description is directed to the operations effected when the subscriber at station D on line A initiates a call to the subscriber at station F on line B and the link allotter circuit has marked link L as the next link to receive a call.

The link allotter circuit comprises relays 601, 602 and 603. Relays 601 and 602 each serve a pair of links, relay 601 serving links L and L' which are illustrated in full, and relay 602 serving two other links one of which is represented diagrammatically by the block identified as L''. Relay 603 allots calls to the pairs of links alternately if calls are being handled one at a time. These relays are of the polarized type and are adjusted so that the armatures will remain on the

contact when the relays are deenergized. This feature allows a circuit design which draws no current from idle links. The windings of the relays are poled so that current flowing from grounded battery through the left-hand winding of a relay to ground causes the armature to close through both windings the position of the armature is indeterminate. When only one call at a time is in progress the links are assigned in rotation. This feature insures the calling subscriber of getting a working link on the second attempt if the first link seized should be inoperative due to a trouble condition.

The allotter circuit illustrated will serve four links. If current is flowing through the right-hand winding of relay 603 to two links (assuming links L and L' to be busy) and to only one link through the left-hand winding, the armature is moved to the lower contact. If all four links are busy the position of the armatures is indeterminate but no error in assignment results due to no ground being supplied to the armature of relay 603 from the lead 604 which is common to all four links. When one link of each pair is busy the positions of the armature of relay 603 is also indeterminate but no error results due to there being an idle link available for either the upper or lower contact.

In the following description it has been assumed that the link allotter circuit has marked link L as the next link to receive a call.

The subscriber at station D removes the receiver from its switchhook whereupon line relay 9 which is individual to the line A and link L operates its preliminary contact in a circuit extending from grounded battery 5 associated with the "all links busy" circuit shown in the upper half of the block L' in Fig. 4 which diagrammatically represents another link circuit, conductor 6, back contacts and second lower armatures of relays 4, 8, 9, and 11, through the closed subscriber's line loop at station D, upper armature and back contact of relay 11, first upper armature and back contact of relay 9, corresponding armatures and back contacts of relays 8 and 4, conductor 2, upper winding of relay 9, "link allotter" lead 13, conductor 605, upper contacts and armatures of relays 601 and 603, conductor 604, conductor 15, back contact and inner left-hand armature of relay 16 to ground.

Relays 9, 8 and 4 are of the well-known type which operate a preliminary contact (first lower make contact) on a small operating current. The closure of this preliminary contact then supplies sufficient power to the relay windings to operate the entire spring pile-up.

Relay 9 operates its preliminary contact in this circuit and then completely operates and holds operated in a circuit extending from grounded battery, lower winding and first lower armature and front contact of relay 9, "hold" conductor 18, normal make-before-break contacts of relay 16, conductor 19, through the link allotter circuit as just described, to ground at the back contact and inner left-hand armature of relay 16 to ground.

Relay 9 completely operated, connects the calling supervisory relay 20 of link L (Fig. 3) across the calling line so that this relay now operates in a circuit extending from grounded battery, upper winding of relay 20, back contact and innermost upper armature of relay 23, tip conductor 24, front contact and inner upper armature of relay 9, back contact and upper arma-

ture of relay 11, through the closed subscriber's line loop, second lower armature and back contact of relay 11, second lower armature and front contact of relay 9, ring conductor 25, innermost lower armature and back contact of relay 23, lower winding of relay 20 to ground. In operating, relay 9 also cuts off the battery 5 from the line circuit A and substitutes therefor the battery associated with the windings of the calling supervisory relay 20.

By the operation of relay 9 the calling line A is connected to the calling end of the link circuit L shown in Fig. 3.

At its armature and front contact relay 20 causes "pulsing" relay 26 to operate. Relay 26, by way of its left-hand armature and front contact connects ground to the winding of slow-to-release relay 16, which relay operates. At its innermost right-hand armature and front contact relay 16 connects ground direct to the "hold" conductor 18 to hold line relay 9 operated. Ground on the left inner armature of relay 16 is transferred from the normal contact to the front contact thus indicating to the link allotter circuit that link L is no longer idle, but busy. Relay 16 holds operated for the duration of the call under control of the calling supervisory relay 20 which controls the operation of relay 26.

The subscriber at station D may now dial the code assigned to the called station F on line B. This code for descriptive purposes will be assumed to be made up of the numerals 0-4-6-0-3 in the order indicated.

The selector switch 101 which is individual to the link circuit L is of the general type commonly used in railway train dispatching. Such a switch is shown in J. C. Field Patent 1,343,256. In the present case the switch differs from that shown in the patent primarily in that it uses a single bank of forty-one terminals and the hold pins characteristic of the Field device are omitted. The regular telephone dial functions in such a manner that in dialing the digit 1 the line circuit is opened and closed once; in dialing the digit 2 the line circuit is opened and closed twice and so on. If the selector magnet 31 were to be controlled directly from the "pulsing relay" it is apparent that, for each combined open and closure of the line circuit effected by the dial, the magnet would be operated twice and would advance the selector two steps. In other words, the dialing of the digit 1 would advance the selector two steps; dialing of the digit 2 would advance the selector four steps, etc. Such functioning reduces the capacity of the selector switch in that only every other terminal may be used. To permit the use of all terminals of the selector, it is necessary to either employ a special dial or else provide some means for halving the pulses effected by the dial, that is, combining each line circuit open and closure so as to produce a single selector operating impulse. Applicant has interposed a relay chain circuit, comprising relays 27 and 32, which functions as a pulse halving circuit and which renders it possible to employ the dial in common use today without sacrificing any of the selector terminals. The manner in which this pulse halving circuit functions will appear presently.

Actuation of the dial 7 at station D causes the line circuit A to be interrupted in the well-known manner so that the calling supervisory relay 20, included in the line circuit, follows the dial pulses. "Pulsing" relay 26, being controlled by relay 20 also follows the dial pulses but relay

16, being slow-to-release, remains operated during pulsing.

The selector switch 101 is controlled by the selector magnet 31. As illustrated, the selector magnet functions each time relay 27 of the pulse halving circuit operates or releases due to the fact that the two right-hand windings are energized when relay 27 is in its released position and the two left-hand windings are energized when the outer armature of relay 27 is moved to engage its front contact. For each operation of the magnet 31 the brush of the selector is advanced one step in a well-known manner. It will be noted, therefore, that for each operation of relay 27 and for each release thereof the selector advances one step.

The selector switch 101 as hereinbefore mentioned includes a single bank of forty-one terminals. The first terminal *a* is called the off-normal terminal or position to which the selector brush is moved when relay 20 first operates upon connection of the link circuit L to the calling line A. Beginning at the next terminal the succeeding terminals may be numbered 1 to 40. Terminals 1 to 9, inclusive, 11 to 19, inclusive, and 21 to 28, inclusive, are called line terminals being allotted to the line circuits to be served by the selector; terminals 10 and 20 are rest terminals; terminal 9 may be assigned to a trunk circuit to an operator if desired; terminal 29 is used for reveritive calls; terminal 30 is the cut-through terminal and the remaining terminals may be used for code ringing purposes.

As hereinbefore described, calling supervisory relay 20, pulsing relay 26 and slow-to-release relay 16 operate when the link circuit L is connected to the calling line A by the operation of relay 9. A circuit for the right-hand windings of selector magnet 31 is also completed to ground at the innermost right-hand armature of relay 16 by way of the back contact and outer armature of relay 27, conductor 100 and the back contact and outermost lower armature of relay 23. The selector magnet 31 operates in this circuit and moves the selector brush to off-normal terminal *a*.

Relay 32 of the pulse-halving circuit also operates as a consequence of the operation of calling supervisory relay 20, in a circuit extending from grounded battery resistance 28, winding of relay 32, normal make-before-break contacts of relay 32, conductor 102, front contact and right-hand armature of relay 26, conductor 109 and thence to ground at the front contact and innermost right-hand armature of relay 16 by way of the back contact and outer armature of relay 23. In operating, relay 32 locks directly to conductor 100 which finds ground at the front contact and innermost right-hand armature of relay 16.

From the description so far given, relays 20, 26, 16 and 32 operated when the link L was connected to the calling line A and the selector 101 was advanced one step to the off-normal position. The subscriber at station D now dials the digit 0 of the code number 0-4-6-0-3 which we have assumed is assigned to the called line B. When the line circuit is opened due to the actuation of dial 7 at station D, relay 20 releases and opens the circuit to relay 26 which relay, in releasing its right-hand armature, opens the path to ground on conductor 100 which ground had been shunting the operating battery of relay 27 through the back contact and inner armature of relay 27 and resistance 29, thus preventing its operation. Now with this shunt removed, relay

27 operates in a circuit extending from grounded battery, resistance 29, winding of relay 27, front contact and armature of relay 32 to ground on conductor 100. Relay 27 operated causes the left-hand windings of selector magnet 31 to be energized to cause the selector to be advanced to terminal No. 1 which immediately succeeds off-normal contact *a* on the selector bank.

When the line circuit A is closed again to complete the first pulse, relays 20 and 26 reoperate, the latter causing relay 32 to release. This release results from the fact that, with relays 27 and 26 both operated, the winding of relay 32 is shunted by ground from lead 100, through the right-hand armature and contact of relay 26 and left inner armature and front contact of relay 27. Though the line circuit A has experienced a break and a closure, the stepping magnet 31 was operated but once and advanced the selector but one step.

When the dial opens the line circuit for the second time during the dialing of the numeral 0 relays 20 and 26 again restore their armatures to normal. Operating ground supplied the winding of relay 27 from lead 100 through the right-hand contact of relay 26 is removed. Relay 27 accordingly releases so that both relays 32 and 27 are now in the released position, the latter relay completing an energizing circuit for the right-hand winding of the selector magnet 31. The selector 101 thereupon experiences another advance movement and its brush now engages contact No. 2. When the line circuit is again closed by the dial, relays 20 and 26 again operate causing relay 32 to operate. This relay holds operated when relay 27 reoperates upon the following line circuit opening, causing the selector magnet 31 to be again energized and to step the selector to position No. 3. It is believed unnecessary to describe any further operation of the pulse halving circuit upon receipt of succeeding ground pulses from relay 26. Suffice it to say that for each combined line circuit opening and closure effected by the dial, the selector advances one step and that advancement occurs only on the line circuit opening, the closure being rendered ineffective in stepping the selector. In other words though each break effected by the dial becomes two pulses, only one of the pulses is effective in operating the selector.

In the connection described it was assumed that the code required to signal the subscriber at station F on line B is 0-4-6-0-3. The digit 0 leaves the selector on a rest terminal, the digit 4 selects the line B, the digit 6 positions the selector brush on the twentieth terminal which is a rest terminal, the digit 0 positions the selector brush on the thirtieth terminal to cut the link circuit through into a ringing condition and the last digit 3 sets the ringing code circuit to send out the ringing code assigned to the station F.

Relay 29 is operated during the pulsing of each digit under control of the left-hand armature of pulsing relay 26. Between digits, it releases and places ground through the marginal low resistance relay 33 on the brush of the selector 101 to cause the operation of a line relay 105 as a connect relay and operates relay 31 as a ringing cut-through relay as will appear presently.

In the connection described, the selector brush rested upon terminal No. 10 upon the dialing of the digit "0". As this terminal is a rest terminal no circuit functions are performed. On the second digit "4" the brush rested upon the fourteenth terminal identified on the drawings by the

letter b. A circuit accordingly exists which may be traced from grounded battery, lower winding of line relay 105 (Fig. 1), seventh lower armature and back contact of relay 105, conductor 1 which extends across Fig. 2 and down along the right-hand margins of Figs. 2 and 4 and thence to terminal b and brush of the selector switch 101, conductor 12, back contact and armature of relay 29, conductor 30, left-hand normal make-before-break contacts of relay 31, armature and back contact and winding of marginal relay 33. Relay 105 operates in this circuit and in attracting its seventh lower armature transfers the grounded lead 1 from the lower winding of line relay 105 to lead 131 which is connected to the upper winding of relay 109 by way of the normal make-before-break contacts of that relay so that relay 109 operates. Relay 105, however, upon operating locks in a circuit extending from grounded battery, lower winding of relay 105, first lower armature and front contact of relay 105, to ground on the "hold" lead 18.

It will now be observed that, due to the operation of relays 105 and 109, the called line B is connected to the conductors 128 and 129 which are connected to the outer upper and second lower armatures of relay 39 which, by way of their front contacts are connected to the outer upper and lower armatures, respectively, of relay 41 which relay controls the application of ringing current from the source 106 to the called line.

If the line B had been busy on a revertive call or is the called line on another connection, relay 109 would have been operated so that battery 107 would be connected to the conductor 1 by way of the front contact and third lower armature of relay 109, outermost lower armature and back contact and seventh lower armature of relay 105 whereupon marginal relay 33 would operate as a buzzer. The transfer contact of relay 33 takes the inductive kick when the operating circuit to relay 33 is opened and places it on conductor 111 which is connected to the tip conductor 24 by way of the back contact and innermost upper armature of relay 23 as a busy indication to the calling subscriber at station D on line A. If line B is busy as the calling line on another connection (therefore, relay 109 is normal) the line relay in link L' (relay 408) or the line relay in link 3 (relay 404) would be operated. Assume relay 408 in link L' operated. Battery 107 through front contact, lower outer armature relay 408, lower outer armature, normal contact and lower seventh armature and normal contact of relay 105 to the terminal on switch 101 will operate marginal relay 33 as a buzzer. The line B in this description is assumed to be idle.

Dialing the digit "6" after the dialing of digit "4" positions the selector brush on a rest terminal and no circuit functions are performed.

When zero is dialed, the selector brush engages the thirtieth terminal which, as hereinbefore stated, is a ringing cut-through terminal. Relay 31 now operates in a circuit extending from grounded battery, winding and right-hand normal make-before-break contacts of relay 31, conductor 34, the thirtieth terminal of the selector switch 101, selector brush, conductor 12, back contact and armature of relay 29, conductor 30 left-hand normal make-before-break contacts of relay 31, armature, back contact and winding of marginal relay 33. Relay 31 operated, locks, by way of its right-hand armature and front contact to the conductor 31 which finds ground at the front contact and innermost right-hand

armature of relay 16. At its left-hand armature relay 31 transfers the lead 30 associated with the selector brush from the winding of relay 33 to the lead 115 which is connected to the inner upper armature of relay 39 which, by way of its associated back contact is connected to the upper winding of relay 39, conductor 38, back contact and outermost upper armature of relay 23 and thence to the "ring start" lead 113 which finds ground at the outermost lower armature and front contact of relay 109 by way of the fifth lower armature and front contact of relay 105.

When the last digit 3 is dialed by the calling subscriber the selector brush engages the third ringing terminal (the thirty-third terminal) whereupon a circuit is established extending from battery 116 associated with the ringing code circuit (Fig. 5) outer right-hand armature and back contact of slow-to-operate relay 200, conductor 117, back contact and second right-hand armature of relay 203, conductor 119, back contact and second right-hand armature of relay 208, conductor 121, back contact and second right-hand armature of relay 209, conductor 123, back contact and second right-hand armature of relay 210, conductor 125, thirty-third terminal of the selector switch 101 and the selector brush, conductor 12, back contact and armature of relay 29, conductor 30, front contact and left-hand armature of relay 31, conductor 115, inner upper armature and back contact of relay 39, upper winding of relay 39, conductor 38, back contact and outermost upper armature of relay 23, "ring start" lead 113, front contact and fifth lower armature of relay 105, front contact and outermost lower armature of relay 109 to ground. Relay 39 operates in this circuit. Relay 39 locks in a circuit extending from grounded battery, lower winding of relay 39, first lower armature and front contact of relay 39, conductor 35, back contact and outermost lower armature of relay 23, to ground at the front contact and innermost right-hand armature of relay 16. In attracting its inner upper armature relay 39 transfers the selector brush lead 115 from the upper winding of relay 39 to the winding of relay 41 and at its fourth lower armature and front contact connects ground at the innermost right-hand armature and front contact of relay 16 to the lead 127 which serves to start the ringing code circuit functioning. At its outer upper and second lower armatures and front contacts relay 39 connects the "ringing tip" conductor 128 and the "ringing ring" conductor 129 of the link circuit L to the two outer armatures of relay 41 which relay, when operated connects the ringing current source 106 to these armatures.

The operation of the code ringing circuit shown on Fig. 5 will now be described.

The code ringing circuit shown on Fig. 5 includes a pulse generating portion consisting of slow relays 140 and 141. When ground potential is applied to the lead 127 as described in the preceding paragraph, relay 141 operates in a circuit including the left-hand armature and back contact of relay 140. Relay 140 now operates to ground on the lead 127 by way of the left-hand armature and front contact of relay 141. Relay 140 opens the operating path to relay 141 causing this relay to release. When relay 141 releases, the operating path to relay 140 is opened and this relay releases thus restoring the circuit to normal for another cycle. Relays 140 and 141 of the pulse generating circuit con-

tinue to operate in this manner as long as ground potential is applied to conductor 127.

During the release of relay 141 ground potential supplied through the right-hand armatures and front contacts of relays 141 and 140 causes the chain of counting relays 200 to 211 to make one step as follows: Ground through the right-hand operated contacts of relays 141 and 140 is transmitted over conductor 142, left-hand armature and back contact of relay 211, conductor 144, normal make-before-break contacts and winding of relay 200, conductor 146 to grounded battery 147. Relay 200 is slow-to-operate and operates in this circuit.

During the operate time of relay 200, ground from conductor 144 is transmitted to the left-hand winding of relay 201 by way of the left-hand armature and back contact of relay 200 so that relay 201 operates in an obvious circuit. Relay 200 is held operated by ground on the "ring hold" lead 127 through the second right-hand armature and back contact of relay 211, conductor 149, inner right-hand armature and front contact and winding of relay 200 to grounded battery 147 by way of conductor 146.

After the operation of relay 200, one of the relays 201 to 211 is always operated causing the chain circuit including the left-hand armatures of these relays to be broken. This circuit is used, however, to hold momentarily the operated relays in the chain as they count up but not when they count down since relay 211 is then operated as will appear presently.

With relay 200 operated and relay 201 locked in the path just described, the pulse of ground which operated relay 201 now causes the operation of relay 202 in a circuit extending from lead 144 (grounded), left-hand armature and front contact of relay 200, left-hand alternate make-before-break contacts of relay 201, left-hand winding of relay 202 to grounded battery 147 by way of lead 146. Relay 202 operated, opens the holding circuit for relay 201 which relay starts to release. As will be described later, the interval of time during which relays 201 and 202 are both operated is used to time an impulse of ringing current in the connected link circuit L.

The pulse of ground which operated relays 201 and 202 will have terminated by the time relay 201 is released. When the next pulse of ground is supplied, relay 203 operates in a circuit extending from ground on lead 144, left-hand armature and front contact of relay 200, back contact and left-hand armature of relay 201 (released), alternate make-before-break contacts of relay 202 (operated), left-hand winding of relay 203 to grounded battery 147 by way of conductor 146. Relay 203 locks in a circuit similar to that in which relay 201 locked as already described. At its left-hand armature relay 203 opens the holding circuit for relay 202 which relay releases. The operating circuit for relay 204 is opened until relay 202 releases. While relay 202 is releasing another ringing impulse is timed.

Pulses of ground from relays 140 and 141 step up the remaining relays 204, 205, 206, 207, 208, 209 and 210 in a manner similar to that already described in connection with the operation of relays 201 and 202, until relay 211 is operated in a manner now apparent.

Relay 211 is held operated from ground supplied by conductor 127 through the second right-hand armature and back contact of relay 201, (the first in the chain) through the first right-hand armature and front contact of relay 211

which is arranged to close before the left-hand normal contacts are opened. Relay 211, operated, opens the holding circuit for relay 200 and for the left-hand winding of relay 210, but immediately provides a holding path for the right-hand winding of relay 210 extending from grounded battery 147, conductor 146, right-hand winding of relay 210, front contacts and first right-hand armatures of relays 210, 209, 208, 207, 206, 205, 204, 203, 202, and 201, conductor 199, front contact and second right-hand armature of relay 211 to ground on "ring hold" conductor 127. Relay 210 is therefore not released until relay 209 is re-operated.

The pulse of ground which operated relay 211, or the succeeding pulse, will operate relay 209. The circuit for relay 209 extends from grounded battery 147, conductor 146, right-hand winding of relay 209, alternate make-before-break contacts of relay 210, front contact and left-hand armature of relay 211, conductor 142 to ground by way of the right-hand armatures and front contacts of relays 140 and 141. Relay 209 operated, opens the holding circuit for the right-hand winding of relay 210 whereupon this relay releases.

With relay 209 operated and relay 210 released the circuit is in condition to operate relay 208 on the next ground pulse. The relays 210, 209, 208, 207, 206, 205, 204, 203, 202 and 201 are stepped down one at a time, beginning at the top of the chain, by the use of the right-hand make-before-break contacts in the same manner that they were stepped up by the use of the left-hand make-before-break contacts. When relay 201 is operated, holding ground for relay 211 is removed at the second right-hand armature and back contact of relay 201 causing relay 211 to release, which relay in turn opens the holding path for relay 201 which relay releases at the end of the pulse of ground supplied from the pulse generating circuit including relays 140 and 141.

The first nine of the ringing codes consist of two groups of equal length ground impulses with a short silent interval between groups. The impulses per group vary from one to three. A tenth code consists of six impulses in one group. As the above described chain of relays steps up, the code is generated and as the relays step down the waiting interval between codes is measured.

Each code starts with a pulse from battery 116 to set up a ringing condition in the link circuit as already described. This causes the link to always start ringing at the beginning of the code even though it should be connected while the ringing circuit was engaged in generating a ringing code for another link.

With all relays in the chain circuit normal, battery 116 is connected to lead 1 (small numeral) Fig. 5 by way of the outer right-hand armature and back contact of relay 200, conductor 117, back contact and second right-hand armature of relay 203, conductor 119 and the back contact and second right-hand armature of relay 208. Battery is further extended to lead 2 (small numeral) by way of the back contact and second right-hand armature of relay 209 and thence to lead 3 (small numeral) through the back contact and second left-hand armature of relay 210. Battery is similarly connected to leads 4, 5, and 6 (small numerals) through the outer right-hand armature and back contact of relay 200, back contact and second right-hand armature of relay 202, conductor 198, and back contacts and third right-hand armatures of re-

lays 208, 209, and 210. Likewise battery is connected to leads 7, 8 and 9 (small numerals) through the outer right-hand armature and back contact of relay 200, back contact and third right-hand armature of relay 201, conductor 197, and the back contacts and fourth right-hand armatures of relays 208, 209, and 210. Battery is connected to lead 10 (small numeral) through the outer right-hand armature and back contact of relay 200, back contact and third right-hand armature of relay 201, conductor 197, and the back contacts and third right-hand armatures of relays 204, 205, 206, and 207.

As mentioned above, each pulse of ground in the ringing code is measured while one of the relays in the chain is operated while the preceding relay is releasing. Code 1, for example, (lead 1 small numeral) consists of two pulses of ground separated by an interval measured by the time required to operate relays 152, 153 and 154.

The codes in table form are as follows:

	Code 1	—	—	
	Code 2	—	—	—
25	Code 3	—	—	—
	Code 4	—	—	—
	Code 5	—	—	—
	Code 6	—	—	—
	Code 7	—	—	—
30	Code 8	—	—	—
	Code 9	—	—	—
	Code 10	—	—	—

The ground for each code is supplied from the fourth right-hand armature and back contact of relay 211. Codes 1, 2 and 3 are generated as follows: Ground from the outermost right-hand armature and back contact of relay 211, by way of conductor 196, second right-hand armature and front contact of relay 204, front contact and second right-hand armature of releasing relay 203, conductor 119, back contact and second right-hand armature of relay 208 to lead 1 (small numeral) gives the first pulse of ground. This pulse of ground is also delivered to leads 2 and 3 (small numerals) through the back contacts and second right-hand armatures of relays 209 and 210, respectively. The time required for operating relays 205, 206 and 207 is used to separate the two groups of impulses. Another pulse of ground is then delivered to lead 1 (small numeral) through the front contact and second right-hand armature of releasing relay 207 and front contact and second right-hand armature of relay 208. This pulse of ground is also placed on leads 2 and 3 (small numerals) by way of the back contacts and second right-hand armatures of relays 209 and 210.

Lead 2 (small numeral) has an additional pulse delivered to it from ground through the front contact and fifth right-hand armature of releasing relay 208 and the front contact and second right-hand armature of relay 209. This pulse of ground also reaches lead 3 (small numeral) through the back contact and second right-hand armature of relay 210.

Lead 3 (small numeral) receives a third impulse of ground in the last half of the code, as shown in the above table, through the front contact and fifth right-hand armature of releasing relay 209 and the back contact and second right-hand armature of relay 210. With this description the circuit operation for the remaining codes should be easily followed; however, the operation for code 7 will also be described. Ground through the front contact and fourth

right-hand armature of relay 202, through front contact and third right-hand armature of releasing relay 201, conductor 197, through the back contact and fourth right-hand armature of relay 208 gives the first pulse of group one of the codes 7, 8, and 9. The second pulse of the first group is generated by ground through the front contact and fifth right-hand armature of relay 203 and through the front contact and third right-hand armature of releasing relay 202 and conductor 197. The third pulse is generated by ground through the front contact and second right-hand armature of relay 204, front contact and the fourth right-hand armature of releasing relay 203. The one pulse in the second group of code 7 is generated by ground through the front contact and second right-hand armature of releasing relay 207, thence through the front contact and fourth right-hand armature of relay 208 to lead 7 (small numeral).

At the end of each code the operation of relay 211 connects ground to "code end" lead 195 by way of its front contact and third right-hand armature.

In the present description we have assumed that code No. 3 is assigned to the substation F on line B. In the manner described, therefore, the code ringing circuit functions to transmit over the conductor 125 a single ground pulse which, after a pause, is followed by three successive ground pulses. Relay 41 in the link circuit responds to these ground pulses in a circuit extending from grounded battery, winding of relay 41, front contact and inner upper armature of relay 39, conductor 115, left-hand armature and front contact of relay 31, conductor 30, armature and back contact of relay 29, conductor 12, brush of selector 101 and the thirty-third terminal thereof, conductor 125 which corresponds to lead 3 (small numeral) of the ringing code circuit. Relay 41 accordingly follows the pulses of ground supplied from the ringing code circuit and, by way of its outer upper and lower armatures and front contacts connects the 20-cycle ringing current source 106 with its superimposed battery to conductors 128 and 129 which, due to the operation of relays 105 and 109 are connected to the called line B. The signaling equipment at the stations on line B is accordingly actuated and the subscriber at station F, recognizing her code, answers the call. The use of the gas discharge tube in series with the bell serves to ground the bell and line only when superimposed ringing voltage breaks down the tube.

After each ground pulse from the ringing code circuit relay 41 releases and connects the answering supervisory relay 44 to the conductors 128 and 129 now associated with the called line B. When the called subscriber responds to the incoming ringing signal, relay 44 operates over the closed (called) subscriber's loop and establishes an obvious energizing circuit for relay 23. Relay 23 operates and allows relays 31, 39, 27, 32 and the selector 101 to release and cuts the left-hand windings of repeating coil 50 into the calling end of the link L. Relay 23 locks to ground from relay 16 through its own second lower armature and front contact. The release of relay 39 releases the code ringing circuit.

The stations D and F of lines A and B, respectively are now connected for communication. The calling end of the connection may be traced from grounded battery, upper winding of calling supervisory relay 20, front contact and second upper armature of relay 23, conductor 10, upper

left-hand winding of repeating coil 50, front contact and innermost upper armature of relay 23, tip conductor 24, front contact and inner upper armature of relay 9, back contact and upper armature of relay 11, through the closed line loop at station D of line A, second lower armature and back contact of relay 11, second lower armature and front contact of relay 9, ring conductor 25, innermost lower armature and front contact of relay 23, lower left-hand winding of repeating coil 50, to ground through the lower winding of calling supervisory relay 20. The answering end of the talking circuit may be traced from grounded battery, upper winding of answering supervisory relay 44, upper right-hand winding of repeating coil 50, back contact and outer upper armature of relay 71, back contact and outer upper armature of relay 39, tip conductor 128, front contact and outer upper armature of relay 105, front contact and upper armature of relay 109, closed line loop at station F of line B, second lower armature and front contact of relay 109, third lower armature and front contact of relay 105, ring conductor 129, second lower armature and back contact of relay 39, third lower armature and back contact of relay 71, lower right-hand winding of repeating coil 50 to ground through the lower winding of answering supervisory relay 44.

At the termination of conversation between the subscribers at stations D and F the receivers at the stations are replaced on their respective switchhooks. The calling and answering ends of the link circuit are therefore opened and the supervisory relays 20 and 44 restore their armatures. Relay 20 released, releases relay 26 which in turn opens the circuit to relay 16, which relay releases and removes ground from its innermost right-hand armature thereby causing relays 23, 9 and 105 to be deenergized. Relay 105 opens the locking circuit for relay 109 and this relay releases. The circuit is accordingly restored to normal.

Revertive call

If the call originating at station D, for example, of line A is to another party on the same party line, that is, a revertive call, a special code is used. The calling subscriber, noting that the first four digits of the code are the same as his own, is instructed to dial the special code with the last digit of the called party's code. Usually, the subscriber is provided with a bulletin listing the parties on his line with the codes to be used for each.

In the present description it will be assumed that the subscriber at station D desires to converse with the subscriber at station E, both stations being on the same line A and link L has been marked by the link allotter as the next link to be used.

Removal of the receiver at station D causes line relay 9 to operate in the manner already described to connect the calling line A to an idle link circuit L. Relays 20, 26 and 16 operate upon connection of the link circuit L to the calling line in a manner previously described. The subscriber at station D now dials a special code such as 0-0-9-1-9. The selector 101 follows the dial pulses through the pulse-halving circuit consisting of relays 27 and 32, in the manner previously described. Dialing the digits 0, 0, places the selector brush on two rest terminals so that no circuit functions are performed. Dialing the third digit 9 positions the brush on the twenty-ninth terminal which is connected to the upper winding

of relay 71 by way of conductor 72 whereupon relay 71 operates in a circuit extending from grounded battery, upper winding of relay 71, conductor 72, twenty-ninth terminal on the selector bank, selector brush, back contact and armature of relay 29, conductor 30, normal left-hand make-before-break contacts of relay 31, armature and back contact and winding of marginal relay 33 to ground. Relay 71 operates in this circuit and locks in a circuit extending from grounded battery, lower winding, front contact and first lower armature of relay 71, back contact and third outer armature of relay 23 to ground at the front contact and first right-hand armature of relay 16. At its inner upper armature and front contact relay 71 connects ground to conductor 73 and thence through the front contact and fourth lower armature of line relay 9, normal make-before-break contacts of relay 11 to battery and ground through the upper winding of relay 11. Relay 11 operates in this circuit and locks in a circuit extending from grounded battery, upper winding of relay 11, front contact and first lower armature of relay 11, conductors 74 and 75, sixth lower armature and front contact of relay 9, conductors 76 and 77 to ground through the lower winding of relay 11. Relay 11 remains locked up for the duration of the connection as will be shown presently.

Relay 71 in attracting its upper second and third lower armatures, connects the calling supervisory relay 20 to the answering end of the link circuit L which is the end which is now connected to the calling line A due to the operation of relays 9 and 11. The supervisory relay 20 which controls the operation of the selector switch 101 is now controlled by the dialing mechanism at station 7 over the answering end of the link. The contact arrangement of relay 11 is such that movement of the second upper armature and the lower third armature cause a make-before-break sequence of the associated contacts.

Dialing of the fourth digit 1 causes the selector brush to reach the thirtieth selector terminal which is connected to the winding of relay 31 by way of conductor 34. Relay 31, accordingly, operates to ground through marginal relay 33 and performs the same functions as it did when operated in the previous description.

The counting relays 45 and 46 are now connected to the "code end" lead 195 of the code ringing circuit by way of conductor 78, front contact and fourth lower armature of relay 71, and the front contact and third lower armature of relay 39. The purpose of relays 45 and 46 will be described presently.

Upon dialing the ringing code 9 which is assigned to the called station E, relay 39 is operated as was previously described and two groups of three ground pulses (see code table) are sent out over lead 125 (connected in this case to the ninth ringing code terminal of the selector bank) from the lead 9 (small numeral) of the ringing code circuit. These ground pulses cause the relay 41 to operate in a manner previously described to connect the 20-cycle current source 106 to the leads 123 and 129 of the link circuit in a manner indicative of the code being transmitted. As relay 41 operates to follow the ringing code, the circuit to relay 20 is broken and relay 20 releases while ringing current is connected to the line. Relay 26 does not release, however, as it is held operated by ground from the front contact and upper third armature of relay 71 through the front contact and lower outermost armature of

relay 39. The lead 128 is connected to the tip conductor of the line A by way of the front contacts and outer upper armatures of relays 9 and 11, whereas the lead 129 is connected to the ring conductor of the line A by way of the front contact and third lower armature of relay 9 and the front contact and second lower armature of relay 11. The subscribers' bells at the stations on line A are sounded accordingly and the subscriber at station E, recognizing the code as her own, answers the call.

In the description of the code ringing circuit shown in Fig. 5 it was shown that after each code was transmitted, relay 211 operated to connect ground to "code end" lead 195. This ground as above mentioned is connected to the counting relays 45 and 46 due to the operation of relays 71 and 39. This ground causes relay 45 to operate in a circuit including its normal make-before-break contacts and resistance 80. The winding of relay 46, however, is shunted due to the connection of the grounded lead 78 to a point between the relay winding and resistance 81 by way of back contact and inner armature of relay 43. Relay 45 accordingly operates and relay 46 remains released. The relay 45 locks in a circuit extending from grounded battery, resistance 80, winding of relay 45, front contact and right-hand armature of relay 45, conductors 81 and 35, back contact and outermost lower armature of relay 23, conductor 18 to ground at the right innermost armature and front contact of relay 16. In attracting its left-hand armature relay 45 prevents the operation of relay 23 upon the operation of relay 46.

When relay 211 in the code ringing circuit releases after the first transmission of the code, ground is removed from the lead 195 and therefore from lead 78, thus removing the shunt from relay 46 so that this relay now operates in a circuit extending from grounded battery, resistance 81, winding of relay 46, front contact and right-hand armature of relay 45 to ground by way of the locking circuit for relay 45 just traced. Relays 45 and 46 accordingly are now operated in parallel.

The code ringing circuit continues to function to repeat the signal to the called station and at the end of the repeated signal, relay 211 again operates to again place ground potential on lead 195 and accordingly, on lead 78 whereupon relay 45 is shunted by virtue of the fact that relay 46, by way of its inner armature and front contact connects the grounded lead 78 to a point between the winding of relay 45 and resistance 80. Relay 45 releases and upon its release, with relay 45 still operated, a circuit is established extending from grounded battery, upper winding of relay 23, conductors 82 and 83, left-hand armature and back contact of relay 45 to ground by way of the front contact and outer armature of relay 46.

Relay 23 operated, opens the locking circuits for relays 45, 39 and 71 causing these relays to release. Relay 39, released, opens the circuit to relay 41 to prevent any further transmission of the ringing code whereas relay 71, released, breaks the connection to the calling supervisory relay 29, which relay releases due to the fact that the tip and ring leads 24 and 25 are open at the upper and second lower armatures of relay 11.

Relay 29 released, opens the circuit to relay 26, which relay releases and causes relay 16 to release. Relay 16, released, opens the locking circuit to relay 23 causing this relay to release and removes ground from the "hold" lead 13 which

causes line relay 9, which was held operated by ground on the lead 18 to release. The contact arrangement of relay 9 is such that the contacts X and Y close before contact Z opens when the relay releases so that the locking circuit for relay 11 which includes the sixth armature and contact Z is maintained closed for an interval of time after the contacts X and Y are opened. The relay 11 is accordingly held operated until a circuit for its operation over the closed line loop is established by the release of relay 9. This circuit extends from grounded battery, upper winding of relay 11, conductor 3, back contacts and outer upper armatures of relays 4, 8 and 9, front contact and upper armature of relay 11, closed line loop, second lower armature and front contact of relay 11, third lower armatures and back contacts of relays 9, 8 and 4, conductors 22 and 71 to ground by way of the lower winding of relay 11. The release of relay 9 frees the link circuit L and the subscribers at stations D and E converse over the line A to which nothing but the windings of relay 11 and the associated battery are connected, as just described.

It will be noted that when all links are busy as evidenced by the operation of relay 16 of link L, relay 16' of link L', relay 16'' of link 3 and relay 16''' of link L''', relay 212 of the "all links busy" circuit operates in a circuit extending from grounded battery, winding of relay 212, back contact and armature of relay 212, conductor 213, front contacts and outermost right-hand armatures of relays 16, 16', 16'' and 16'''. Relay 212 operates in this circuit as a buzzer to place an inductive kick on lead 214 which is connected to the tip conductors of all the line circuits by way of the back contacts and inner upper armatures of the line relays, such as relays 4, 8, and 9 of the line A and of corresponding relays of lines B and C to indicate to a calling subscriber that no links are available.

If the time interval between the connection of a link to a line and the answer of the called subscriber, or the completion of a reverte call, or the time interval between the hanging up of the called party and the calling party is greater than a predetermined interval, the link circuit functions similar to a reverte call so as to free the link and hold the calling line on its associated relay, such as relay 11 or relay 109. The operation is initiated by the operation of the timing relay 17 which may be of the well-known dash-pot type. This relay is operated from ground on the normal contact of the answering supervisory relay 44, the normal contact and second right-hand armature of relay 16 through the winding of relay 17 to grounded battery. Relay 17 operated, connects ground through its right-hand inner armature and front contact to the lower winding of relay 39 which relay operates and locks as previously described. Ground is also connected to the upper winding of relay 71 through the left-hand armature and front contact of relay 17. Relay 71 also operates and locks as previously described. With relays 39 and 71 operated, the link functions as on a reverte call to count two repetitions of the ringing code. Relay 41 is, however, not operated. At the end of the second repetition, if the calling subscriber has not, in the meantime, hung up, the link functions as previously described for a reverte call. An alarm 405 is actuated when relay 17 operates on a non-reverte call.

When the calling party on a non-reverte call hangs up first the link releases as previously de-

scribed for a normal call. However, when the line relay associated with the called line (such as line 3) is released and the windings of relay 109 are thereby connected to the loop, relay 109 is held operated until the called subscriber on line B hangs up and thereby prevents a link from being seized as for a new call.

What is claimed is:

1. In a telephone system, subscribers' line circuits, a link circuit, a selector switch individual to said link circuit and having a terminal for each of said line circuits, and means comprising a relay for each of said line circuits responsive to the actuation of the switchhook on one of said line circuits for extending said one of said line circuits to said link circuit, said relay operating also upon the actuation of said selector switch to the terminal individual to the said one of said line circuits in response to the initiation of a call on another of said line circuits to cause the connection of said link circuit to the said one of said line circuits.

2. In a telephone system, a subscriber's line circuit, a source of current normally connected to said line circuit, a link circuit, a source of current normally connected to said link circuit, a line relay energized by current from said first source in a circuit including said subscriber's line circuit when the subscriber thereon initiates a call, and contact means controlled by said relay when operated in response to the initiation of a call, for transferring said line circuit from said first source of current to the source of current associated with said link circuit and for establishing a locking circuit for said line relay independent of said line circuit.

3. In a telephone system, a line circuit, a plurality of stations on said line circuit, a dialing mechanism at each of said stations, a link circuit having calling and answering ends, a selector switch individual to said link circuit, means for controlling said selector in response to the actuation of the dialing mechanism at one of said stations, said means being normally connected to the calling end of said link circuit and means controlled by said selector when actuated by said dialing mechanism in accordance with a prearranged code for transferring said selector controlling means from the calling end of said link circuit to the answering end thereof whereby any further actuation of the dialing mechanism after the transfer causes the operation of said selector controlling means by way of the answering end of said link circuit.

4. In a telephone system, line circuits, a calling station and a called station on one of said line circuits, a dialing device at said calling station, a link circuit for extending connections between said line circuits and having calling and answering ends, a selector switch, selector control means normally connected to the calling end of said link circuit, means responsive to the initiation of a call at said calling station for connecting said one of said line circuits to the calling end of said link circuit, means responsive to the actuation of the dialing mechanism at said calling station in accordance with a prearranged code for transferring said selector control means from the calling end of said link circuit to the answering end thereof and for connecting said one of said line circuits to the answering end of the link circuit, signal means at said called station, a source of signaling current and means responsive to further actuation of said dialing mechanism subsequent to the transfer of said selector

control means for connecting said source of signaling current to said one of said line circuits to cause the operation of said signal means.

5. In a telephone system, line circuits, a pair of relays for each of said line circuits, a link circuit having calling and answering ends, means responsive to the initiation of a call on one of said line circuits for causing the operation of one of the associated pair of relays to cause the connection of the line circuit to the calling end of the link circuit and means responsive to a call incoming to one of said line circuits for causing the conjoint operation of the associated pair of relays to cause the connection of the line circuit to the answering end of said link circuit.

6. In a telephone system, a line circuit, a subscriber's station on said line circuit, a link circuit having a calling end and an answering end, means comprising a relay normally connected to said line circuit and responsive to the removal of the receiver at said station for connecting said line circuit to the calling end of said link circuit and means also comprising said relay and responsive to a call incoming to said line circuit for connecting said line circuit to the answering end of said link circuit.

7. In a telephone system, a calling line, a called line, a link circuit having calling and answering ends, a line relay for each of said lines, a second relay for each of said lines, a selector switch individual to said link circuit, means responsive to the initiation of a call on said calling line for operating the line relay associated therewith to cause the calling line to be connected to the calling end of said link circuit and subscriber controlled means on said calling line for actuating said selector switch to cause the conjoint operation of the line relay and the second relay associated with said called line whereupon said called line is connected to the answering end of said link circuit.

8. In a telephone system, a line circuit, a dial station on said line circuit, a link circuit, a selector switch individual to said link circuit, means responsive to the removal of the receiver at said station for connecting said line circuit to said link circuit, a stepping magnet for said selector, a control circuit for said magnet, a pulsing relay responsive to the operation of the dial at said dial station for repeatedly opening and closing the control circuit to said magnet and a relay chain interposed between said pulsing relay and said magnet for causing said magnet to step once for each combined open and closure of said control circuit.

9. In a telephone system, a subscriber's line circuit, a dial station on said line circuit, a link circuit, a selector switch individual to said link circuit, means responsive to the removal of the receiver at said station for connecting said line circuit to said link circuit, a stepping magnet for said selector, a control circuit for said magnet, a pulsing relay responsive to the operation of the dial at said dial station for repeatedly opening and closing the control circuit to said magnet, a relay included in said control circuit adapted to step said magnet in both its operate and release positions and means cooperating with said relay and included in said control circuit for causing said relay to step said magnet only when said control circuit is opened and to hold the magnet operated during the closed period of said control circuit.

10. In a telephone system, a calling line, a called line, a link circuit having calling and an-

swering ends, a supervisory relay associated with the answering end of said link circuit, means responsive to the initiation of a call on said calling line for connecting the calling end of said link circuit to the calling line and the answering end to the called line whereby said supervisory relay is connected across the called line to be operated upon the response of a subscriber on the called line, and means controlled by said supervisory relay and operating a predetermined interval of time after the connection of the supervisory relay to the called line and before the response of a subscriber thereon for effecting the release of said link circuit from the called and calling lines.

11. In a telephone system, line circuits, a calling and a called station on one of said line circuits, a dialing device at said calling station, a link circuit for extending connections between said line circuits and having calling and answering ends, a selector switch, selector control means normally connected to the calling end of said link circuit, means responsive to the initiation of a

call at said calling station for connecting said one of said line circuits to the calling end of said link circuit, means responsive to the actuation of the dialing mechanism at said calling station in accordance with a prearranged code for transferring said selector control means from the calling end of said link circuit to the answering end thereof and for connecting said one of said line circuits to the answering end of the link circuit, a code ringing circuit, means responsive to a further operation of said dialing mechanism subsequent to the transfer of said selector control means for connecting said code ringing circuit to said link circuit whereupon said code ringing circuit functions to transmit a definite ringing code over the answering end of the link circuit, means for causing the code ringing circuit to repeat the ringing code, and means controlled by the code ringing circuit and automatically effective after a repetition of the ringing code for releasing the link circuit.

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