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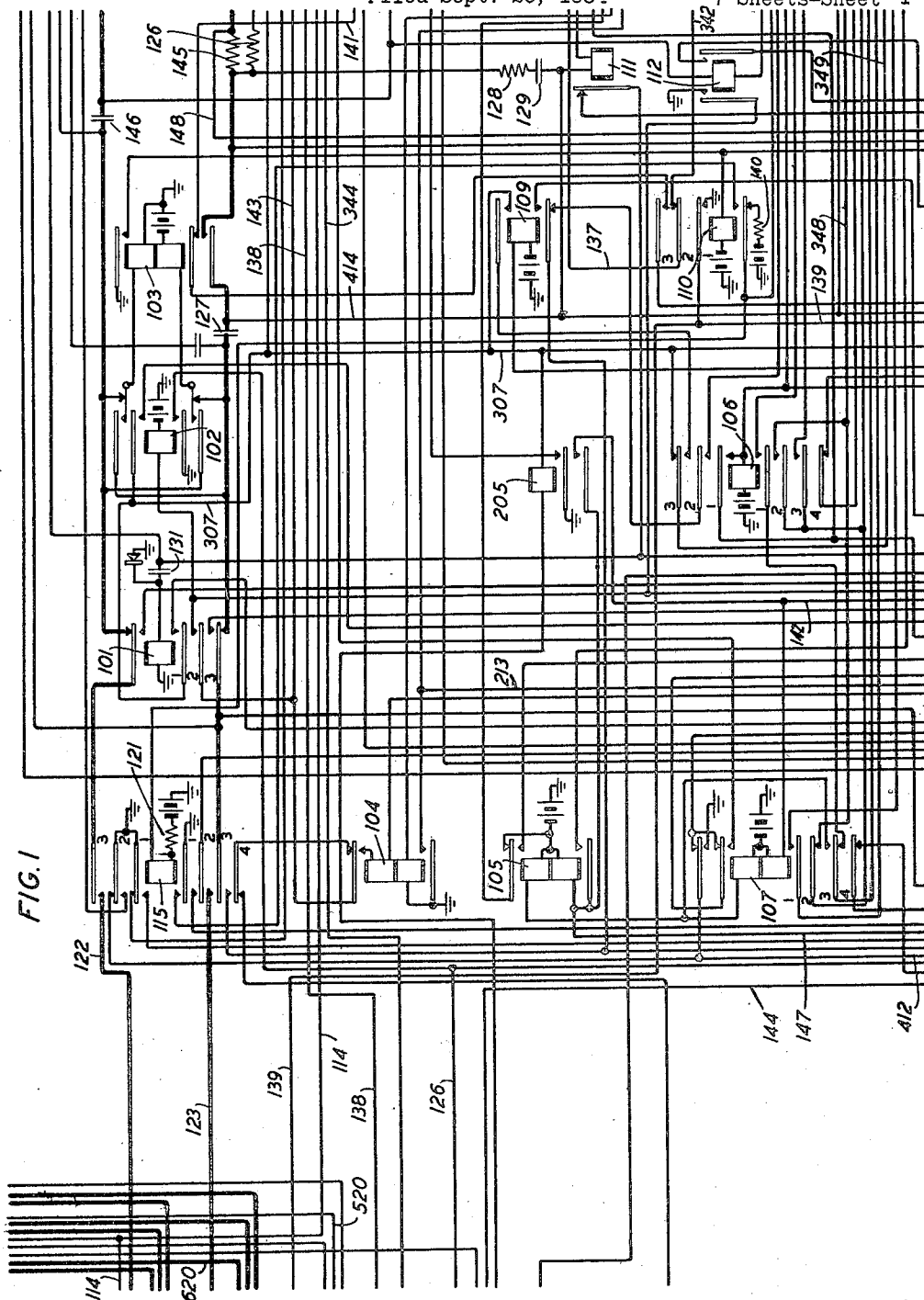
E. P. G. WRIGHT ET AL

2,025,408

TELEPHONE SYSTEM

Filed Sept. 26, 1934

7 Sheets-Sheet 1



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7 Sheets-Sheet 2

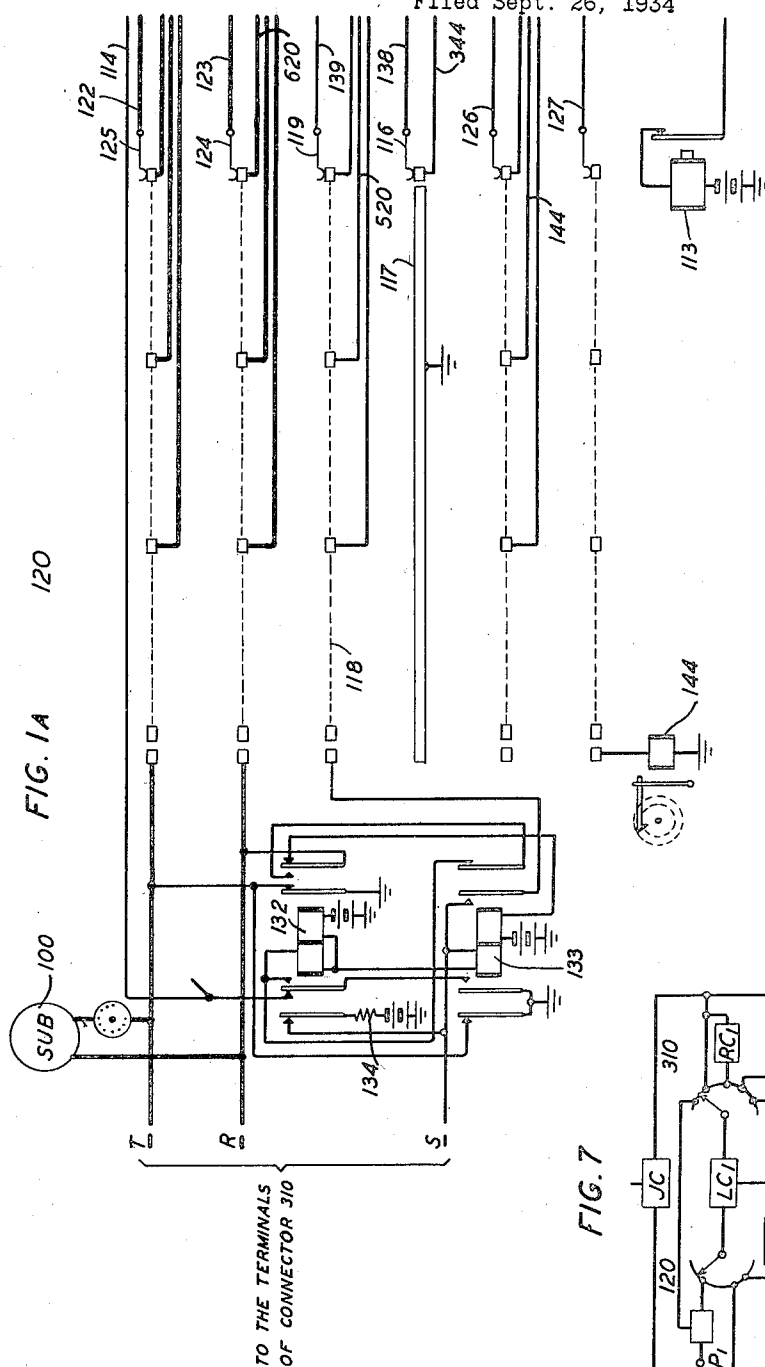
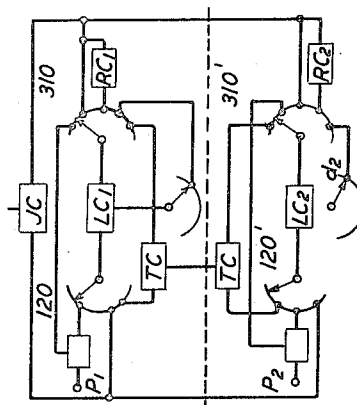


FIG. 1B

FIG. 5	FIG. 6
FIG. 1A	FIG. 1
FIG. 2	FIG. 4

FIG. 7



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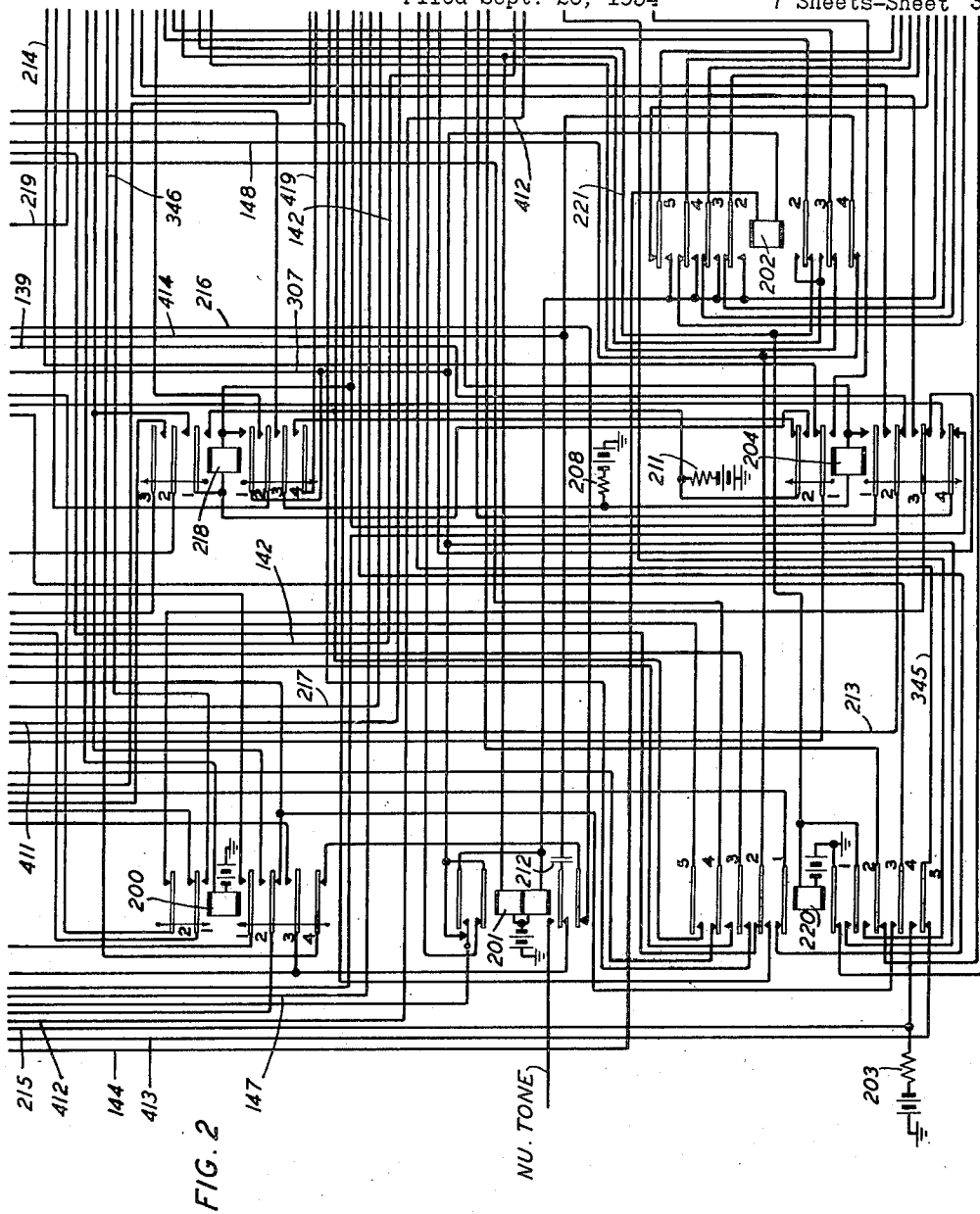
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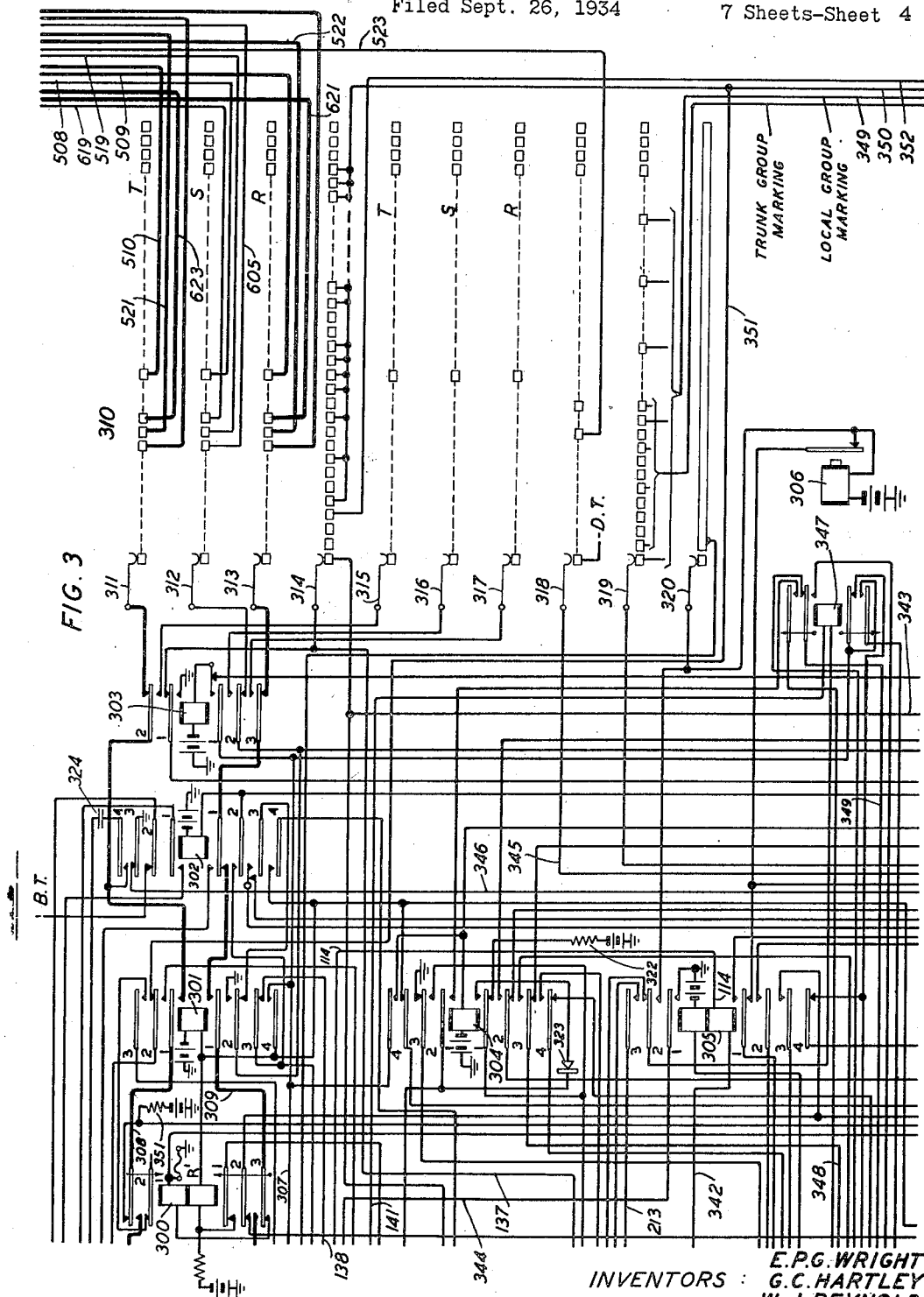
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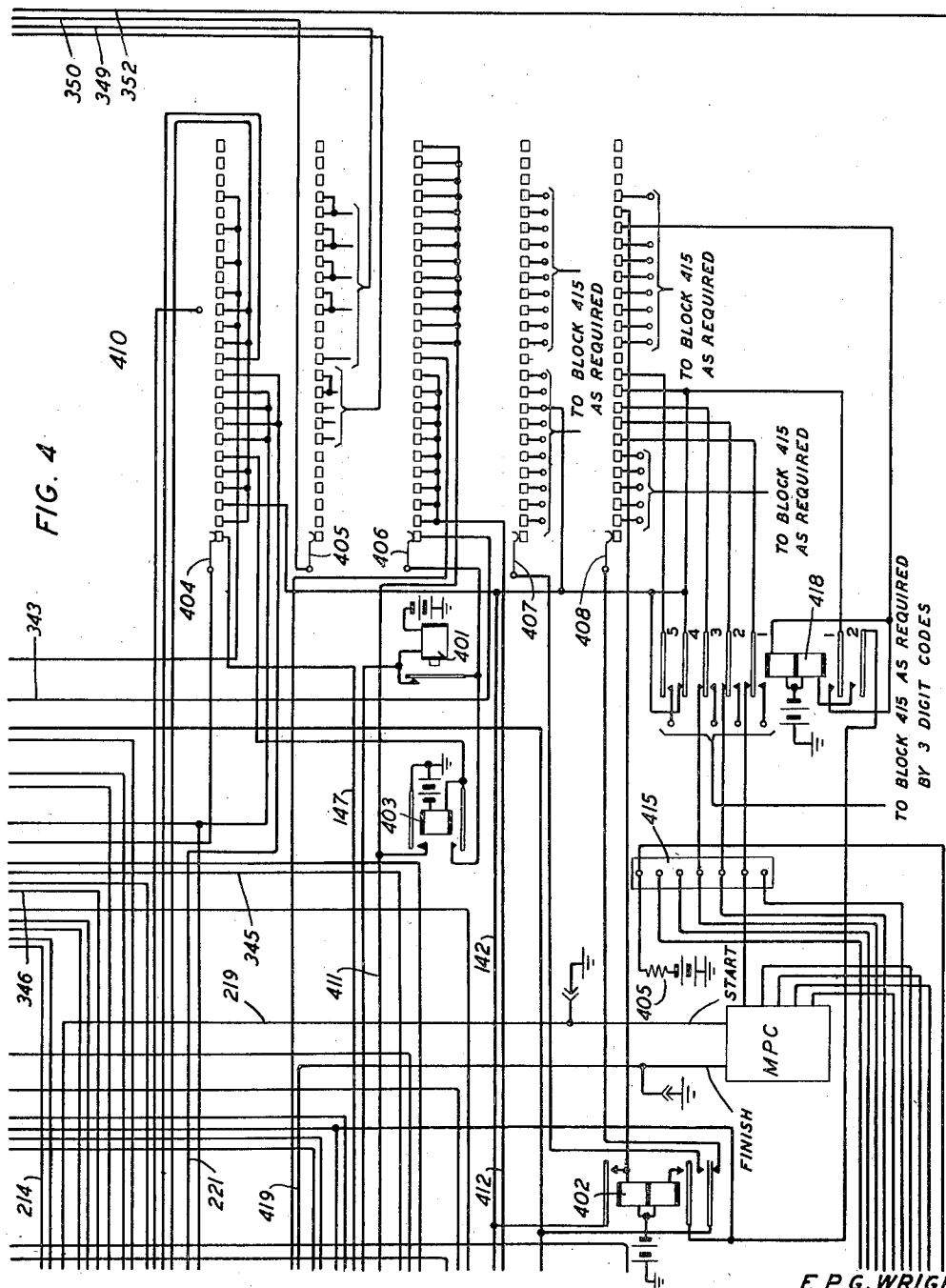
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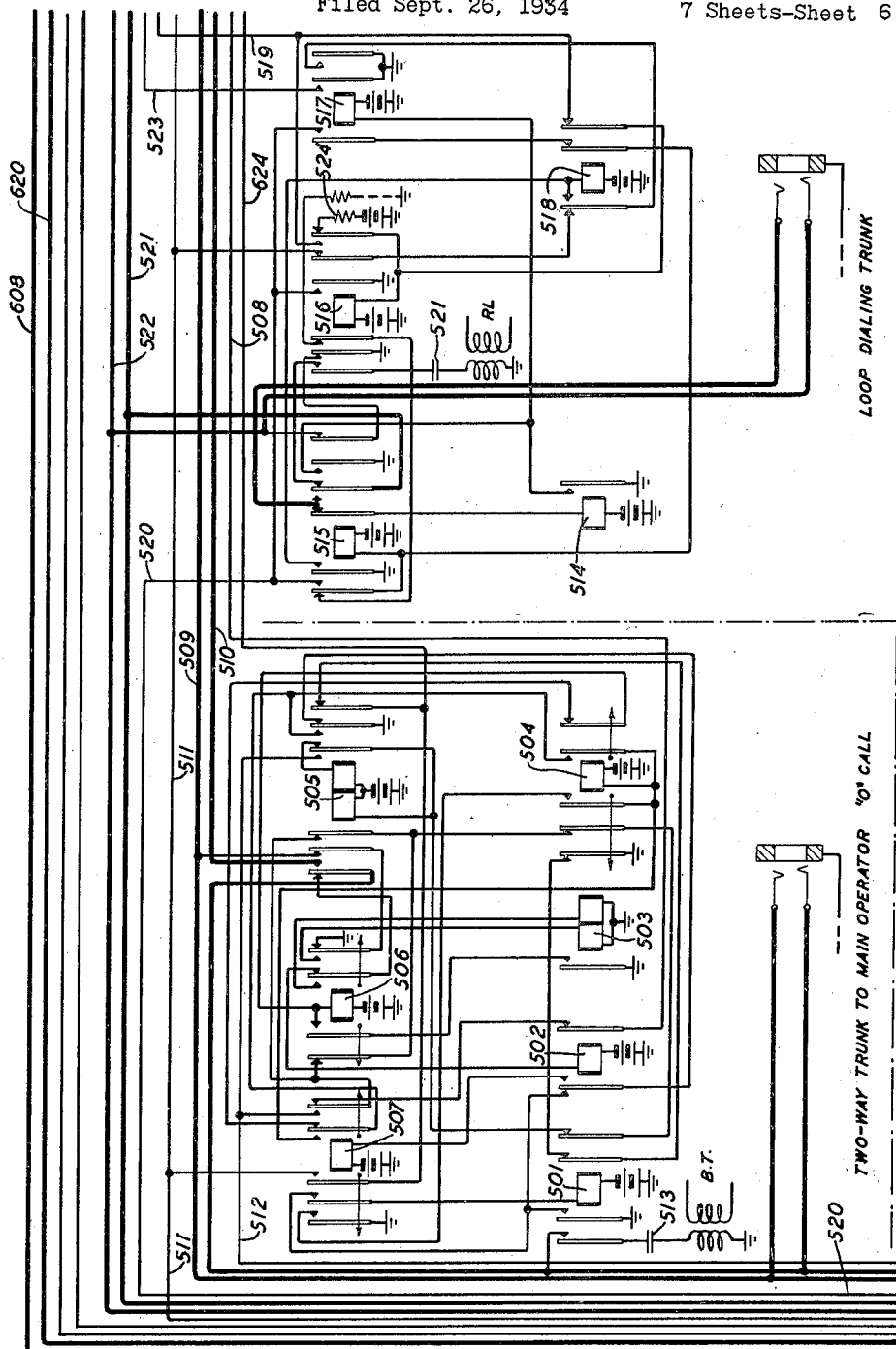
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FIG. 5



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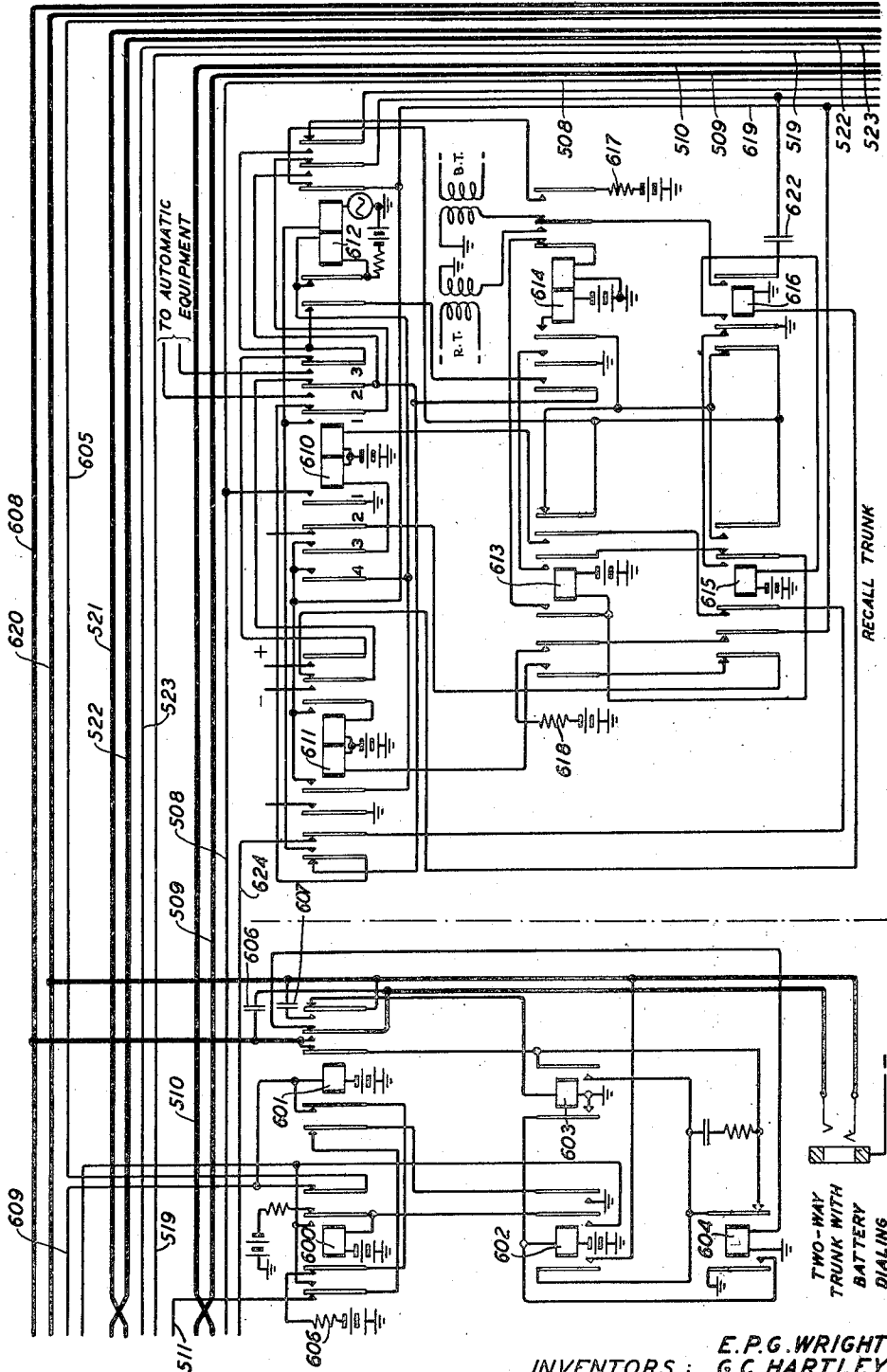
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FIG. 6



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UNITED STATES PATENT OFFICE

2,025,408

TELEPHONE SYSTEM

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Application September 26, 1934, Serial No. 745,490
In Great Britain October 6, 1933

12 Claims. (Cl. 179—18)

This invention relates to automatic or semi-automatic telephone exchange systems and more particularly, although not exclusively, to small exchanges for use in rural areas.

One object of the invention is to supply alternative trunking facilities without the use of registering mechanisms.

It is desirable to avoid the use of a plurality of registering mechanisms on rural boards and therefore it is proposed to reach an adjacent board on an alternate trunking basis by the use of a link circuit which, in response to the first digit of a two-digit number designating said adjacent board, selects a tie-line to the said board and absorbs the second digit. If, on the other hand, no tie-line is available, the link, in response to the first digit, selects a trunk to the main office where the connection to the required board is then made in response to the second digit.

Another object of the invention is to allow coin-box subscribers to have speech connection with a number of other exchanges by dialing a single digit and without payment. Some well known coin-box lines do not allow speech without payment unless the single digit 0 is dialed. With a known design of rural board, the operator can only be reached by dialing two digits, such as 01, and consequently arrangements have been made to modify the coin box. According to the present invention, the operator is reached by dialing the single digit 0 and therefore the standard coin box will be used. Difficulty arises in cases where access is obtained to other manual exchanges by dialing other single digits because it is necessary for money to be inserted before speech can commence with the operator who does not guarantee the required connection. We propose to arrange the switching mechanism so that manual exchanges may be obtained by dialing a high digit initially, whereas automatic connections are only completed with an initial digit below 7, in which case it is necessary to insert coins.

A further object of the invention is to provide access over a trunk either direct to a manual board or direct to automatic equipment. The exchange equipment is, therefore, arranged so that, by dialing different digits or combinations of digits, the same trunk or trunk group is seized and thereafter a discriminating signal is sent over the trunk to extend the connection either to the manual board or to the automatic equipment.

Another object of the invention is to provide

recall facilities for a subscriber who finds a wanted connection unavailable. The particular arrangement proposed is that recall facilities are provided for trunk calls to a manual board. When this facility is required on a trunk giving access either to a manual board or to automatic equipment, the link is arranged to discriminate between the two types of calls and on the dialing of a "recall" digit to give recall facilities on calls to the manual board only if a trunk extending thereto is not available at the time. The subscriber is then rung when a trunk becomes free, the trunk is seized and the operator is signaled.

Another object of the invention is to provide facilities for extending connections to areas designated by different numbering systems, as, for instance, a connection between a three digit local board and a four-digit main exchange area. In such a case, the rural subscribers are given four digit numbers, the link absorbing the first digit in setting up a local connection and using it in setting up an interoffice connection.

Yet another object of the invention relates to multi-metering. The link, which is the subject of this invention, may be arranged either for multi-metering or single metering. The multi-metering arrangement is such that tariff discrimination may take place in response not only to one digit but also in response to two, three and more digits, the equipment being capable of modification to discriminate after additional digits also if required.

Other objects of the invention relate to coin-box facilities. Excess fee calls from coin boxes may be connected to an operator at the main exchange or to N. U. tone without extra cost. An extra wiper on the finder switches is used for coin-box discrimination and for discrimination between other different types of incoming calls, and for calls between two similar rural boards, forming in effect one exchange, when the terminating board must be arranged to receive a digit less than usual. Coin-box discrimination can be also provided on tie lines.

Another object of the invention is to provide centralized testing facilities for testing equipment at one exchange from the centralized testing facilities. In the preferred embodiment, one trunk is provided for access and hold purposes and a second junction for testing subscribers' lines, these being connected to finder banks and to final selector wipers, respectively. The final selector may be stepped from line to line from the distant exchange.

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

Fig. 1A shows a subscriber's line and trunk circuits terminating on the banks of the line finder 120 which is a part of the link shown in Figs. 1 to 4, inclusive;

Figs. 1 to 4, arranged as shown in Fig. 1B, show the link circuit having a line finder 120, a line and trunk connector 310 and a registering mechanism 410;

Figs. 5 and 6 show the various trunks which may be used both outgoing from connector 310 and incoming to the finder 120 for connections outgoing from or incoming to the local office in which said link is located. While these trunks are typically representative of the possible kinds of extensions and are shown, for purposes of illustration, extending more or less indiscriminately from the banks of connector 310, it is obvious that, if desired, only one group of each may be used to the exclusion of the other for any particular digit or group of digits marking a trunk group; and

Fig. 7 shows, in diagrammatic form, the equipment of two associated one hundred line boards.

Referring first to Fig. 7, up to one hundred subscribers P1 and both way trunk and tie line circuits JC and TC can be connected to the banks of the finders 120 and connectors 310 of a group of link circuits LC1 having marker or pilot switches 410, and form a rural board. Two such boards, comprising links LC1 and LC2, respectively, may be connected together as shown by tie lines comprising both way circuits TC. A number of groups of junctions may be connected to the boards. The switches 310, 310' have access to recall circuits RC1, RC2 which are last choice in the group of outgoing trunks to a main exchange when seized to give access to an operator. By dialing a further digit when a recall circuit is seized, the link circuit and recall circuit are locked up, the calling party can restore so that, when a trunk becomes free, the calling party will be rung and the trunk seized.

A number of different types of call will now be described with reference to all the figures which show the detailed circuit arrangement.

Local call

When the local subscriber 100 initiates a call, line relay 133 operates over a circuit extending from battery through the right winding of said relay, right outer back contacts of cut-off relay 132, subscriber's loop to ground on the right inner contacts of relay 132. Relay 133 operates, connects battery potential through the left and right windings, respectively, of relays 132 and 133 and resistance 134 to the S conductor to guard against the seizure of the line, and connects ground through its left inner contacts and the left inner back contacts of relay 132 to the common start conductor 114. A circuit for relay 305 is thereby completed extending from ground on said conductor, lower winding of relay 305, conductor 342, No. 2 contacts of relay 110, conductor 137, brush 314 and first terminal of its bank in switch 310, conductor 343, terminal and brush 406 of register switch 410, interrupter contacts of switch magnet 401, winding of said magnet to battery. Relay 305 operates but magnet 401 does not and on operating closes a self-interrupting circuit for magnet 113 of line finder 120 extending from

ground on the upper No. 1 contacts of relay 305, conductor 344, normal contact and brush 116, conductor 138, lower No. 3 contact-set of relay 301, conductor 143, upper back contacts of relay 104, lower No. 4 back contacts of relay 115, interrupter contacts of magnet 113 to battery. The switch brushes are now driven in search of the calling line, the circuit for magnet 113 through brush 116 being completed to ground on bank 117 after the brush has advanced beyond the normal terminal.

The calling line is designated by the presence of battery through the right inner contacts and left winding of relay 133 and right winding of cut-off relay 132 on its representative terminal 15 on bank 118 so that when brush 119 engages said terminal, a circuit for relay 104 is completed extending from battery as traced to brush 119, conductor 139, lower No. 2 back contacts of relay 204, conductor 213, upper No. 3 contact-set of relay 203, lower winding of relay 104 to ground. Relay 132, however, does not operate in this circuit so that ground remains connected to the common start conductor 114. Relay 104, however, does operate, arrests the further movement of switch 120 by opening the circuit of magnet 113, extends the ground on its lower contacts to the terminal of the line engaged to brush 119 and further locks in a circuit extending from ground on bank 117, brush 116, conductor 138, lower No. 3 contact-set of relay 301, conductor 143, locking contacts of relay 104, upper winding of said relay, upper inner back contact of relay 204, conductor 214, lower No. 2 contact-set of relay 305, winding of relay 115, resistance 121 to battery, and at the bottom back contacts of relay 110, in parallel with resistance 140 to battery. Relay 115 operates in this locking circuit and switches the link line conductors 122 and 123 through to the link circuit. Relay 103 now operates over the extended line in a circuit which is traced from battery through its lower winding, lower normal contacts of relay 102, normal contacts of the No. 3 contact-set of relay 101, lower No. 3 contact-set of relay 115, conductor 123, brush 124 and line terminal, subscriber's loop, brush 125 and line terminal, conductor 122, upper No. 3 contact-set of relay 115, upper back contacts of relay 101, upper normal contacts of relay 102, upper winding of relay 103 to ground. Relay 103 operates and closes ground through its upper contacts to the winding of relay 110 which operates and opens the circuit of relay 305 which now releases. Relay 115, however, does not release as a result of the release of relay 305 but is held locked over the lower front contacts of relay 110 to ground through its own lower No. 1 contact-set. With the release of relay 305, relay 104 releases but the busy condition to brush 119 is now maintained by ground through the No. 1 contact-set of relay 110 directly to brush 119. A circuit is now also closed for relay 105 extending from battery through the lower winding of said relay, conductor 147, normal terminal and brush 404, lower No. 3 back contacts of relay 304, conductor 348, lower No. 2 contacts of relay 107, upper back contacts of relay 347, conductor 349, upper No. 3 back contacts of relay 106, conductor 307, upper normal contacts of relay 201, to ground on the upper No. 1 front contacts of relay 115. Relay 105 operates and closes a contact in the dial pulsing circuit as described hereinafter.

Dial tone is now transmitted to the subscriber over a path extending from the source of tone DT connected to the normal terminal of brush 75.

318 of connector 310, conductor 345, lower No. 5 back contacts of relay 226, conductor 413, lower No. 4 contacts of relay 107, lower inner back contacts of relay 201, condenser 212, conductor 414, condenser 127, through the line loop as already traced, to ground through the upper winding of relay 103. The subscriber now dials the required number. If a local connection is desired, the digit 2 is dialed whereupon relay 103 will respond to two interruptions of the dial. When relay 103 releases on the first impulse, a circuit is completed from ground on the upper No. 3 contact-set of relay 302, conductor 346, lower No. 4 back contacts of relay 202, lower outer contacts of relay 201, conductor 216, No. 3 contacts of relay 110, lower inner contacts of relay 103, conductor 141, winding of relay 347, upper No. 2 back contacts of relay 305, upper front contacts of relay 105, conductor 217, winding of register magnet 401 of register 410 to battery. The magnet operates and, when the line is again closed after the dial interruption, brushes 404 to 408, inclusive, of register 410 advance to the first terminal. Relay 347 also operates in the dialing circuit but, being slow to release, remains in its operated position during dial interruptions and closes a locking circuit for relay 105 over its lower contacts, lower outer contacts of relay 347, to ground on conductor 307 so that when the brushes of switch 410 are stepped off the first terminal relay 105 will not release.

At the end of the second dial interruption, magnet 401 advances the brushes to their respective second terminals and relay 347 releases whereupon relay 105 also releases. A circuit is now closed for relay 107 extending from battery through its lower winding, conductor 142, No. 2 terminal and brush 404, lower No. 3 back contacts of relay 304, conductor 348, lower No. 2 contacts of relay 107, upper inner back contacts of relay 347, conductor 349, upper No. 3 back contacts of relay 106, conductor 307, upper outer normal contacts of relay 201, to ground on the front contacts of the upper No. 1 contacts of relay 115. Relay 107 operates over its lower winding and locks through its upper winding, lower No. 3 front contacts, lower inner contacts of relay 347, conductor 307, and thence as traced to operating ground on the contacts of relay 115. Relay 105 is likewise provided with the same holding ground to its upper winding so that, when its locking circuit through the lower contacts of relay 347 is opened by the release of relay 347, relay 105 does not release.

With relay 107 operated, a self-interrupting circuit is established for register magnet 401 extending from battery through said magnet and interrupter contacts, brush 406 and the common terminals 1 to 10, inclusive, conductor 412, upper outer front contacts of relay 107 to ground. Register switch 410 is thus driven to the eleventh set of terminals where it awaits the dialing of the next digit of the called line. On the first impulse, relay 347 operates as before and completes a circuit for relay 106 extending from battery through the winding of said relay, lower No. 4 back contacts of relay 304, lower No. 1 contacts of relay 107, upper inner front contacts of relay 347, conductor 349, upper No. 3 back contacts of relay 106 to ground on conductor 307. Relay 106 operates and locks over a circuit path through its upper No. 1 contacts, lower No. 2 back contacts of relay 202, lower No. 4 front contacts of relay 115, upper back contacts of relay 104, conductor 143, lower No. 3 contacts of relay 301, con-

ductor 138, brush 118 to ground. The operation of relay 106 now closes a circuit for magnet 306 of connector 310 extending from battery through the winding of said magnet, interrupter contacts, lower No. 1 back contacts of relay 305, upper No. 2 contacts of relay 106, lower back contacts of relay 105, lower No. 4 front contacts of relay 115, upper back contacts of relay 104, and thence as traced to ground on commoned contact bank 117. Magnet 306, under the control of the back contact of relay 109, now drives brushes 311 to 320, inclusive, to the beginning of the required group of subscribers as more particularly described hereinafter.

Switch 310, the trunk and line connector, has two groups of switching wipers, namely, wipers 311-314 and 315-318 associated with a wiper switching relay 303. In the lower group of bank levels, subscribers' lines certain P. B. X. groups only are connected, while in the early part of the upper group, outgoing trunk and tie line groups are connected. A single marking bank, that associated with brush 319, is provided to which trunk group marking conductors and local subscriber group marking conductors are connected which extend to the bank associated with brush 405 of the register switch 410. Hence, when the second digit has been dialed and brush 405 of register 410 has been advanced to some terminal in the group of subscribers in which the called line is located, and the brushes of switch 310 have been advanced along the terminals of their corresponding banks until brush 319 connects with the local group terminal connected to the terminal on which brush 405 has been advanced, a circuit is completed for relay 109 which extends from battery through the winding of said relay, upper No. 2 contacts of relay 202, lower No. 3 back contacts of relay 204, brush 319 and group terminal included in the bracket line 349, terminal in the group to which brush 405 is connected, brush 405, conductor 350, upper No. 2 back contacts of relay 301 to ground on the upper No. 2 front contacts of relay 115. Relay 109 operates, opens the driving circuit of magnet 305 and arrests any further movement of switch 310. At the end of the digit, relay 347 releases and relay 305 is reoperated in a circuit extending from battery through its upper winding, lower No. 3 contacts of relay 106, upper inner back contacts of relay 347, conductor 349, upper No. 3 front contacts of relay 106, upper contacts of relay 109 to ground on conductor 307.

It will be observed that the winding of relay 303 is connected through its continuity contacts to the odd terminals, beginning with the thirteenth of the bank of terminals accessible to brush 404. Remembering that at the time the subscriber began dialing the second digit the brushes of switch 410 were resting on their respective eleventh terminals, it is plain that if the second digit is an even one, brush 404 will be resting on an odd terminal of the bank at the time the switch comes to rest so that at the time the circuit for relay 305 is closed, a parallel circuit to relay 303 is simultaneously completed through the lower No. 2 contacts of relay 106, conductor 348, lower No. 3 back contacts of relay 304, brush 404 and cooperating odd terminal, lower No. 1 normal contacts of relay 303, winding of said relay to battery. Relay 303 operates and switches over the wipers of connector 310 to the required outlets on the lower set of banks. On the other hand, if the digit dialed is odd, brush 404 will be resting on an even terminal 75

and the parallel branch of the circuit to the winding of relay 303 will not be closed, in which event the wipers connected to the normal contacts of relay 303 will be operative to extend the connection to a line on the upper set of banks.

The operation of relay 305 indicates that the second digit has been received. The third digit is now dialed, but instead of register magnet 401 responding to the dial impulses, trunk connector magnet 306 is operated on the impulses over a circuit extending from battery through the winding of magnet 306, upper No. 2 contacts of relay 305, winding of relay 347, conductor 141, back contacts of relay 103, upper No. 3 contacts of relay 110, conductor 216, lower outer back contacts of relay 201, lower No. 4 back contacts of relay 200, conductor 346, to ground on the upper No. 3 back contacts of relay 302. The brushes of switch 310 are now advanced on each pulse causing them to rest on the terminals of the wanted line at the end of the digit. When relay 347 operates on the first impulse, relays 107 and 105 release due to the fact that their locking circuit is opened on the lower back contacts of relay 347 and, when relay 347 releases at the end of the digit, a circuit is completed for relay 204 extending from battery, resistance 208, winding of relay 204, lower No. 2 contacts of relay 300, lower No. 3 contacts of relay 305, lower No. 1 contacts of relay 106, lower No. 3 back contacts of relay 107, lower inner contacts of relay 347, conductor 307 to ground. The operation of relay 204 completes a circuit for relay 218 extending from battery, resistance 211, the top No. 2 front contacts of relay 204, winding of relay 218, lower No. 3 contacts of relay 305, lower No. 1 contacts of relay 106, lower No. 4 back contacts of relay 107, lower inner contacts of relay 347, conductor 307 to ground. Both relays 204 and 218 lock over their lower No. 1 contacts to ground on conductor 307.

Now if the called line is an individual line, relay 109 will be held operated in a circuit over the upper No. 2 contacts of relay 200, lower No. 3 front contacts of relay 204, top inner back contacts of relay 303, brush 314, and terminal multiplied to conductor 350, conductor 351, upper No. 2 back contacts of relay 301, upper No. 2 front contacts of relay 115 to ground. This ground is multiplied on the bank accessible to brush 314 only for regular lines, last lines of private branch exchange groups and trunk groups. Due to the fact that there is a single marking bank (that accessible to brush 314) for group discrimination and hunting and that trunk groups and subscribers' lines occupy corresponding positions in the two banks of switch 310, it is necessary to segregate the private branch exchange groups in that portion of the bank not occupied by trunk groups. It will also be observed that relay 109 will always operate independently of the circuit above traced through brush 314 if relay 303 has operated; the circuit, in this case, being completed to ground on the top inner front contacts of relay 303. The reason for this is that all private branch exchange groups having numbers in the odd tens group are segregated on the lower set of banks.

With relay 204 operated, relay 104 is now used to test if the wanted line is free. If the line is free, then a circuit is completed from ground through the lower winding of relay 104, upper No. 3 contacts of relay 305, conductor 213, lower No. 2 front contacts of relay 204, lower No. 2 front contacts of relay 303, brush 316, respectively, of

switch 310 to battery through the cut-off relay in the called line circuit (not shown). Relay 104 now locks over ground through brush 116, conductor 138, lower No. 3 contacts of relay 301, conductor 143, upper front contacts and upper winding of relay 104, top No. 1 front contacts of relay 204, winding of relay 301 to battery, operating the latter relay which then locks over its lower No. 4 contacts to ground on conductor 307. Relay 104 further connects ground to brush 316 for operating the cut-off relay of the called line, this ground extending from the lower contacts of relay 104, conductor 213, lower No. 2 front contacts of relay 204, lower No. 2 front contacts of relay 303 to brush 316.

When relay 104 operates, the locking circuit of relay 106 is broken at its upper back contacts causing this relay to release which, in turn, opens the circuit of relay 305 which releases also. Further, since the ground multiplied to the terminals of the bank accessible to brush 314 is extended over the upper No. 2 back contacts of relay 301, then, when relay 301 operates this ground is disconnected from brush 314 whereupon relay 109 releases. When relay 301 operates, ground is connected to the battery side of the locking circuit of relay 104 through the lower No. 2 contacts of relay 301 causing said relay to release. But the line cut-off relay is now held directly from this ground since it extends to the lower No. 2 contacts of relay 303. The line is, therefore, held and the tip and ring conductors from the link are switched through to the called line over the upper and lower No. 1 contacts of relay 301.

The called subscriber's line will now be rung from the link over a ringing circuit extending from source of current R, upper winding of relay 300, lower No. 3 back contacts of relay 300, lower No. 1 contacts of relay 301, lower No. 1 back contacts of relay 302, lower No. 3 front contacts of relay 303, brush 317 and terminal, subscriber's loop (not shown), brush 315, top No. 2 front contacts of relay 303, top No. 1 front contacts of relay 301, top outer back contacts of relay 300, resistance 351 to battery and ground. When the subscriber answers, relay 300 will operate and break its lower No. 1 contacts whereupon relay 300 will then remain operated in parallel with relay 301 over its lower winding. The operation of relay 300 removes ringing from the line and switches the tip conductor 308 from resistance 351 to the winding of relay 112, the other side of which is connected to ground upper No. 2 back contacts of relay 304. It further switches the ring conductor 309 over its No. 3 bottom front contacts, conductor 148, upper No. 2 back contacts of relay 220, bottom outer front contacts of relay 103, winding of relay 111, conductor 414, lower No. 1 back contacts of relay 304, resistance 322, to battery. Both of these relays operate over the called subscriber's loop, the operation of relay 112 closing a circuit to relay 102 from ground through its left contacts, causing said relay to operate and reverse the calling loop at its top and bottom outer front contacts. On this type of call, however, this reversal has no effect since relay 103 remains operated on the reversed as well as the direct current flow.

If the calling line is equipped for metering, then when relay 112 operates, a ground impulse is transmitted from the metering impulse circuit MPC along conductor 219, right contacts of relay 212, lower No. 3 contacts of relay 218 to resistance 208 and effects a short circuit of the winding of relay 204 and causes said relay to re-

lease. If the link is equipped to provide for multi-metering, then when relay 204 is released, metering impulses will be transmitted to the subscriber's meter as more particularly described hereinafter. If, however, the link is to be arranged for single metering only, solid ground is connected to the right contacts of relay 112 and causes the short circuit and release of relay 204 as already described. Under such circumstances, the metering impulse circuit MPC is not provided and permanent ground is connected to conductor 419 whereupon, after the release of relay 204, relay 218 is short-circuited through lower No. 4 contacts of relay 218, top No. 2 back contacts of relay 204, resistance 211 to battery, causing said relay to release. Relay 218 is, however, of the slow release type and, during the time it is still operated, a circuit is completed extending from ground through the winding of the calling subscriber's meter 144, brush 127, upper No. 3 contacts of relay 218, lower No. 2 contacts of relay 115, lower No. 4 back contacts of relay 204, lower No. 2 back contacts of relay 304, lower No. 3 back contacts of relay 220, resistance 405, to battery. In link circuits equipped for single metering, as for the case now temporarily assumed, resistance 405 is multiplied to terminals 12 to 21, inclusive, on the bank accessible to brush 408 of register switch 410 corresponding to lines that are to be metered. In a link circuit equipped for multi-metering, the meter pulse will be received from the meter circuit MPC to be described later.

At the termination of the conversation the calling subscriber restores and opens the circuit of relay 103 which releases and opens the circuit of relay 110. Relay 110 releases cut-off relay 132, unlocks relay 115 which in releasing disconnects ground from the holding conductor 307 whereupon all relays locked thereto are restored to normal. A self-driving circuit is now completed for finder magnet 113 extending from battery through its winding and interrupter contacts, lower No. 4 back contacts of relay 115, top back contacts of relay 104, conductor 143, lower No. 3 contacts of relay 301, conductor 138, brush 116, bank 117 to ground. The finder switch brushes are thereby restored to their normal terminal where the driving circuit is broken.

When relay 115 releases, a driving circuit for register magnet 401 is also completed, extending from battery through its winding and interrupter contacts, brush 406 and connecting terminals, conductor 411, top inner and outer back contacts of relay 107, to ground on the upper No. 2 back contacts of relay 115. Inasmuch as all the terminals beyond the eleventh and accessible to brush 406 are commoned to conductor 411 the switch magnet will drive the switch brushes until their respective normal terminals are reached.

Call to a private branch exchange subscriber

If the call is to a private branch exchange subscriber, connector 310 is positioned on the required line in the manner already described. None of the outlets of private branch exchange groups on the bank accessible to brush 312 is connected to ground except the last line of each of the groups so that when relay 204 operates (on the first pulse of the third digit), relay 109 releases since no ground is available on brush 312 at the time the brush advances to the first line of a private branch exchange group. Relay 104 now tests the called line as before. Should the line be busy and relay 104, therefore, should

fail to operate then, inasmuch as relay 305 is re-operated after the second digit and relay 218 on the first pulse of the third digit, a self-interrupting circuit for magnet 306 is provided extending from battery through the winding of magnet 306, interrupter contacts of said magnet, lower No. 2 contacts of relay 218, lower No. 1 contacts of relay 305, upper No. 2 contacts of relay 106, lower back contacts of relay 109, lower No. 4 front contacts of relay 115, back contacts of relay 104, conductor 143, lower No. 3 contacts of relay 301, conductor 138, brush 116 to ground. The switch magnet, therefore, will continue to advance its brushes under the control of relays 109 and 104. When it reaches the terminals of a free line, relay 104 will operate as already described. If no free line in the group is available, the switch brushes are advanced to the last outlet of the group which is connected to ground over the terminal accessible to brush 312 and relay 109 is operated over its holding circuit in the case of an individual line, as already described. If the last line is free, the test circuit for relay 104 is completed causing said relay to operate as described and hold the line for future operations. If the last line is busy, relay 109 operates, relay 104 remains normal and a circuit is completed for relay 200 extending from battery through the winding of said relay, lower No. 3 normal contacts of relay 302, upper No. 2 contacts of relay 218, lower front contacts of relay 109, lower No. 4 front contacts of relay 115, back contacts of relay 104, conductor 143, lower No. 3 back contacts of relay 301, conductor 138, brush 116 to ground. Relay 200 is made slow to operate so that if relay 104 should come up in the meanwhile, relay 200 will not operate. Busy tone is now connected to the calling line from source of tone BT, upper No. 2 contacts of relay 302, lower No. 3 contacts of relay 200, lower inner back contacts of relay 201, condenser 212, conductor 414, condenser 127, over the calling loop as previously traced to ground through the upper winding of relay 103.

Disconnection now takes place as previously described when the calling line restores.

In the above description of a call to a P. B. X. subscriber, it has been assumed that the lines of the P. B. X. group are located in the top half of the terminal banks of connector 310 and that the sleeve conductor of each of the lines is accessible to brush 312. However, the P. B. X. group may be located in the bottom half of the terminal banks of connector 310, in which event the second digit of the P. B. X. group would be such as to cause brush 404 of register 410 to be positioned on an odd terminal whereupon relay 303 will be operated and the P. B. X. group would be reached by brushes 315, 316 and 317; brush 317 contacting with the sleeve conductor of the lines in the group.

Calls to main-automatic exchange

The trunks to the manual exchange are used for extending calls to a manual board and to any automatic train which may be reached by way of the manual exchange. If a call to an operator is desired, the digit 0 is dialed; if the automatic equipment is required the digit 9 is dialed. In either case the link is seized by the calling line in the manner described for a local call. The register switch 410 responds to the first digit and its brushes are driven to the set of terminals corresponding to said digit, indicating thereby the trunk group required. If the digit 0 is dialed for a call to the operator then, when relay 347 re-

leases at the end of the digit, relay 220 operates over a circuit extending from battery through the winding of said relay, conductor 221, strapped to terminal 0 in the bank accessible to brush 404, brush 404, lower No. 3 back contacts of relay 304, conductor 348, lower No. 2 contacts of relay 107, (relay 107 not having operated since brush 404 did not stop on the second terminal) top inner back contacts of relay 347, conductor 349, top No. 3 back contacts of relay 106, to ground on conductor 307. Relay 220, on operating, locks to ground on conductor 307 through its lower No. 2 front contacts.

A circuit is now closed for relay 106 extending from battery through its windings, lower No. 4 contacts of relay 220, lower No. 2 back contact of relay 200, lower No. 4 front contacts of relay 115, top back contact of relay 104, conductor 143, lower No. 3 back contacts of relay 301, conductor 138, brush 116, to ground. The operation of relay 106 now causes a driving circuit to be closed for the trunk connector magnet 306 extending from battery through its winding, interrupter contacts, lower No. 1 back contact of relay 305, top No. 2 front contact of relay 106, lower back contact of relay 109, lower No. 4 front contact of relay 115, and thence as previously traced to brush 116 and ground. The brushes of switch 310 are now driven to the beginning of the required groups of trunks under the control of relay 109 over the terminal bank accessible to brush 319 and thence as cross-connected to the particular junction terminal in the terminal bank accessible to brush 405. When the first terminal of the trunk group is reached by brush 319 and relay 109 operated as previously described, a circuit is completed for relay 305 extending from battery through its upper winding, lower No. 3 contact of relay 106, top inner back contact of relay 347, conductor 349, upper No. 3 front contact of relay 106, top contact of relay 109 to ground on conductor 307. The previously described circuits for relays 204 and 218 are now completed causing these relays to operate, while a testing circuit is provided for relay 104 extending in part from ground through the lower winding of said relay, upper No. 3 contact of relay 305, conductor 213, lower No. 2 front contact of relay 204, lower No. 2 back contact of relay 303 to brush 312 and terminal.

When the brushes of switch 310 reach a free trunk, relay 104 operates in a circuit completed over brush 312, sleeve conductor 508, right contacts of relay 502, right outer back contacts of relay 507, left outer contacts of relay 506, left middle contacts of relay 504, right outer contacts of relay 501, both windings of relay 505 (the right winding extending through the right inner back contacts of relay 505) to battery. It will be observed, however, that the driving circuit of magnet 306 is controlled through the bottom back contact of relay 109 while the holding circuit of relay 109 (after the operation of relay 204) in turn depends on the presence of ground on the terminals of the bank accessible through brush 314. However, the trunk groups on this bank are so wired that no ground is connected to the terminals of the trunk groups except for the last trunk in each of the groups which are then multiplied together through a conductor connected to ground through the No. 3 upper contacts of relay 302. Therefore, the trunk connector will continue to drive the brushes over the terminals of the bank so long as relay 109 does not operate and so long as relay 104 is also down as a result of not finding an idle trunk. Switch 310 there-

fore will continue to drive over the trunk group as described for private branch exchange groups and, if a free trunk is found, relay 104 will operate and open the circuit of magnet 306. If all the trunks in the group are busy, magnet 306 will continue to operate and drive the brushes to the last trunk of the group where relays 109 and 200 operate as before and furnish the subscriber with the busy signal.

If a trunk is found, relay 505 operates in the above described circuit, disconnects relay 502 at its left outer and middle back contacts from conductors 509 and 510 extending to the banks of line finder 120 for inward calls and operates relay 506 in a circuit which extends from battery through its winding, right outer contacts of relay 504, right inner back contacts of relay 507 to ground on the right middle front contacts of relay 505. Relay 506 operates and removes the high resistance relay 503 from the line.

In this type of a call, however, and since the top No. 1 contacts of relay 220 are open, the ground connection from conductor 307 through lower No. 4 contacts of relay 301 to the battery side of the lower winding of relay 300 is missing at the time said ground is applied to the winding of relay 301. Relay 300, therefore, will operate in parallel with 301 and no ringing is applied over the called trunk. With relay 220 operated, a trunk is seized with relay 111 connected to the ring and relay 312 to the tip thereof through a signaling loop (not shown) in the trunk at the main exchange and this condition causes the distant end of the trunk to switch direct to an operator in any suitable manner.

When the call is released, the link circuit removes ground from conductor 508 and relay 505 releases, whereupon relay 504 releases. During the slow release of relay 506, the high resistance relay 503 is applied to the tip and ring conductors 509 and 510, respectively. If there is battery in either conductor due to a busy flash, relay 503 will operate and hold relay 506 over ground on its left contacts, thereby maintaining the busy condition for the trunk. When relay 503 releases, relay 506 will release, causing the trunk to test free. Thus the trunk is held busy at the incoming end until it is free at the distant end.

If the call originates from a coin box subscriber a circuit is closed for relay 202 extending from battery through resistance 203, conductor 215, terminal and brush 126, conductor 144, winding of relay 202, to ground on conductor 307. (Relay 202 would also come up on a local call from a coin box subscriber, but without effect as described hereinafter.) With relays 220 and 202 operated, with the consequent opening of the upper No. 2 back contacts of the former and the lower No. 4 back contacts of the latter, the battery extended through to the ring side of the 60 line is now through resistance 322, and since resistance 322 is high, it imposes a marginal condition at the terminating end of the trunk which is used to cause the distant end of the trunk to give a discriminating coin box signal (not shown) either by flash or by lighting a coin box calling lamp in any suitable manner.

When the operator replies, battery is connected to the tip side of the trunk and ground on the ring (not shown), that is, to conductors 510 and 509, respectively, whereupon a circuit is completed for relay 112 to ground on the upper No. 2 back contacts of relay 304, and relay 111 is operated to battery through resistance 322 on the lower No. 1 back contacts of relay 304 if, at this

time relay 202 is released as described below since, with resistance 145 in the ring side of the line, relay 111 cannot operate. The operation of the link circuit after relay 112 operates is, in this case, the same as described on a local call except that contact 10 on the terminal of the register switch 410 accessible to brush 403 is not connected to resistance 405, as in the single metering case, or to a meter pulse lead as in the multi-metering so that no battery potential is extended to the subscriber's meter during the releasing time of relay 103 as previously described. In general, metering is not required on 0 level calls.

With relay 112 operated, an obvious circuit is closed for relay 102 which, when operated, holds relay 110 operated over a circuit path from battery through the winding of relay 110, upper No. 4 front contact of relay 220, upper inner front contact of relay 102, to ground on conductor 307. Relay 102 also connects ground to resistance 203 via its lower inner contacts to shunt relay 202 which, upon releasing, again shunts resistance 145 from the ring side of the line and thereby causes the operation of relay 111 as already described.

Should the calling subscriber hang up in this case, relay 103 will release, followed by the release of relay 111. But his line circuit is not cleared until the operator releases the call. She can, if she desires, re-ring the calling line by applying ringing current from the ringing key of her cord (not shown) to the ring side of the line to operate relay 101 over the following path: ground through the winding of relay 101, condenser 131, contacts of relay 111, upper No. 2 front contact of relay 220, bottom No. 3 front contact of relay 300, conductor 309, No. 1 back contacts of relay 302, No. 3 armature of relay 303, brush 317 and terminal, ring side of the outgoing trunk to ringing source in the operator's cord (not shown). With relay 101 operated, ringing current is now locally applied to the calling line in a circuit extending from ringing source R1, upper No. 3 contact of relay 220, lower No. 3 front contact of relay 101, bottom No. 3 front contact of relay 115, conductor 123, brush 124, over the subscriber's loop, brush 125, conductor 122, upper No. 3 contact of relay 115, top front contact of relay 101, upper No. 5 contact of relay 220 to battery and ground through resistance 351. When the subscriber answers, relay 103 operates followed by relay 111 and relay 101 will release.

On an incoming call, a loop is applied to the distant end of the trunk end, as a result relay 502 operates in a circuit extending from battery through its winding, right inner back contact of relay 506, right outer back contacts of relay 505, operator's loop, left middle back contacts of relay 505 to ground on the right outer back contact of relay 506. Relay 502 operates and closes a circuit for relay 507 extending from ground on the right middle back contact of relay 505, left front contacts of relay 502, winding of relay 507 to battery. As a result, a start signal is extended to the link from ground on the left outer contacts of relay 504, right inner contacts of relay 501, right outer back contacts of relay 505, left inner contacts of relay 507, conductor 511 connected to the start conductor 114. A free link hunts for the trunk and serves it since the link test relay 104 tests over conductor 512 and operates to battery over a circuit which extends through the right outer front contacts of relay 507, left outer contacts of relay 506, left middle contacts of relay 504, right outer contacts of relay 501, right inner

back contacts of relay 505, right and left windings of relay 505 to battery. Relay 505, however, only operates when solid ground is connected to conductor 512 in the same way as described for a local call. As a result, relay 502 releases followed by the slow release of relay 507. During the interval in which relay 507 is releasing, a circuit is closed for relay 504 extending from battery, through the right inner front contacts of relay 507 to ground on the right middle front contacts of relay 505. Relay 504 operates and locks over its right inner contacts to operating ground. Dialing is direct on to relay 103 in the link, the setting up of which, on the terminals of the wanted line, is the same as already described.

When the called subscriber answers, relay 102 in the link operates, reverses the tip and ring of the line and serves to extend metering and supervision to the main exchange in any suitable manner such as by polarized apparatus responsive to the reversal of current.

On the release of the call, relay 505 deenergizes when ground is removed from conductor 512. If there is still a loop on the calling side of the line due to a trouble condition, relay 502 reoperates when relay 505 releases and reoperates relay 507 over the left front contact of relay 502 to ground on the right middle back contacts of relay 505; relay 504 holding in the meanwhile over its left inner contact to ground on the left outer contacts of relay 507. When the holding loop is broken, relays 502, 507 and 504 release and the trunk is free. The slow release times of relays 507 and 504 give an adequate guard to govern the release of any slow release relays at the distant calling end.

If, for any reason, impulsing stops before the trunk on an incoming call has been served by a free link, relay 502 responds to the impulses and holds relay 507 during the impulse transmission. A circuit is then completed for relay 501 extending from battery through its windings, left middle contacts of relay 507, left back contacts of relay 502 to ground on right middle back contacts of relay 505. Relay 501 operates and then locks over its own left inner contacts. The operation of relay 501 disconnects the start conductor 512 at its right outer contacts, busies the trunk by removing the windings of relay 505 from conductor 503 at its right outer contacts and sends busy tone to the operator over a path extending from source of tone BT, condenser 513, left outer contacts of relay 501, over the operator's loop, left middle contacts of relay 505, to ground on the right outer back contacts of relay 506. The circuit is then held in this condition until the distant end releases.

If, on outgoing calls from the local exchange, split ground signaling is used and delayed metering is necessary or, on incoming calls to the local exchange, loop dialing is required, the trunk circuit shown to the right of Fig. 5 is used instead of that to the left of the figure, which trunk further provides ring back tone on outgoing calls if no tone is supplied in the manual exchange.

On outgoing calls with this trunk, the digit 0 is dialed and, of course, relay 220 operates as already described. The switch 310 is then driven to the particular trunk group after which relay 104 is applied to the sleeve terminal and sleeve conductor for test purposes. When a free trunk circuit is found, relay 104 operates over a previously traced circuit path to brush 312, conductor 519, right outer contacts of relay 518, winding of relay 516 to battery and in parallel

therewith resistance 524 to battery. Relay 516 operates and locks over its right outer front contacts to test conductor 519. The trunk is now busy to other link finders by ground on conductor 520, through the right inner contacts of relay 516, and the start conductor 511 is broken at right middle contacts of relay 516. Ring back tone is now returned to the calling subscriber over a path extending from source of tone RL, condenser 521, left outer contacts of relay 516, right middle back contacts of relay 515, conductor 521, terminal and brush 311, over the calling subscriber's loop through the link back to brush 313 and terminal, conductor 522, through the operator's loop, right inner back contacts of relay 515, winding of relay 514 to battery. The left middle back contacts of relay 516 remove ground from conductor 522, and the operator receives a calling signal due to the presence of battery through resistance 322, relay 111, on the ring side of the line from the link. If the calling line is a regular subscriber, that is, a non-coin box line, then relay 202 is normal and the battery signal on the ring side of the line is low, due to the fact that resistance 125 is short-circuited as already described and the marginal coin box signal in the operator's loop is operated to indicate a non-coin box line. If, on the other hand, a coin box line is calling, relay 202 is operated, the battery signal is of high resistance and the marginal coin box signal is not operated. In the case of the low resistance condition, relay 111 operates in the link but not on the high resistance condition.

When the operator answers, one leg of the trunk is grounded and relay 514 operates, in turn operating relay 517 over an obvious circuit while, at the same time, a circuit is completed for relay 515 from battery through its winding, right inner contacts of relay 518, left contacts of relay 517 to ground on the right inner contacts of relay 516, said relay locking over left outer front contacts to operating ground. Relay 518 now operates over an obvious circuit to ground on the left inner contacts of relay 515 and locks over its left contacts to ground on the right outer contacts of relay 517. Ring tone RL is now disconnected from the line at the right middle back contacts of relay 515 while the right middle front contact of this relay switches the operator's circuit on to the line conductors 521 and 522. Relay 514 is disconnected at the right inner contacts of relay 515 and releases, but relay 517 is held over the right middle contacts of relay 515.

The ground on the right inner contacts of relay 517 is connected to conductor 523 which, in turn, is connected to a terminal in the bank accessible to brush 313 of switch 310. If relay 220 is operated, indicating an operator's call, then the fact that the lower No. 5 front contacts of relay 220 are operated causes the ground on conductor 523 to be connected to conductor 345 to short-circuit relay 202 which, if operated, (as it would be on a coin box call) releases and short-circuits resistance 145 in series with relay 111 so as to operate the marginal coin box signal in the operator's circuit and indicate thereby that the coin has to be collected by the operator. Conversation may now proceed between the operator and the calling subscriber.

If the operator completes the call and desires to operate the calling subscriber's meter, she presses her meter key in the cord circuit (not shown) which replaces the ground on both conductors of the trunk with a metallic loop. As a result, relays 111 and 112 in the link operate in

series through the loop and the call will be metered due to the operation of relay 102 following the operation of relay 112 as already described. It will be noted that no battery is required at the manual exchange in order to complete this call so that this type of work is suitable for use to magneto offices.

When making a call to the exchange, the operator at the manual exchange loops the trunk, as a result of which relay 514 operates. Relay 517 then operates and extends a start signal to the link over the right outer contacts of relay 517, left back contacts of relay 518, right middle back contacts of relay 516 to start conductor 511. The left contacts on relay 517 further serve to close battery through the winding of relay 515 to conductor 520 which serves to operate relay 104 at the time the link has searched for and found the calling trunk. Relay 515 also operates in the test circuit, locks up to ground supplied to conductor 520 through the lower contacts of relay 104, disconnects relay 514 and ground from the calling loop and further switches the calling loop through to relay 103 in the link over its right middle front contacts. The operation of relay 515 further closes an obvious circuit for relay 518 which also operates and locks to ground on the right outer contacts of relay 517.

The operator now dials directly into the link and gets reverse battery supervision back from the link when the called subscriber answers.

If two-way trunks with battery dialing are required between the local exchange and the manual exchange, then a trunk circuit of the type shown on the left of Fig. 6 is used. On outgoing calls from the link to this circuit, the link operates as already described for the trunk immediately preceding, that is, by connecting ground on brush 312. As a result, relay 601 operates in a circuit which extends from ground on said brush, conductor 605, right outer contacts of relay 600, winding of relay 601 to battery and, in parallel with resistance 606 to battery through its left inner contacts and left inner contacts of relay 606. Relay 601 operates and switches the line through its right inner and outer front contacts by short-circuiting condensers 606 and 607. The tip and ring conductors are, therefore, connected straight through to the manual end. A calling signal and coin box discrimination signal are given by battery through relay 111 as already described and, when the operator answers, battery is put out on the line to operate relay 112 and gives the operator hold and metering if the link is arranged to do so.

When making an incoming call to the local exchange, the operator extends ground on the ringside of the line and operates relay 603. Relay 602 now operates over an obvious circuit and connects ground over its right outer contacts, left outer contacts of relay 601, left outer back contacts of relay 600, to starting conductor 511 whereupon a link is started to find the calling trunk. When brushes 125 and 124 connect with the trunk terminals, a loop is closed extending from battery through the lower winding of relay 103 to brush 124 and terminal as previously described, conductor 620, left contacts of relay 602, right contacts of relay 603, right inner back contacts of relay 601, tip conductor 608, brush 125 and terminal and thence as previously described through the upper winding of relay 103 to ground. Relay 600 operates in series with the test relay 104 in the manner as previously described for other trunk circuits and then locks over its right

inner contacts to the ground on the No. 2 contacts of relay 104, also as previously described, while the operation of the breaking of the right outer contacts of this relay serves to busy the link to outgoing calls. When the operator throws the dial key (not shown), battery is extended on the tipside of the trunk causing relay 604 to operate and open the loop holding relay 103 which now responds to further dial interruptions. The call is thus set up in the link end, when the wanted subscriber answers, the link tip and ring conductors are reversed by relay 102, as already described, while brush 126 and its cooperating contact is grounded by the bottom inner front contact of relay 102. Inasmuch, however, as conductor 609 is connected to the trunk outlet on the terminal cooperating with brush 126, relay 601 operates to said ground. The right inner contacts of said relay break the pulsing loop while its right front contacts switch the trunk through to the link. Relay 103 now holds to the distant manual end. Since the talking leads are reversed by relay 102, relay 103 will hold over its grounded winding to the battery which operated relay 603. When the called subscriber restores, relays 112 and 111 release, in turn followed by the release of relay 103. Since, however, relay 601 also releases at the time the bottom inner contacts of relay 102 are open, relay 603 is again put out on the line. Relay 603 now operates and, in turn, operates relay 602 whereupon the link relay 103 will be reoperated over the local loop made by the contacts on relays 602 and 603. The operator now receives correct supervision since there is now ground on both conductors of the local trunk.

Call to the automatic equipment of the main exchange

A subscriber wanting to make a call to a subscriber reached by the automatic equipment in the main exchange dials 9 for the first digit. Switch 410 responds to this digit in the usual manner. In this case, however, instead of relay 220 operating, as in the case of an operator's call, relay 304 operates in a circuit which extends from battery through the winding of said relay, terminal block 415 and conductor extending to terminal No. 9 of the bank of terminals accessible to brush 404, brush 404, lower No. 3 back contact of relay 304, conductor 348, bottom No. 2 contact of relay 107, top inner back contact of relay 347, conductor 349, upper No. 3 back contact of relay 106, conductor 307 to ground. Relay 304 operates and locks over its upper No. 4 front contact to ground on conductor 307.

The same group of trunks are now searched by switch 310 as in the case of a zero level call, due to the fact that outlets 9 and 10 on terminals accessible to brush 405 of the register switch 410 are common to the same group of trunks beginning with conductor on terminal 10 accessible to brush 319 of switch 310. With relay 304 operated, a circuit is now completed for relay 106 extending from battery through the winding of said relay, bottom No. 4 front contact of relay 304, bottom No. 2 back contact of relay 200, bottom No. 4 front contact of relay 115, back contact of relay 104, conductor 143, bottom No. 3 back contact of relay 301, conductor 133, brush 116 to ground. Relay 105, which was operated at the beginning of the digit, is released at the end as already described so that no further digits will effect switch 410.

Trunk switch magnet 306 is now reoperated

over a self-interrupting circuit previously traced through the bottom No. 1 back contact of relay 305 and top No. 2 contact of relay 106 and bottom back contact of relay 109, and the brushes of said switch are driven to the beginning of the trunk group whereupon relay 109 operates as already described for a zero level call. Each of the trunks in the group is now tested as before and a free one is seized as in the zero level call. If all the trunks are busy, the brushes of switch 310 will run to the last trunk whereupon relay 109 will operate over a circuit extending from battery through the winding of said relay, upper No. 2 contacts of relay 200, lower No. 3 front contacts of relay 204, upper No. 1 back contact of relay 303, brush 314 and cooperating last terminal of the trunk group, conductor 352 to ground on the lower No. 1 contacts of relay 220. In case of an all trunks busy condition, therefore, and in a connection involving the automatic equipment at the main exchange, the switch 310 will stop on the trunk preceding that to which the recall circuit mentioned in the zero level call is connected. This recall circuit can, therefore, only be seized by calls which are dialed zero. When a free trunk is found, relays 104 and 301 will operate as before and the tip and ring of the line are switched through to the outgoing trunk. Since relay 304 is operated and relay 220 released, relay 300 operates and holds in parallel with relay 301 and therefore no ringing is sent out to the trunk. Further, since relay 304 is operated, a metallic loop is closed through to the outgoing trunk in the line extending from the tip conductor 308, top outer front contact of relay 300, winding of relay 112, top No. 2 front contact of relay 304, winding of relay 111, bottom outer contact of relay 103, resistance 145, bottom No. 3 front contact of relay 300, to the ring conductor 309. This loop is closed through the regular line relay to battery and ground at the incoming selector of the automatic train at the main office (not shown).

Calling subscriber now dials the directory number of the wanted line. These further digits, instead of being received by register switch 410, are repeated over the trunk to the distant automatic train over a loop extending from ground on the tip side of the trunk (not shown), top outer armature of relay 303, top No. 1 contacts of relay 301, conductor 308, top outer front contact of relay 300, top No. 1 contact of relay 304, top outer front contact of relay 347, bottom outer front contact of relay 103, resistance 145, lower No. 3 front contact of relay 300, conductor 309, bottom No. 1 front contact of relay 301, lower No. 1 back contact of relay 302, to the ring side of the line and thence to battery and ground in the trunk. During the pulsing the outer front contacts of relay 347 are used to short out the high impedance bridge provided by relays 112 and 111 in series, since relay 347 comes up either in series with the winding of magnet 401 for further digits used for multi-metering discrimination as described hereinafter, or to battery on relay 105 through the upper No. 2 back contact of relay 305 for digits not required for discrimination, or for all digits in the single metering case. Since the equipment in the automatic exchange provides battery on the ring side of the line and ground on the tip side, relay 111 will operate whenever relay 347 is back after the distant end has been seized. This operation, however, has no function in this type of call. Further, relay 112 will not operate at this instant since rectifier 323 is low resistant to current in

this direction and the line is not, therefore, reversed.

When the called subscriber answers, the direction of current flow in the talking conductors is reversed and relay 111 will operate in this current reversal as will relay 112 since, in this case, the rectifier 323 which shunts relay 112 will be of high resistance with current in this direction. Relay 112 now operates relay 102 over a previously described circuit path. The latter reverses the lines to the calling subscriber although this is not required in the present call.

If the link is to be used for single metering only on calls of this type, terminal No. 9 on the bank accessible to brush 408 is strapped to resistance 405 and the calling subscriber's meter will receive a battery pulse through a circuit path which extends from resistance 405, brush 408, lower No. 2 front contact of relay 304, lower No. 4 back contact of relay 204, lower No. 2 contact set of relay 115, upper No. 3 front contacts of relay 218, brush 127 and terminal, winding of register magnet 144 to ground, during the releasing time of relay 218 after relay 204 has operated. If, however, it is not required to meter a call of this type, terminal 9 is left blank so that no metering pulse is sent out. If the link is used for multimetering, then the metering will take place as described herein-after.

If the call to the automatic equipment of the main exchange originates from a coin line, then relay 202 is operated at the time the link is seized, as already described. No coin box signal, however, is sent out to the distant office since, in this case, the lower No. 4 contacts of relay 202 are short-circuited by the No. 2 back contacts of relay 220. If it is required that coin box subscribers shall not have access directly to the main automatic equipment, then terminal 9 on the bank of terminals accessible to brush 404 is connected to terminal 11 which, in turn, extends to the armature of the lower No. 3 contact set of relay 202. Under such circumstances, when the calling subscriber dials 9 a circuit is completed for relay 201 extending from battery through its upper winding, lower No. 3 front contacts of relay 202, eleventh terminal cross connected to the ninth terminal on the bank accessible to brush 404, upper No. 4 contacts of relay 304, to ground on conductor 307. With the operation of relay 201, the calling subscriber receives NU tone over a circuit extending from source of tone on the bottom inner contact of relay 201, condenser 212, conductor 414, condenser 127 and thence as previously traced through the subscriber's loop, back to ground through the upper winding of relay 103. The operation of relay 201 further locks said relay to its lower winding through its upper outer contacts to ground on the upper No. 1 front contacts of relay 115 while ground is disconnected from conductor 307 thereby releasing all relays locked thereto.

Trunk to subsidiary exchanges

Up to six exchanges can be reached, if required, from the banks of switch 310 in addition to those used for the main exchange line inasmuch as digits 3 to 8 inclusive are yet available. The circuit as shown is actually arranged for reaching three additional trunk groups by dialing digits 6, 7 and 8. Digits 1, 3 and 4 are dead codes and the contacts corresponding to these digits on the terminals of the bank accessible to brush 404 are wired to the upper winding of relay 201. If,

therefore, a dead code is dialed, relay 201 will operate and give NU tone to the subscriber as already described. Inasmuch as the register magnet impulse circuit from the inner contact of relay 103 is carried through the bottom outer back contact of relay 201, further impulsing is prevented after the dialing of a dead digit while the holding conductor 307 is broken at the top outer contact of relay 201 so as to drop off all relays holding thereto. Terminal 5 on the bank of terminals accessible to brush 404 is shown connected to the winding of relay 403 in connection with the use of switch 410 for digit absorption when the digit 5 is dialed. Digits 6 and 8 give access to subsidiary automatic exchanges and digit 7 gives access to a subsidiary manual exchange. Combined automatic and manual working is not given to these subsidiary exchanges.

If the digit 6 is dialed, relay 304 will operate at the end of the digit over a circuit completed to brush 404 on contact 6 thereof and the required group of trunks will be marked by relay 109 over the marking conductors from the bank of terminals accessible to brush 319 to contact 6 of the terminal accessible to brush 405. The circuit will operate exactly as described for a main office automatic call except that the required group of trunks will be tested.

If the digit 8 is dialed, operation would be exactly similar for the third group of trunks to be tested. If digit 7 is dialed then relay 220 will operate at the end of the digit in a circuit completed over the terminal 7 accessible to brush 404 and the operation will be exactly as described in the call to the main office zero level.

Incoming trunk call—Trunk offering

When a call is made on an incoming trunk, the trunk is found and seized by a link circuit as a calling subscriber's line is found in a local call. The operations are similar to those described for other classes of calls since it is possible for the trunk to be connected either to a local subscriber, or through the link to a trunk to a distant exchange. In calls to a local subscriber, if the subscriber's line is busy, relay 200 operates in the link and busy tone is transmitted back over the calling loop in the usual way.

If the call is from an operator, she can offer the call to the busy line by operating her ringing key. This puts ringing current to the ring side of the line and operates relay 101 over a circuit extending from the ring side of the incoming trunk (not shown) brush 124, conductor 123, lower No. 3 contact of relay 115, lower No. 1 contact of relay 200, condenser 131, winding of relay 101 to ground. The operation of relay 101 causes the release of relay 103, but relay 110, which is held operated from the top contact of relay 103, now holds over a path extending through the upper No. 4 back contact of relay 220, lower No. 1 contact of relay 101, to ground on conductor 307. With relay 200 operated, relay 101 completes a circuit for relay 102 through the lower No. 2 contact of relay 101, top back contact of relay 104 to previously traced ground on brush 115 and also for relay 302 over the top No. 1 front contact of relay 200, lower No. 2 contact of relay 101 to the aforetraced ground on brush 115. Relays 102 and 302, in operating, are provided with a holding circuit over the lower No. 2 contact of relay 302 to the back contact of relay 104 so that, when relay 101 releases at the time the operator releases her ringing key, these relays hold up. With

relay 302 operated, the winding of relay 200 is connected over the No. 3 front contact of relay 302, lower No. 2 back contact of relay 301, No. 2 armature of relay 303 and thence either to brush 312 or to brush 316. If, now, the subscriber's line is busy, ground on the sleeve lead will hold relay 200 which, in turn, insures that relay 102 holds over the upper No. 2 front contact of relay 200. Relay 102 gives supervision back to the operator since, when said relay operates, it reverses the talking conductors at the top and bottom outer contacts. The link is switched through to the busy line through the top No. 4 contact and the No. 1 bottom contact of relay 302, said circuit including the condenser 324. The operator can, therefore, talk to the subscriber and ask him to accept the call. When both subscribers have cleared the line, ground is removed from the test lead of the called line and relay 200 releases whereupon relay 102 is released, the line reversed and the operator given a clear signal. The operator then throws her ringing key which will cause the link to switch through to the required subscriber so that the call is completed with an additional set-up. Since relay 302 is still operated, ringing on the ring side of the line operates relay 101, the upper No. 1 contacts of relay 302 to the winding of relay 101 through condenser 131. A circuit is now completed for relays 301 and 102 extending from ground on bank 117, brush 116, conductor 138, lower No. 3 contact of relay 301, conductor 143, lower No. 2 contact of relay 101, winding of relay 102 to battery, and upper No. 1 back contact of relay 200, lower No. 4 contact of relay 302, winding of relay 301 to battery. The operation of relay 301 releases relay 302 at the bottom No. 3 contact of relay 301. The ringing circuit to the called subscriber's line is then connected over a previously traced circuit from source of ringing current and upper winding of relay 300 and thence as previously traced over the subscriber's loop back to resistance 322 and battery over the top, outer back contact of relay 300.

Multi-metering

If the link is used in a multi-fee metering area, terminal banks accessible to brushes 497 and 498 of register switch 410 are used to give meter discriminations. The trunk groups reached by digits 6, 7 and 8 are direct trunks to distant exchanges which are used for calls to these exchanges only. The metering can, therefore, be determined completely by these digits. In the case of the main exchange, however, calls can be set up to the main exchange and from thence to a number of other exchanges. If, for instance, the digit 0 is dialed, the operator will normally take care of metering so that no automatic metering is required. In the case of the digit 9, however, the exchange to be reached may not be determined until either the second, third, or fourth digit has been dialed. The register switch 410 is arranged, therefore, so that if digit 6, 7 or 8 is dialed, it remains on the terminal to which it is driven and the number of metering impulses is determined by the connection from the meter pulse conductors 1 to 5 via the front contacts of the lower Nos. 1, 2 and 3 contact sets of relay 207 to contacts 6, 7 and 8 on the terminal bank accessible to brush 408. It will be noted that the tenth contact of the bank accessible to brush 408 is disconnected on lower No. 1 front contact set of relay 207 so that, if 0 is dialed, there will be no automatic metering.

On the other hand a number of automatic exchanges may be reached via the parent exchange by dialing the digit 9 and the particular exchange to which connection is desired is then not known until a second digit is dialed. However, inasmuch as the second digit is repeated to the distant exchange without registration on switch 410, said switch can be given a second setting to correspond to the second digit by virtue of which setting the number of meter pulses can be determined. Further, the desired exchange may be reached only through another parent exchange which can be reached by direct switching from the first parent exchange by dialing a specific two digit code. But since the second parent exchange may itself be the center of a number of subsidiary exchanges, these latter exchanges may then be reached by dialing a third digit, in which event the number of meter pulses can be determined by a third setting of switch 410 made responsive by the impulses of the third digit. In other words, the principle adopted for multi-metering in this invention is the following: that if a certain digit is individual to an exchange it determines the exchange tariff and switch 410 remains on the trunk selected by the digit. If the digit is common to several exchanges a further digit is required to determine the tariff and switch 410 will be driven to a new home position after which it will accept another digit and thereby determine the tariff.

For the purpose of disclosing, and more completely understanding, this part of our invention we will describe the link multi-metering operations for (a) exchanges reached by single digit codes; (b) exchanges reached by two digit codes; and (c) exchanges reached by three digit codes and (d) exchanges reached by four digit codes. It is understood, however, that no limitation is intended by limiting the description or disclosure to three digit codes. The simple principle underlying the determination of the tariff by a digit individual to an exchange is capable of unlimited expansion to as many digits as may be required to reach an exchange and as such is included within the scope of the invention.

If the wanted exchange is selected by a single digit, say 7, and two meter impulses are required for a successful connection to this exchange, then, at the end of this digit, the brushes of switch 410 will be positioned on terminal 7 of their respective terminal banks as already described for a local call. When relay 347 releases at the end of the digit, relay 105 releases and disconnects the dial pulsing circuit from register magnet 401. The subsequent digits are now repeated to the distant exchange and the call completed in the same way as previously described for an automatic train reached through the main exchange by dialling 9. Now terminal 7 on the bank accessible to brush 408 is connected via the upper No. 2 back contact of relay 418 either directly to the No. 2 pulsing conductor of the meter pulse control MPC or through the moving spring of the upper No. 2 contacts of relay 202.

The meter pulse control circuit, briefly indicated in Fig. 4 by the box labeled MPC, is a pulsing device arranged to emit from one to five battery pulses on each of the pulsing leads 1 to 5, respectively, between the time it is started by the closure of the starting mechanism and the time it is stopped as described hereinafter. Such devices are well known in the signaling art and may be arranged in any convenient form, as for instance, a cam for each lead with battery con-

nections controlled by the circumference of each cam and closed as many times in one cycle as is necessary to transmit the required number of pulses on each one of the pulsing leads. These
 5 cams can all be driven by a magnetic clutch or other suitable means and actuated by the closure of a starting circuit as, for instance, on start conductor 219. After one complete pulse cycle the cams may be prevented from any further rotation by the operation of a "stop" magnet over
 10 conductor 419 whereby the cam shaft drive is disengaged from the driving element. The magnetic drive or whatever suitable operating contrivance is used, must be so arranged as to operate
 15 from an external battery source so that, when started, a ground pulse is transmitted back over the starting conductor as a signal to the link to receive the forthcoming meter impulses.

When the called subscriber answers, relay 112
 20 is operated over the called loop in the manner described and a circuit is completed to the meter control circuit extending from battery through resistance 203, lower No. 3 contacts of relay 218, right contacts of relay 212, conductor 219, to
 25 ground through the starting mechanism of the motor control circuit. When the ground pulse is connected to conductor 219, relay 204 is short-circuited which, in releasing, causes the subscriber's meter 144 to be connected to brush 408
 30 over the following path: ground through the winding of the meter 144 and terminal on line-finder 120, brush 127, upper No. 3 contacts of relay 218, lower No. 2 contacts of relay 115, lower
 35 No. 4 back contacts of relay 204, lower No. 2 front contacts of relay 304, brush 408, terminal 7, upper No. 2 back contacts of relay 418, upper No. 2 back contacts of relay 202, pulse conductor No. 2 to battery in the meter control circuit. The meter will now receive two pulses.

40 At the end of the pulse cycle, the meter control circuit connects ground to the "finish" conductor 419 whereupon relay 218 is short-circuited over the following path; ground on conductor 419, lower No. 4 contacts of relay 218, upper No. 2
 45 back contacts of relay 204, resistance 211, thereby shorting the battery which holds relay 218 operated. With the release of relay 218 the meter circuit is opened and the remaining operations of the link are the same as those already described.

50 Offices reached by two digit codes in the present embodiment of the invention are those which can be reached by the automatic equipment at the main exchange and therefore have the digit 9 as the first digit. The second digit may be any other
 55 digit from 1 to 7, inclusive, and also 0. It is obvious from what has already been said in connection with reaching the automatic equipment by dialling digit 9, that said digit is used to select a trunk in the group extending between the calling exchange and the main exchange through the
 60 automatic equipment of which subsidiary exchanges may be reached by the dialling of another digit designating the desired subsidiary exchange. Hence, the second digit is individual to the wanted exchange and by positioning switch
 65 420 in accordance with the value of this digit the meter tariff for the exchange can be determined. That is, when digit 9 is dialled as a first digit it is necessary to restore switch 420 back to its home
 70 position after it has responded to said digit so that it can, on the second digit, assume the position called for by the second digit individual to the called exchange.

75 At the end of digit 9, switch 420 is on terminal 9. The terminal accessible to brush 408 is

strapped to the lower winding of relay 107. Hence, relay 107 operates over a circuit extending from battery through the lower winding of said relay, conductor 142, terminal 9 and brush 408,
 5 lower No. 2 contacts of relay 304, lower No. 4 front contacts of relay 204, lower No. 4 back contact of relay 108, lower No. 3 front contacts of relay 304, conductor 348, lower No. 2 back contacts of relay 107, upper back contacts of relay 347, conductor
 10 349, upper No. 3 back contacts of relay 106, conductor 307 to ground. Relay 107 now locks over its upper winding and lower No. 3 front contacts to ground on conductor 307 via the lower inner contacts of relay 347 and further holds relay 105
 15 over its upper winding and which relay, it will be remembered from the description of a local call, operates after relay 115. Switch 420 is now driven to terminal 11 over a circuit from battery through the winding of magnet 401 and the inter-
 20 rupter contacts thereof, brush 406 and the 9th terminal of the cooperating terminal bank, conductor 412 to ground on the upper outer front contacts of relay 107.

On the dialling of the next digit, which has been assumed to be "7", switch 420 is pulsed to
 25 terminal 18 over a previously described pulsing circuit and the position of the switch for the second digit determines the meter tariff for the two digit codes. At the end of the digit 7 relay 347 releases, accompanied by the release of relays
 30 105 and 107. Subsequent digits will be repeated over the trunk in the manner already described but switch 420 will not respond to them since the stepping circuit is now disconnected by the release of relay 105, and the switch will remain on ter-
 35 minal 18.

Now terminals 12 to 18, and 21 on terminal bank of brushes 408 are reserved for codes "91" to "97" and "90" and these are two digit exchange codes requiring no further discrimination. These ter-
 40 minals, therefore, are strapped to the appropriate terminals on connecting block 415 in accordance with the number of meter pulses required by each of the separate codes.

When the call is answered, metering occurs
 45 exactly as in the single digit code but the number of operations of the meter 144 depends on the meter pulse lead to which terminal 18 accessible to brush 408 is strapped.

Offices characterized by three digit codes are, 50 in the present embodiment of the invention, those whose first two digits are "98" and "99". In such codes it becomes necessary, for tariff purposes, to reset switch 410 in accordance with the value of the third digit of the code. This is done as fol-
 55 lows:

Let it be assumed that "98" has been dialed. Then, according to operations already described, the brushes of switch 420 will be on the 19th terminal of their respective terminals. But inas-
 60 much as the 19th terminal accessible to brush 408 is connected to the upper winding of relay 418, this relay operates over a circuit completed from battery through the upper winding of said relay, 19th terminal and brush 408, lower No. 2 front
 65 contact of relay 304 and thence as previously traced to ground on conductor 307. Relay 418 operates and locks over its lower winding and lower No. 1 contact to ground on conductor 307 by way of the lower locking contact of relay 218.
 70 It further extends its operating ground by way of its locking contact to conductor 142 and thereby completes the circuit of relay 107 over its lower winding. Relay 107 operates, locks over its upper winding and lower No. 3 contacts over a pre- 75

viously traced circuit and further holds relay 105 on its upper winding through said locking circuit. A self-interrupting circuit for magnet 401 is now completed through battery, winding of said magnet, interrupter contacts, 19th terminal and brush 406, conductor 411, upper inner front contacts of relay 107, upper No. 2 front contacts of relay 301, to ground on the upper No. 2 front contacts of relay 115. Switch 420 is thereby driven to its home position and there awaits the dialing of the third digit of the code to which it will respond since relay 105 is operated and the dial impulse circuit for operating magnet 401, and previously traced, is now closed.

The impulses of the third digit will now be effective to advance the brushes of switch 410 to any one of their respective terminals 1 to 10 and since the terminals accessible to brush 408 are strapped to the terminal block 415 according to the number of meter pulses required for each of the digits 1 to 10 the appropriate number of meter pulses will be transmitted at the time the charge is made for the call.

If it is assumed that the three digit code above considered is 986, then, after the third digit is dialed, the brushes of switch 410 will be on their respective terminals 6. When the digit has been received, relay 347 releases and, since relay 107 can no longer be operated through the 9th terminal accessible to brush 408, relay 105 releases and disconnects magnet 401 from the pulsing circuit. Subsequent digits will therefore not step switch 410 and when metering occurs as previously described, the tariff will be determined by the strapping from terminal 6 accessible to brush 408.

It will be observed that terminals 6, 7 and 8 accessible to brush 408 are connected to the upper moving springs 1, 2 and 3 of relay 418 and that the respective cooperating back springs are connected to the terminals of block 415 as required by the meter charges for the single digit offices 6, 7 and 8. On the other hand, the front contacts associated with the moving springs are connected to the terminal block 415 as required by the meter charges for three digit codes and particularly by the codes ending in 6, 7 and 8. In the case of single digit codes, relay 418 is not operated so that the back springs are effective to give the required meter pulses while in the case of three digit codes relay 418 is operated and if the third digit of the code happens to be a 6 or a 7 or an 8 the front spring of relay 418, making with the moving spring connected to the terminal marking the last digit of the code, will be effective to give the required meter pulses.

It will be further observed that meter pulse conductors 2, 3, 4 and 5 are carried through the back contacts of relay 202 which relay, it will be remembered, operates on calls from coin-box lines. The front contacts of the upper 2, 3, 4 and 5 armatures of relay 202 are, in turn, connected to the lower winding of relay 201 which is further connected to a terminal on block 415. This terminal is further strapped to all the terminals accessible to brush 408 representing codes which are not available to coin-box lines since the coin-box may not be arranged for variable collections as would have to be the case if calls were to be completed to offices behind the single charge area. If, now, a coin-box subscriber does dial such an office relay 202 would operate as already described and a circuit would be completed from ground on brush 408, terminal on block 415 connecting with the lower winding of relay 201 to

battery. Relay 201 would then operate and transmit NU tone to the subscriber, indicating to him that the office desired could only be reached by way of the operator at the main exchange.

If code "99" is dialed as the first two digits of a three digit code, then after the dialing of the second 9, the brushes of switch 410 will be their respective 20th terminal and of which that accessible to the brush 408 is strapped to discriminating relay 402. This relay, therefore, operates in a circuit completed over its upper winding, 20th terminal and brush 408 to ground on relay 115 as before traced and then locks over its lower winding and inner contact to ground on conductor 307 via the lower locking contact of relay 218. Relay 402 further extends the operating ground through its upper contact to conductor 142 and thence to the lower winding of relay 107 which now operates and holds relay 105 in the same way as previously described for other three digit codes. As in the case of "98", the brushes of switch 410 will now be driven to their respective home terminals after which magnet 401 will respond to the impulses of the third digit. But inasmuch as relay 402 is operated in this case, the meter pulses will be taken from the terminal on brush 407 to which it is driven by the impulses of the third digit. The first ten terminals accessible to brush 407 are strapped to the pulse conductors on block 415 in accordance to the number of pulses required to operate the subscriber's meter for those three digit codes which have 9 as their middle digit.

The link circuit disclosed in Figs. 1 to 4 inclusive as an embodiment of this invention is arranged for metering offices designated by four digit codes and beginning with "998". If 998 is dialed switch 420 does not remain in position as described for "996" but drives to a new home position and accepts a fourth digit. At the end of the code 998, the brushes of switch 420 will be on terminal 8 and relay 402 will have been operated. Terminal 8, accessible to brush 407, is strapped to conductor 142 which connects with the lower winding of relay 107 and this relay operates over circuit completed through brush 407 and terminal 8 cooperating therewith, lower front contacts of relay 402, lower No. 2 front contact of relay 304, lower No. 4 front contacts of relay 204, lower No. 4 contacts of relay 106, lower No. 3 front contacts of relay 304, conductor 348, lower No. 2 back contacts of relay 107, upper back contacts of relay 347, conductor 349, upper No. 3 back contacts of relay 106, conductor 307 to ground. Relay 107 operates, locks and holds relay 105 over a previously traced circuit whereupon switch 410 is driven to the 11th set of terminals. The next digit now influences magnet 401 since the impulse circuit is closed by the operation of relay 105 and the switch is driven to a set of terminals from 12 to 21 depending on the value of the digit. The terminals 12 to 21 accessible to brush 407 can, therefore, be strapped to pulse leads on block 415 to give correct tariffs for the exchange codes 9981 to 9980. Metering then takes place as before described.

Four digits local numbering

When the rural automatic exchange is used in an area requiring four digits numbering, any suitable digit can be prefixed to the normal numbering and the register switch 410 made to absorb this digit on calls to local subscribers. For instance, if the prefix digit is a 5, terminal 5 on the bank accessible to brush 404 is wired to the wind-

ing of relay 403. When, therefore, a digit 5 is dialed into the link as the first digit, relay 403 operates over a circuit completed through the winding of said relay, terminal 5 and brush 404, lower No. 3 back contact of relay 304, conductor 348, lower No. 2 back contact of relay 107, upper back contact of relay 347, conductor 349, upper No. 3 back contact of relay 106 to ground on conductor 307. Relay 403 locks through its lower contacts to previously traced ground on conductor 412, through the commoned terminals accessible to brush 406 while through its upper contacts it connects ground to the commoned terminals 12 to 24, inclusive, accessible to said brush. The effect of this operation is to cause switch 420 to be driven back to its normal position after it has been advanced through previously traced circuits to the 12th terminal set. Relay 403 is locked in parallel with winding of switch magnet 401 and releases when the switch has reached its normal position. The link then accepts the remaining three digits, as already described, for a three digit call.

Extension to two hundred lines

If, due to unexpected expansion, it is desired to extend the working of the rural automatic exchange beyond one hundred lines, a second board can be placed in the same building and the two boards used as one exchange without any change in the numbering scheme. If the local hundreds digit on the first board is assumed to be 2, then the lower winding of relay 107 in its link is strapped to terminal 2 on the bank of terminals accessible to brush 404, as shown. The hundreds digit of subscribers on the second board, on the other hand, would be given a suitable number, such as 3, and, on the links of this board, the lower winding of relay 107 of its link is strapped to terminal 3. In the links of the first board, the winding of relay 304 is strapped to terminal 3 in the terminal bank accessible to brush 404 while terminal 3 on the bank accessible to brush 405 is wired to mark a group of tie lines between the two boards. In the links of the second board the winding of relay 304 is strapped to terminal 2 of the bank accessible to brush 404 while terminal 2 of the brush accessible to 405 is wired to mark the other end of these tie lines if they are both way, or a similar group if they are one-way trunks.

Either board serves its own group of subscribers on all types of calls in a normal manner. If a call is originated on the first board either from a local subscriber or a distant exchange, and required to be connected to a line in the second board, the hundreds digit 3 will be dialed in the first board. Relay 304 will be operated in the link and a tie line of the second board is seized as in an outgoing trunk call. A free link in the second board will hunt for and seize this tie line and will be seized as for an incoming call. The test conductors of tie lines of this sort are connected to the terminal bank accessible to brush 126 and from thence to winding of relay 205. When the incoming second link is seized and the calling tie-line found, relay 205 operates in a circuit completed from ground on the No. 1 front contact of relay 115, and conductor 307, winding of relay 205, terminal at brush 126 to the called line test circuit in the first link. A circuit is now completed for relay 107 extending from battery through its lower winding, No. 2 bottom contact of relay 205, conductor 147, normal terminal and brush 404, lower No. 3

back contacts of relay 304, conductor 348, lower No. 2 back contacts of relay 107, top inner back contacts of relay 347, upper No. 3 back contacts of relay 106, to ground on conductor 307. Relay 107 is now locked over its No. 4 contact while a circuit is completed for driving switch 410 off its normal terminal extending from ground on the inner contacts of relay 205, conductor 343, normal terminal of brush 406, interrupter contact and winding of magnet 401 to battery. The switch is now driven to terminal 11. Thus, although no digit has been dialed into the second link it is in a condition to accept the tens and units digits and connect the call to the required line.

If a call comes into the second board for a subscriber on the first board, the hundreds digit 2 will be dialed in the link of the second board. Relay 304 will operate in this link and the tie-line will be seized to the first board in the manner as already described. A link in the first board will seize this line and will be set as described above in a condition to receive the tens and units digits. As described, the call in such a condition uses two links in series.

Recall of subscriber on a call to a busy trunk

This feature is only required on calls to an operator. A subscriber dials zero and, if the trunks are all busy, receives a busy tone, as already described. If he wishes to be rung when a trunk becomes free, he dials a further digit receives "ring-back" tone and then hangs up. Immediately a trunk becomes free, it is seized and busied at both ends, the subscriber is then rung and when he answers gets busy tone and the operator receives a calling signal. If the subscriber wishes to make call before he is rerung, he can break down the condition by lifting and depressing the switchhook. He is then free to make another call and the trunk will be released. If the trunks to the operator are used for combined manual and automatic working the rering condition is not set up when a call is made to automatic and all the trunks are busy. If the subscriber dials zero and does not wish to be rerung, he hangs up without again dialing and no rering condition is then set up.

Two forms of this feature are here considered: (a) a recall circuit, as shown on the right side of Fig. 6 to which the call is completed and held during the subsequent conversation. In this type of call a subscriber seizes a link and dials zero. If all the trunks are busy, switch 310 is driven to the last trunk in the zero level group to which the recall circuit of Fig. 6 is connected. This circuit is tested and, if free, is seized by the link which cuts through. If the subscriber dialed 9, the same junction group would be tested, but since in this instance, relay 220 is normal, switch 310 is stepped on to the trunk preceding the recall circuit, the link is made busy on this trunk and the recall circuit is not seized.

The recall circuit tests free if there is battery on test conductor 619 to which the relay 104 in the link operates and locks in series with relay 301, the test battery in this case being through conductor 619, middle back contact of relay 615, middle back contact of relay 613, resistance 618 to battery. The recall circuit is therefore seized and the lines are switched in as a result of which relay 616 operates through a circuit extending from ground, through the winding of relay 616, right middle back contact of relay 610, right middle back contact of relay 611, 75

left outer back contact of relay 610, right inner back contact of relay 611, right middle back contact of relay 612, conductor 621, brush 313, lower No. 3 back contact of relay 303, lower No. 1 back contact of relay 302, lower No. 1 contact of relay 301, conductor 309, lower No. 3 front contact of relay 300, conductor 148, lower No. 4 back contacts of relay 202, conductor 414, winding of relay 111, lower No. 1 back contacts of relay 304, resistance 322 to battery. The operation of relay 616 closes an obvious circuit for relay 615 and busy tone is then superimposed upon the tip and ring conductors from source of tone BT, right middle back contacts of relay 614, right contacts of relay 616, condenser 622, to the ringside of the line. If the subscriber now restores, the link and recall circuit will both be dropped. If the subscriber wishes to be rung back when a junction becomes free, he dials the digit 1. As a result, relay 103 in the link responds to the impulse through the lower inner back contact and over the ringside of the line repeats it to relay 616. Since relay 301 is operated, no switches respond in the link. On the impulse, relay 616 which releases and a circuit is completed for relay 613 extends from battery through the winding of said relay, right inner front contacts of relay 615 to ground on the left back contacts of relay 616. When relay 616 reoperates at the end of the impulse, relay 613 holds in series with relay 614 through the right winding of the latter relay over a circuit completed through the left inner contacts of relay 613, right winding of relay 614, right inner back contacts of relay 614 to ground. Relay 614 operates and holds over a locking circuit extending from battery through its left winding and left inner contacts, right outer contacts of relay 615, right inner back contacts of relay 612, to ground on conductor 619. Relay 613, however, releases when its circuit is broken at right inner contacts of relay 614 and the subscriber receives ringback tone from source of tone RT, right middle front contacts of relay 614, right contacts of relay 616 and thence as traced over the ringside of the line. Upon receipt of ringback tone signal indicating to the subscriber that he will be recalled, he restores his receiver whereupon relay 103 releases in turn releasing relay 616. The release of relay 616 causes the release of relay 615 whereupon a circuit is completed for relay 613 over a previously described path which causes said relay to reoperate and then lock over the right inner back contacts of relay 615, right inner contacts of relay 613 to ground on the left middle contacts of relay 614. Since relay 614 is now held over the left outer back contacts of relay 616, battery is extended through resistance 617 and the right outer back contacts of relay 612 over the tip conductor 623 of the line for the purpose of holding relay 112 and therefore relay 102. Relay 110 in the link, therefore, is prevented from releasing because of the holding circuit through the top No. 4 front contacts of relay 220, top inner front contacts of relay 102, to ground on conductor 307. The link, therefore, does not release and the subscriber's line is held busy.

The recall circuit in the right of Fig. 6 is shown associated with the two-way trunk to the main operator on the extreme left of Fig. 5 through relay 610. By the addition of similar relays, such as relay 611, the recall circuit may be associated with other trunks and the recall feature thereby extended to all of them. If the recall circuit is associated with more than one trunk, then when

one trunk becomes free, relay 610, for instance, operates over a circuit completed from battery through its right winding, right middle contacts of relay 613, left inner contacts of relay 615, left middle contacts of relay 611, conductor 624, right outer back contacts of relay 505, right inner back contacts of relay 501, to ground on the left outer contacts of relay 504. Relay 610 then locks over its left winding and left No. 2 contacts to ground on the test conductor 619.

The trunk is immediately seized by ground on conductor 508 through the left inner contacts of relay 610. If the trunk is manual, no call is extended, but for combined 9 and zero level trunks, the loop is extended over the right outer front contacts of relay 610, left outer back contacts of relay 612, left outer contacts of relay 614, right middle front contacts of relay 610 to the trunk line so that the distant end seizes an automatic selector as in the No. 9 level call. Ringing is sent out through the right winding of relay 612, right inner front contacts of relay 610, right middle back contacts of relay 612, conductor 621, to the ring side of the line and operates relay 101 through a previously described circuit which in turn causes the calling subscriber to be rung. When the subscriber answers, relay 103 operates in the link and relay 612 operates over the negative side of the trunk and the lower front contacts of relay 103 in series with relay 111. Relay 612 now switches the line straight through from the link to the trunk.

If the trunk is to manual, the operator will now get a calling signal and the subscriber receives the ringing tone from the distant exchange. The call then proceeds in a normal manner. If, after hanging up his receiver, the subscriber does not wish to be rerung, he lifts his receiver again causing thereby the operation of relay 616. The release of relay 616 causes the release of relay 614 which, in turn, causes the release of relay 613. The subscriber now replaces his receiver and, since holding battery through resistance 617 to the tip side of the trunk is removed, the link and recall circuit release and the subscriber is free to make another call.

(b) In an alternative form of the recall feature, the ringback circuit is seized if the trunks are all busy, but is not held during the subsequent conversation. With this scheme, the link circuit is slightly modified, all the wiring of terminals 12 and 21 inclusive and all the banks of switch 410 are moved on three terminals so as to occupy the space 15 to 24. The subscriber dials zero and, if all the trunks are busy, relay 220 fails to operate in the link although register 410 has been advanced to terminal 10. Under such circumstances the subscriber gets busy tone from the link and if he desires to be recalled, dials 1. The register 410 responds to this impulse and relay 220 operates over a circuit completed to terminal 11 of the bank accessible to brush 404. But from the corresponding terminal on the terminal bank accessible to brush 405 a special outlet is marked which is wired to a recall circuit which immediately precedes the trunk group. The recall circuit is seized and when the subscriber restores holds the link as in the preceding case (a). When a trunk becomes free the subscriber is rerung as in (a), but when he answers the link drops the recall circuit and hunts for a free trunk. It is arranged that until the recall circuit is dropped one trunk at least is held free. The link seizes the free trunk

and extends the call to an operator in a normal way.

Alternative trunking

A simple modification of the link circuit enables alternative trunking to be used. This is particularly valuable in rural networks where small groups of one and two trunks are common. The principle is that if the out-dialing digit to an exchange in the direct route is, say, 7, the main automatic route is 9 and the alternative route is, say, 92, then the direct route code is made 72. If 7 is dialed and the direct route is free, a trunk is seized and the next digit 2 is absorbed. If 7 is dialed and no direct route is available, the 9 level group is tested and a free trunk seized. The second digit 2 is then sent out over the trunk, is received by an automatic selector at the central exchange and causes the trunk in the alternative route to be seized and the call is set up normally. The second digit on a 7 call is absorbed in the link by accepting it on switch 410. This is arranged with its three spare terminals preceding instead of succeeding the tenth digit outlet. The circuit would be arranged to step register 410 to contact with terminal 11 if 7 were dialed and no trunk were found and with 14 if a tenth digit is required for a local call. The receipt of digit 2 when switch 410 is in position 11 would have no effect as terminal 13 would be blank. If no trunk is found switch 310 is caused to drive on and hunt over the ninth level trunks and seize a free trunk. The second digit is then repeated over the trunk and not on to the switch 410. As an alternative, the unwanted digit in the direct route can be absorbed in the trunk circuit or in the distant exchange.

Centralized line testing

By using two trunks it is possible to make complete tests of the rural automatic subscribers' lines and line circuits from the test desk in the distant center exchange. All links may be arranged for this purpose, or only one. If only one is equipped, arrangements are made so that a condition on the calling trunk starts up this link only. The two trunks, one for controlling the distant link and one which has access to the line under test, are both seized by the test clerk. By a special calling signal such as the center point to ground, it is arranged that the control trunk is seized by the test link, the test trunk being merely seized and held busy. The link is set into the test condition by prefixing the subscriber's number by a test digit, such as digit 4. In order that the feature should not be used by a subscriber, this digit must be followed by ringing on the negative side of the link. The link is arranged as follows:

Test digit 4 is received by switch 410. Terminal 4 on the terminal bank accessible to brush 404 is connected to a TD relay (not shown) which would operate at the end of the digit and sends busy tone back on the line. A subscriber dialing this digit will, therefore, get busy and hang up. Relay TD would operate relay 403 over a path through brush 405 on terminal 4 as a result of which switch 410 would be driven home and relay 403 would release. Relay TD would lock up. The test clerk would then dial the required subscriber's number, but the circuit of relay 104 would be broken by a contact on relay TD so that the link would go busy with relay 200 operated and switch 310 on the required line. The test clerk now throws the ringing key and re-

lays 101 and 302 would operate as in the case of trunk offering. Relay 200 is applied to the line circuit by way of the test lead and wipers 311 and 313 would be connected via the trunk contacts of a relay PD (not shown) direct to the test trunk and so direct back to the main exchange without interfering potentials. Relay 200 on the test lead will give supervision back to the control trunk indicating that the required line is free. The test clerk would then seize the line by ringing a second time as in a trunk completing case. This would connect ground to the terminal accessible to brush 312 or 316 and so would operate relay 132 and remove the line relay 133 from the line. The clerk can, therefore, make measurements on the line with and without the line relay.

A further feature can be added so that switch 310 is stopped on the subsequent lines without releasing the trunk. The link can be arranged so that an impulse, or a ringing impulse, will break down the condition set up above and step switch 310 on to the next line with the link in the busy condition and operate relays PD and 200. Relay 302 can then be operated and the line seized by ringing as before.

Exchange prohibition

Attention has already been drawn to the fact that certain calls can be barred to coin box subscribers. This facility can also be extended to other classes of lines and considerable economies effected. It may be that rural exchange subscribers are allowed calls up to a certain maximum tariff, but that some exchanges in the area to which the exchange belongs would necessitate a higher tariff and must be barred from automatic access. The barred exchanges may only be identified after the third or fourth digit and if this discrimination were to be dealt with at the point reached in the connection when the last of the discriminating digits has been dialed, it would be necessary to segregate the switches with definite groups carrying different classes of traffic. According to the present invention, however, the terminals of switch 410, which would be used for metering tariff discrimination, are strapped, for barred exchanges, to relay 201 to give NU tone locally. Thus, segregation of switches in the special groups is avoided with considerable economy in the number to be provided.

Metering

Attention is also drawn to the facility, to which attention has not been particularly drawn heretofore, that metering may be automatic on certain outgoing manual trunk groups and under control of the distant operator on other manual trunk groups. Further, what may be termed a "split-answering" facility is given to operators controlling metering. By this is meant that the reply of the operator to an incoming call sends back a signal to the cut-off ringback tone, while metering takes place later when the wanted subscriber has replied by throwing of the metering key.

What is claimed is:

1. In a telephone system, a first office, a second office, a main office, a tie line connecting said first office with said second office, a trunk line connecting said first office with said main office, means in said main office for establishing a continuous connection between said trunk and said second office, and a link in said first office comprising means responsive to a digit designating

said second office for connecting said link to said tie line if said tie line is free, means responsive to the same digit for connecting said link to said trunk if said tie line is not free, and means in said link for repeating digits over said trunk to said means in said main office for completing a connection to said second office.

2. In a telephone system, a first office, a second office, a main office, a tie line connecting said first office with said second office, a trunk line connecting said first office with said main office, another trunk line connecting said main office with said second office, means at said main office responsive to the impulses of a number designating a called line in said second office for extending a connection between said main office and said second office over the trunk extending between said two offices, a calling line in said first office having an impulse sender, and a link in said first office for extending said calling line to said second office comprising means for connecting said link to said calling line, means responsive to the impulses of a digit from said line for connecting said link with said tie line if free, means responsive to the impulses of the same digit for connecting said link with said main office trunk if said tie line is not free and means responsive to the impulses of other digits from said calling line if the connection is extended to the main office trunk for repeating said impulses to said impulse responsive means at said main office for completing the connection to said second office over the trunk connecting said main office with said second office.

3. In a rural telephone system, a plurality of telephone offices, trunk lines interconnecting all of said telephone offices, a calling line equipped with an impulse sender in one of said offices, and a link circuit in said office comprising a line finder, a connector and an impulse register, trunk lines extending from said connector to said different telephone office, means responsive to the initiation of a call by said calling line for extending said line finder to said line, means responsive to the impulses of a digit from said line for extending said connector to a trunk line extending to a particular office, means responsive to the impulses of the same digit for extending said connector to the trunk line of another telephone office if said first trunk line is not free, and means responsive to other digits for completing the connection from said calling line to said particular office over the trunk line extending between said other telephone office and said particular office.

4. In an automatic telephone system requiring a number of switching digits for establishing interoffice connections and one digit less than this number for establishing local connections, a link circuit for extending both types of connections and an impulse register in said link adapted to respond in all cases to the maximum number of digits required for interoffice connections, and means responsive to a first digit designating a local connection for rendering said digit ineffective in establishing a local connection.

5. In an automatic telephone system comprising two offices adapted to work as one office and having a discriminating digit assigned to the lines of each office, a link in each office comprising a line finder and a trunk connection, tie lines connecting both offices accessible to the line finder of the link in one office and the trunk connector in the link of the other office, means responsive to the initiation of a call by a line in one of said offices for a line in the other of

said offices for connecting the line finder of the link in the calling office to said calling line, means responsive to the discriminating digit of the line in the called office for extending the link of the calling office to one of said tie lines, means responsive to the seizure of said tie line for operating the link of the called office to connect the line finder thereof to said tie line and means in said link in the called office responsive to other digits of the called line for completing the connection thereto.

6. In an automatic telephone system comprising two offices adapted to work as one office and having a discriminating hundreds digit assigned to the lines of each office, a link in each office comprising a line finder, a trunk connector and an impulse register, said register having definite recording terminals for each of the three digits of a line number, tie lines connecting both offices accessible to the line finder of the link in one office and the trunk connector in the link of the other office, means responsive to the initiation of a call by a line in one of said offices for a line in the other of said offices for connecting the line finder of the link in the calling office to said calling line, means responsive to the registration of the hundreds digit of the called line in the impulse register of the link connected to the calling line for extending said link to one of said tie lines, means responsive to the seizure of said tie line for operating the link of the called office to connect the line finder thereof to said tie line and for advancing the impulse register of said link to the beginning of the tens recording terminals, and means responsive to the registration of the tens and units digit in the impulse register of the link in the called office for completing the connection to the called line.

7. In a rural automatic telephone system, a link circuit for establishing connections over a trunk line extending to an office adapted for manual and automatic working, comprising means responsive to a digit designating a manual connection for adapting said trunk to manual supervision and means responsive to a digit designating an automatic connection for adapting said trunk to repeat dial impulses.

8. In a rural automatic telephone system, a link circuit comprising a line finder, a trunk connector and an impulse register, a calling line with an impulse sender terminating on said line finder, trunks extending to a combined manual-automatic office terminating on said trunk connector, means responsive to the setting of said impulse register for a digit designating a manual connection for seizing one of said trunks and connecting thereto a battery and ground bridge for manual working, and means responsive to the setting of said impulse register for a digit designating an automatic connection for seizing one of said trunks and connecting an impulse repeater thereto for automatic working.

9. In a telephone exchange system comprising a link circuit terminating at one end in a connector switch, a group of outgoing trunks accessible to said switch, a calling line having a message register, means for associating said line with said link circuit, means for operating said switch to select an idle trunk circuit, an impulsing switch associated with said link, a pair of relays, means for selectively operating said switch in accordance with the destination of a call, means for operating said pair of relays after the selective operations of said switch, means for releasing each of said pair of relays in succes-

sion and means controlled by said impulsing switch for variably operating said message register in the interval between the successive release of each of said pair of relays.

- 5 10. In a telephone system adapted for the variable registration of telephone connections, a number of offices interconnected with each other by trunk lines, each of said trunk lines being designated by a particular switching digit, a calling line in one of said offices having an impulse
10 sender and a message register, and a link in said office for establishing a connection between said calling line in said office and a called line in any other of said offices comprising an impulse register, means in said register for recording the
15 switching digit of the trunk connecting the calling line with the called office and means in said link responsive to the setting of said register for the trunk switching digit for variably operating
20 the message register of said calling line.

11. In an automatic telephone system, a first established connection between two lines, an automatic calling line, means responsive to the

initiation of a call by said calling line for establishing a second connection between said calling line and one of said two lines, means for establishing a talking circuit over said second connection, means for signaling said calling line
5 over said second connection when said first connection is disrupted, means for ringing the one of said two lines over said second connection when said first connection is disrupted, and means responsive to the answer of said one of
10 said two lines for reestablishing the talking circuit over said second connection.

12. In a telephone system for the automatic extension of connections, a calling line equipped with dial, a group of trunks, means for extending
15 said calling line to one of said trunks, means responsive to the dialing of a digit if all of said trunks are busy for seizing one of said trunks when free, and means for signaling said calling
20 line when said trunk is connected to said line.

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