

Aug. 1, 1939.

T. F. CROCKER

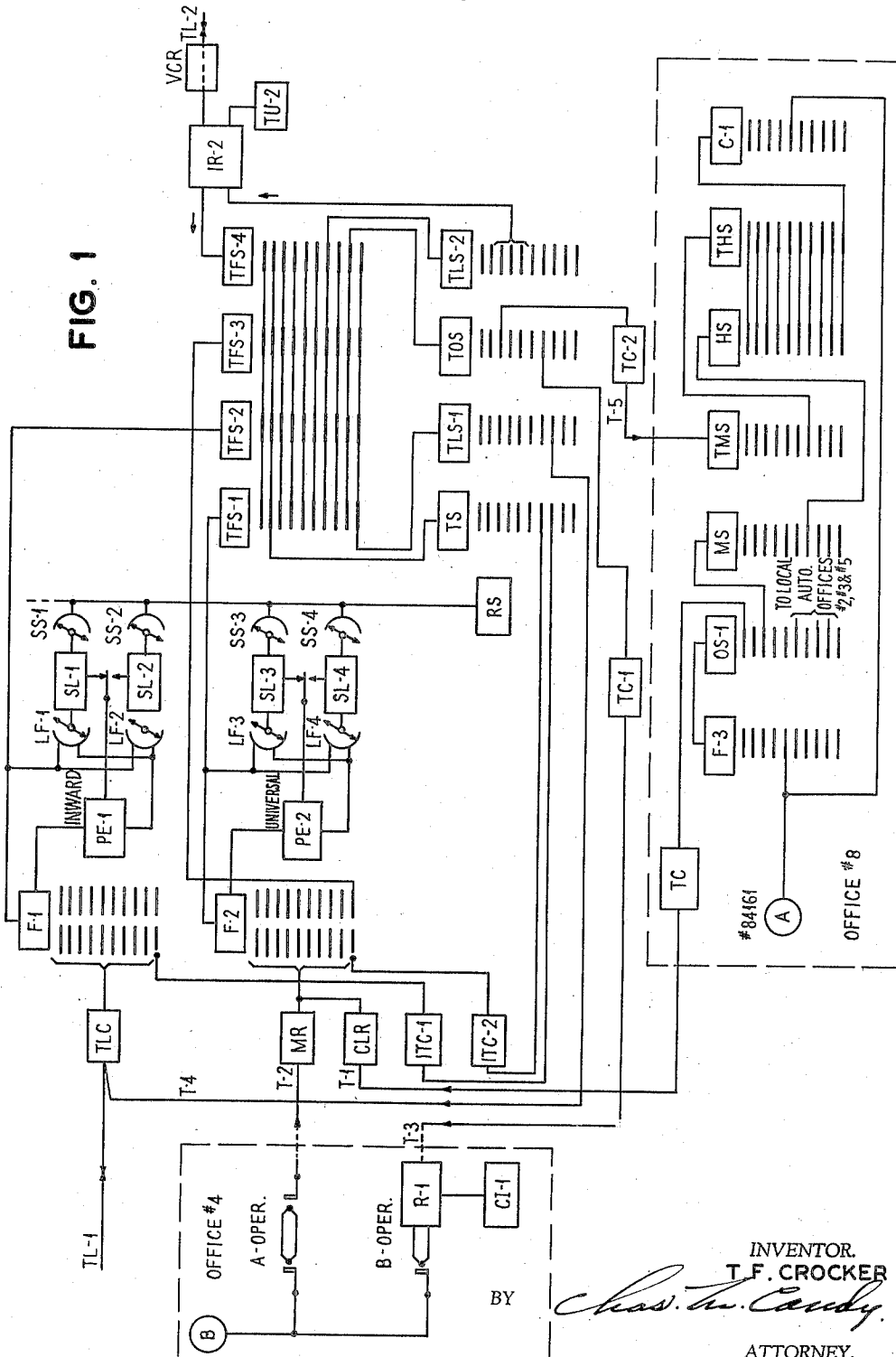
2,167,710

TELEPHONE SYSTEM

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21 Sheets-Sheet 1

FIG. 1



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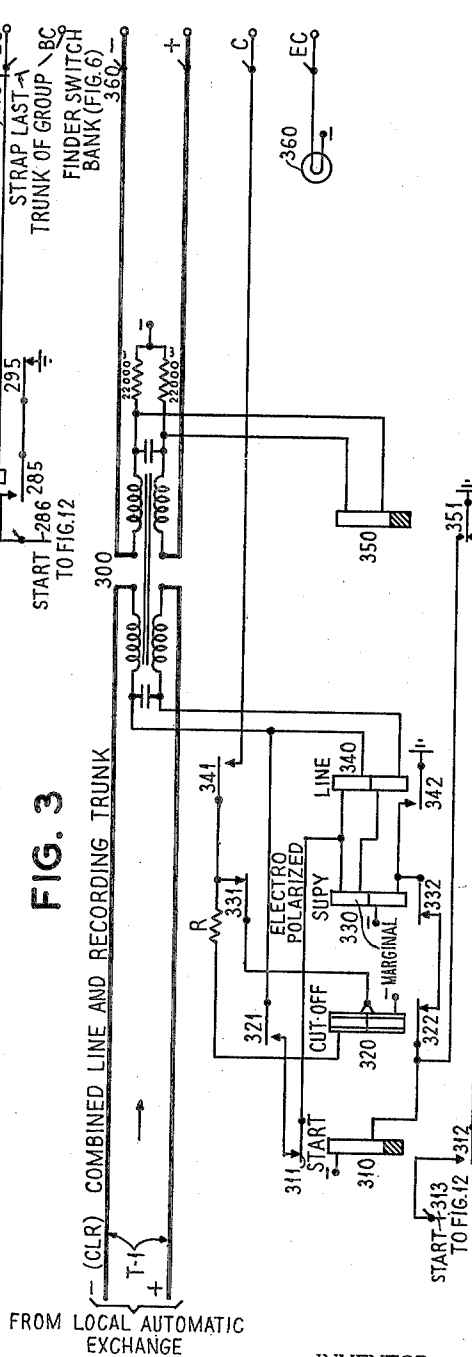
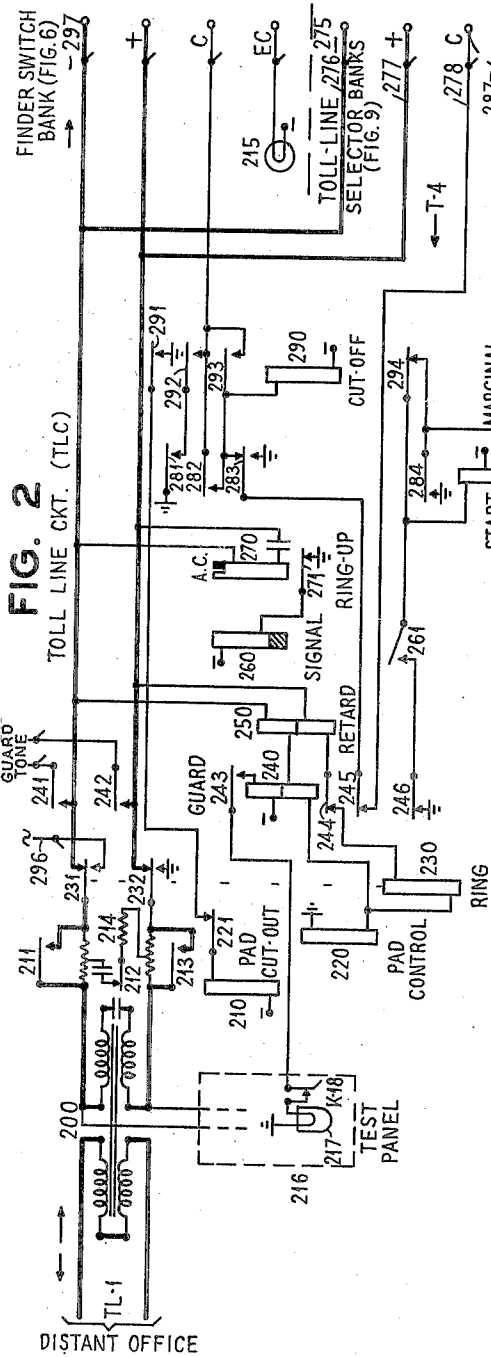
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21 Sheets-Sheet 2



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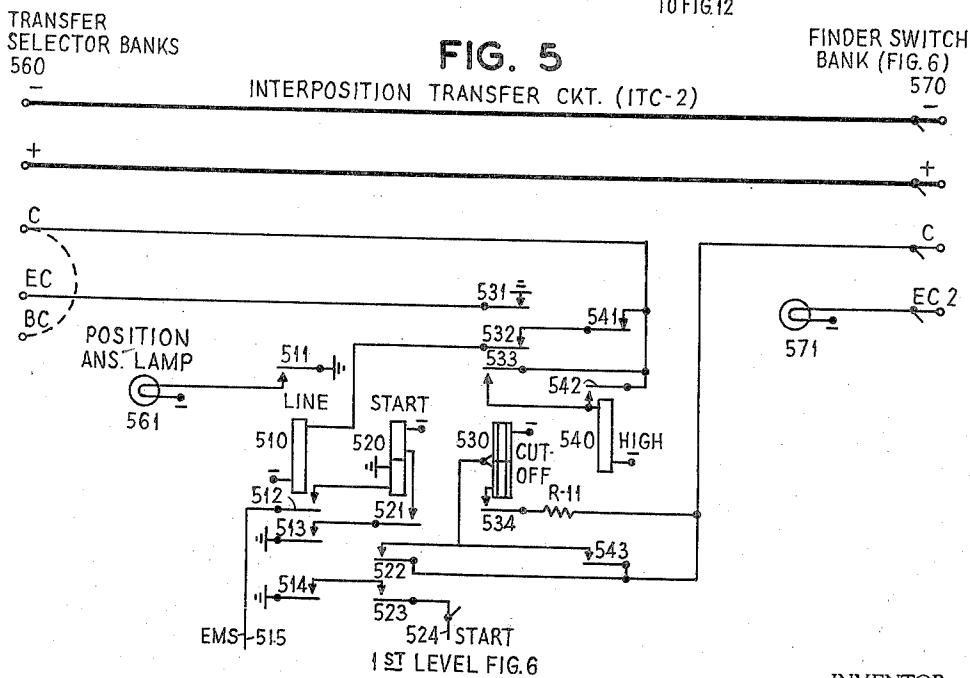
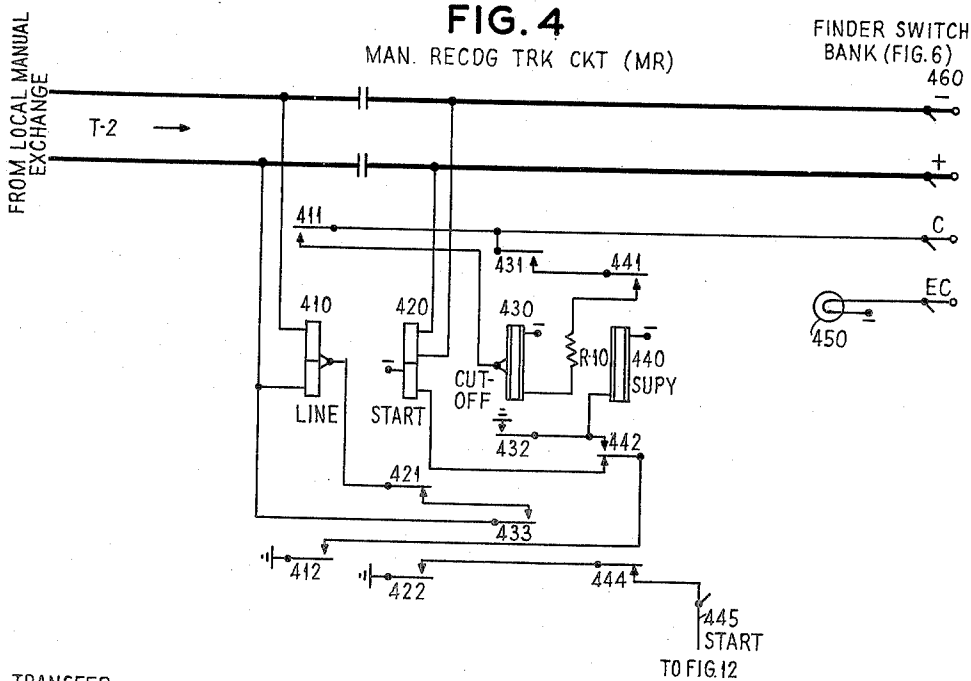
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21 Sheets-Sheet 3



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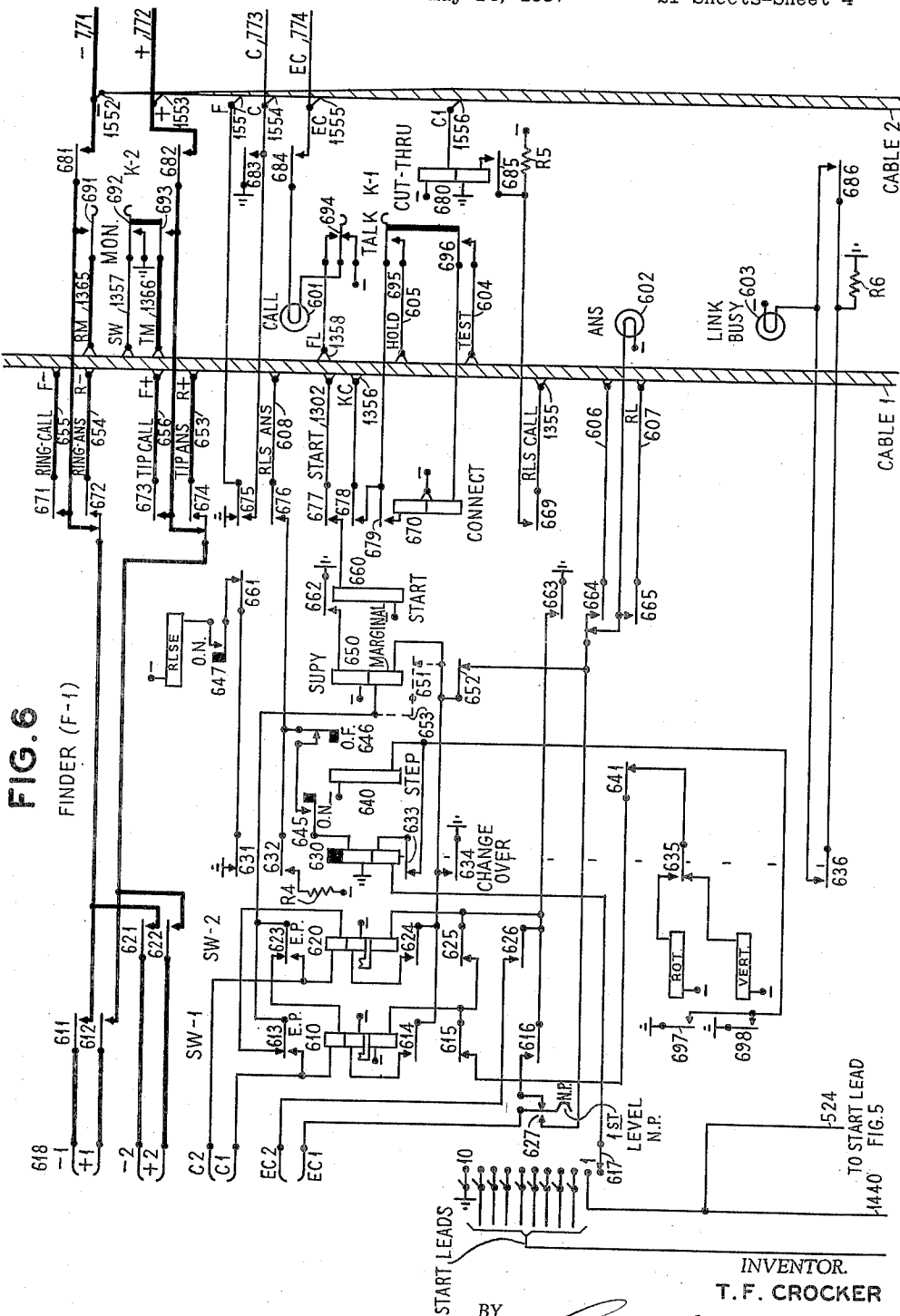
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TELEPHONE SYSTEM

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START LEADS

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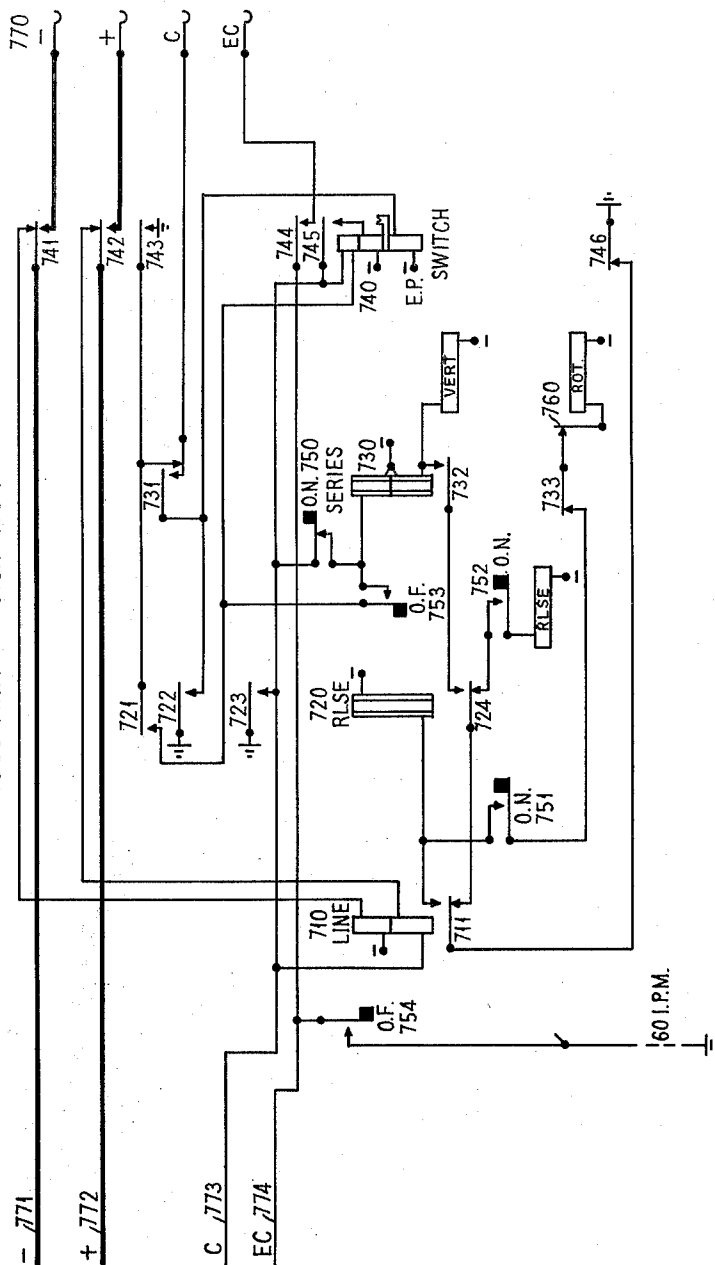
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FIG. 7

TOLL FIRST SELECTOR TFS-1



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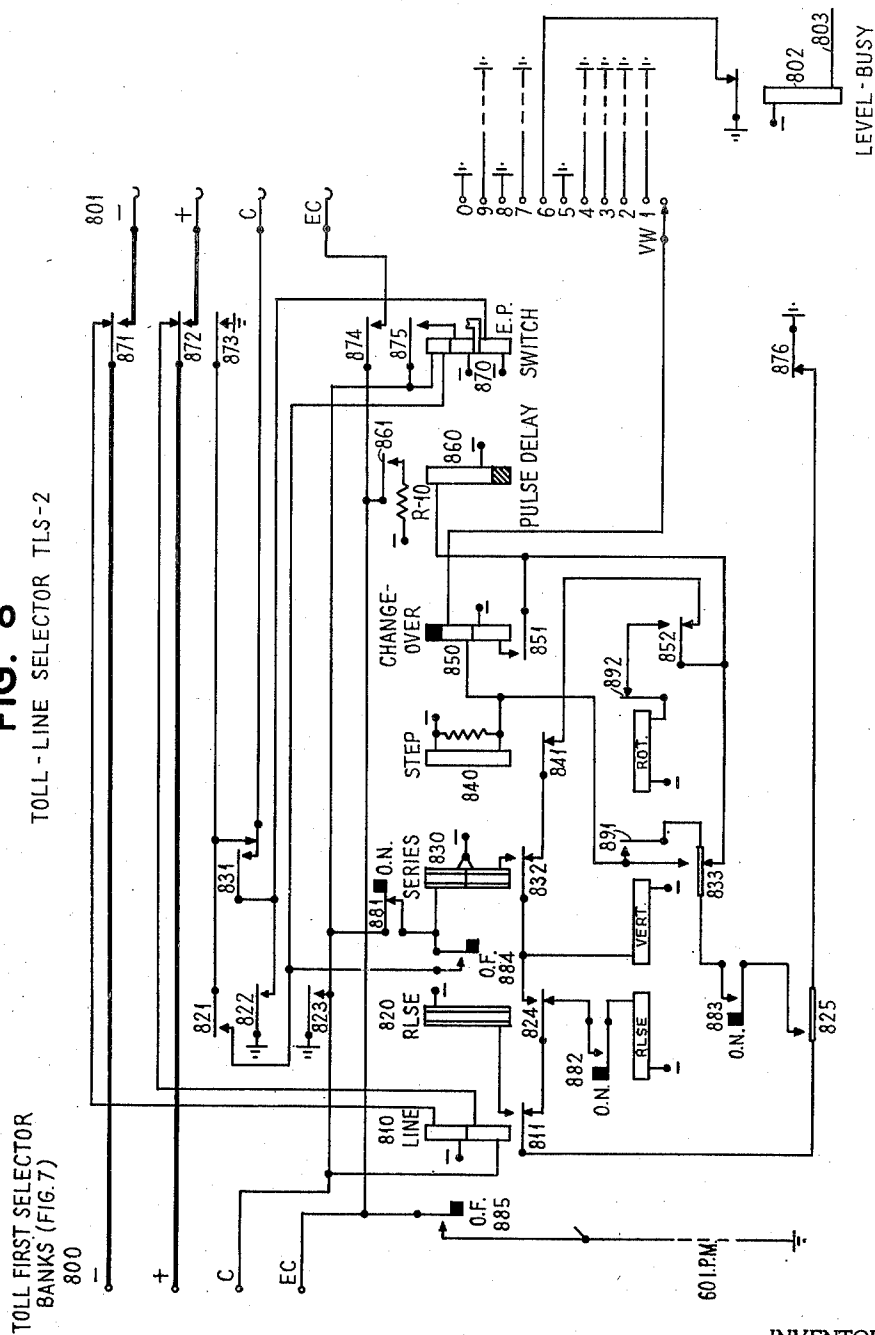
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FIG. 8
TOLL-LINE SELECTOR TLS-2



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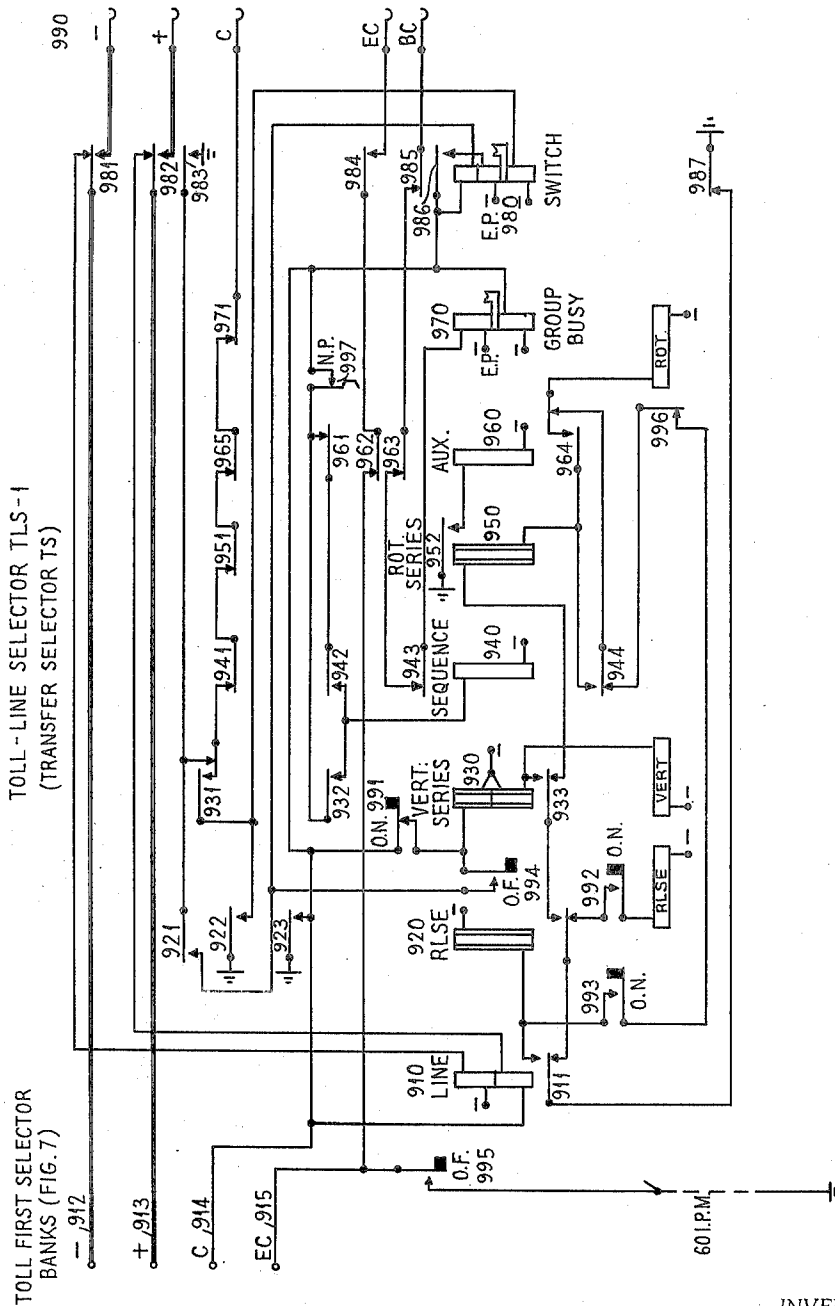
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FIG. 9



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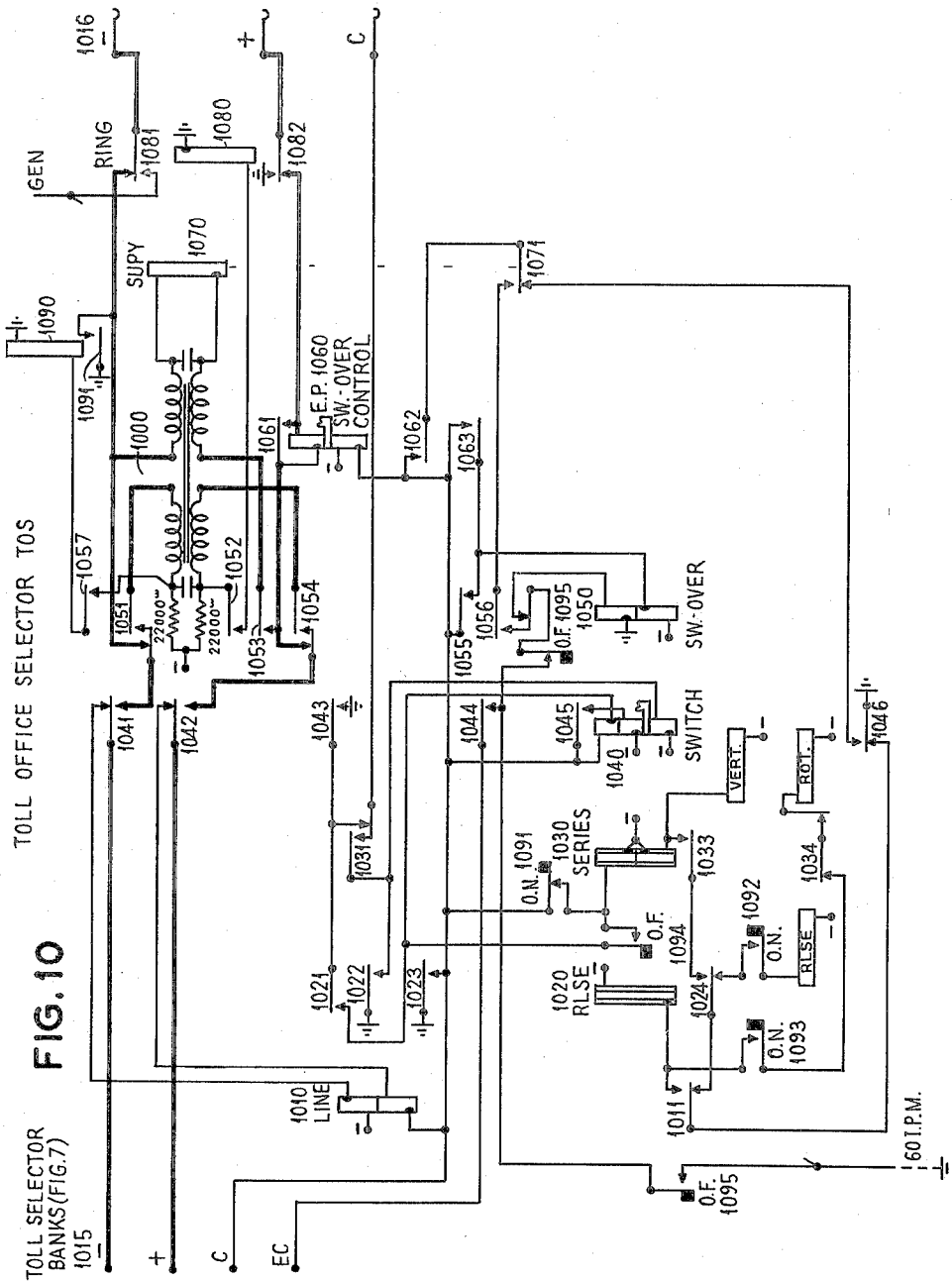
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21 Sheets-Sheet 8



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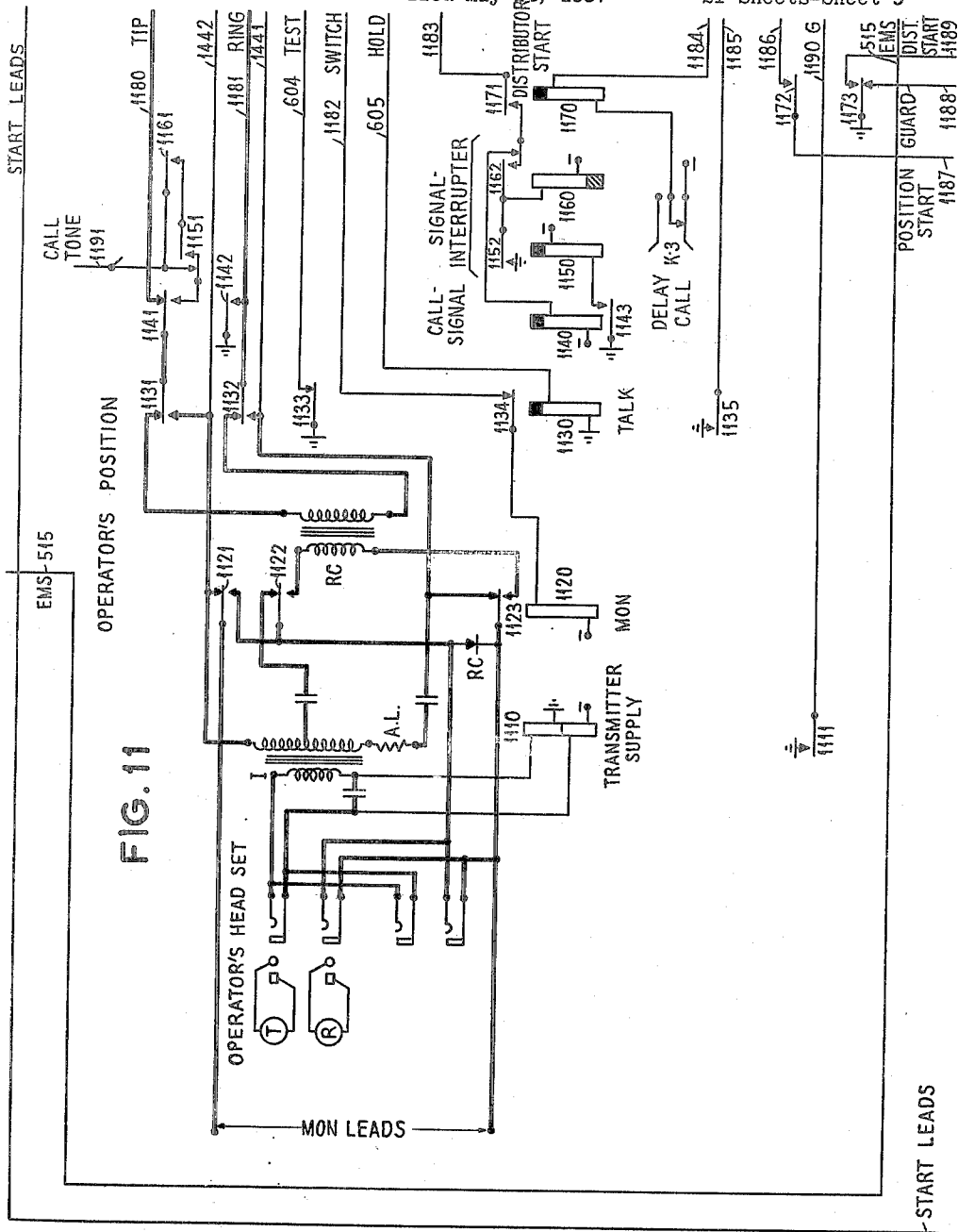
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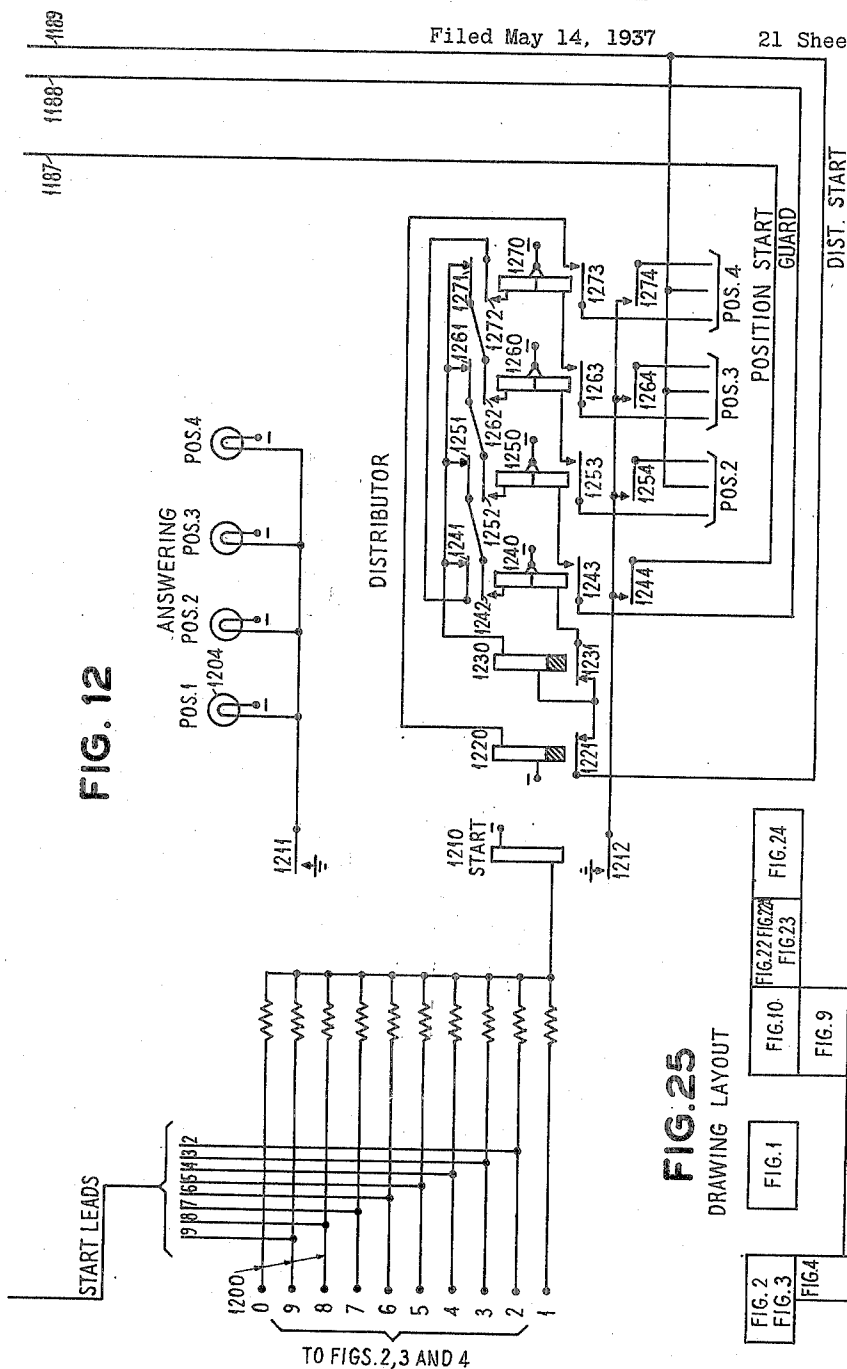


FIG. 12

FIG. 25

DRAWING LAYOUT

FIG. 1	FIG. 10	FIG. 22 FIG. 23	FIG. 24
FIG. 2	FIG. 3	FIG. 9	FIG. 19
FIG. 4	FIG. 5	FIG. 8	FIG. 18
FIG. 6	FIG. 7	FIG. 17	FIG. 20
FIG. 11	FIG. 13	FIG. 16	FIG. 21
FIG. 12	FIG. 14	FIG. 15	

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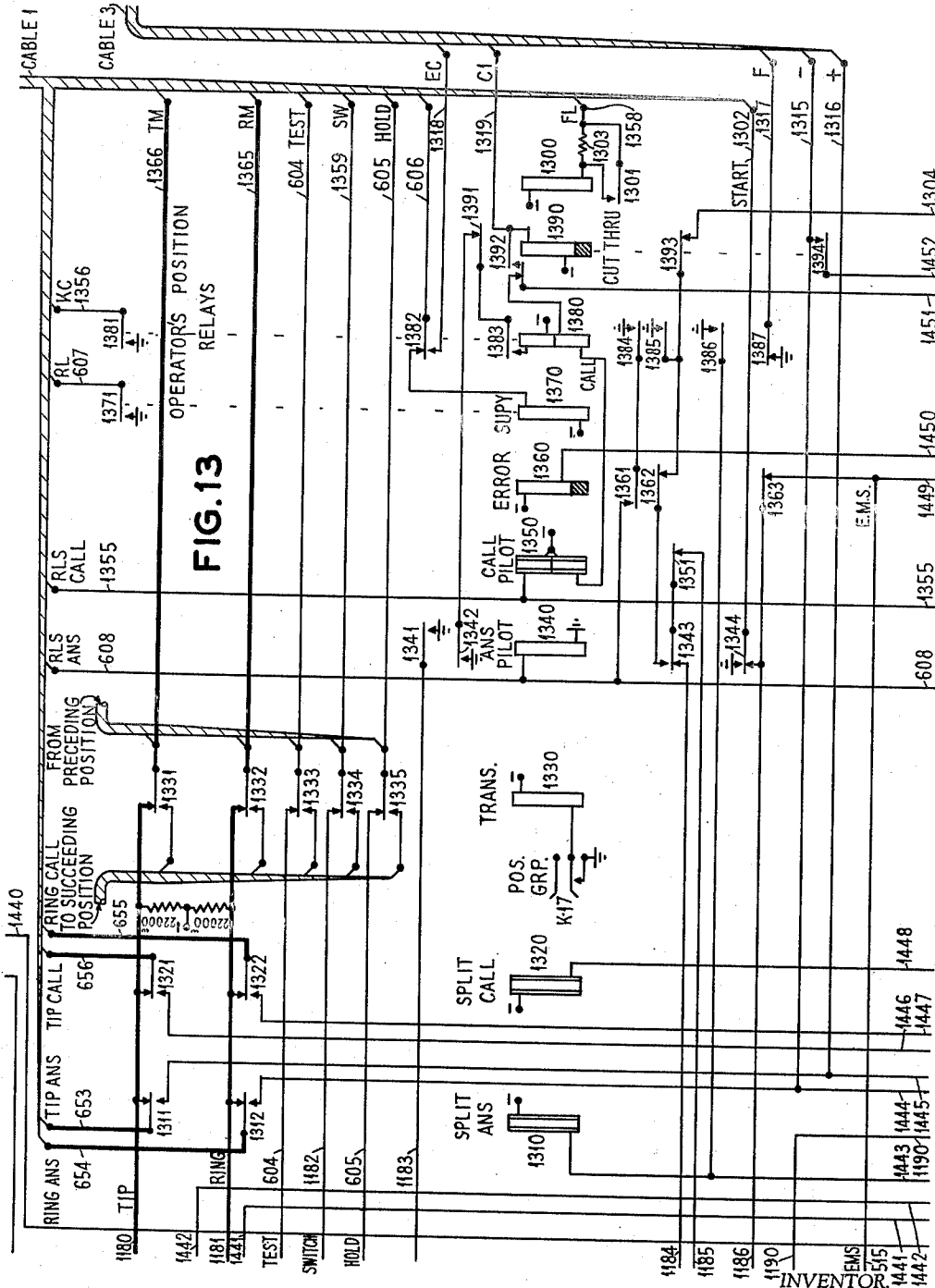
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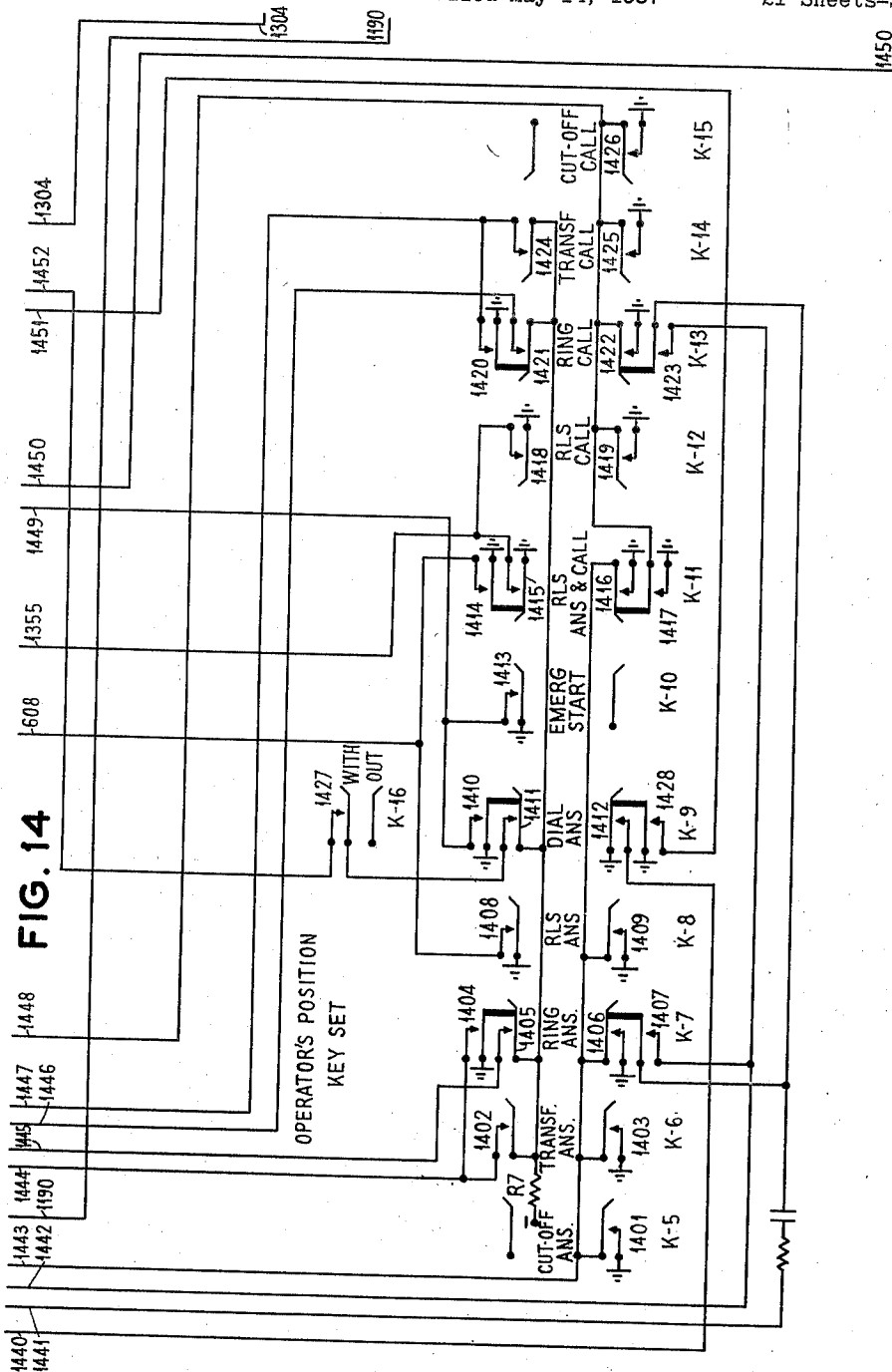
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21 Sheets-Sheet 12



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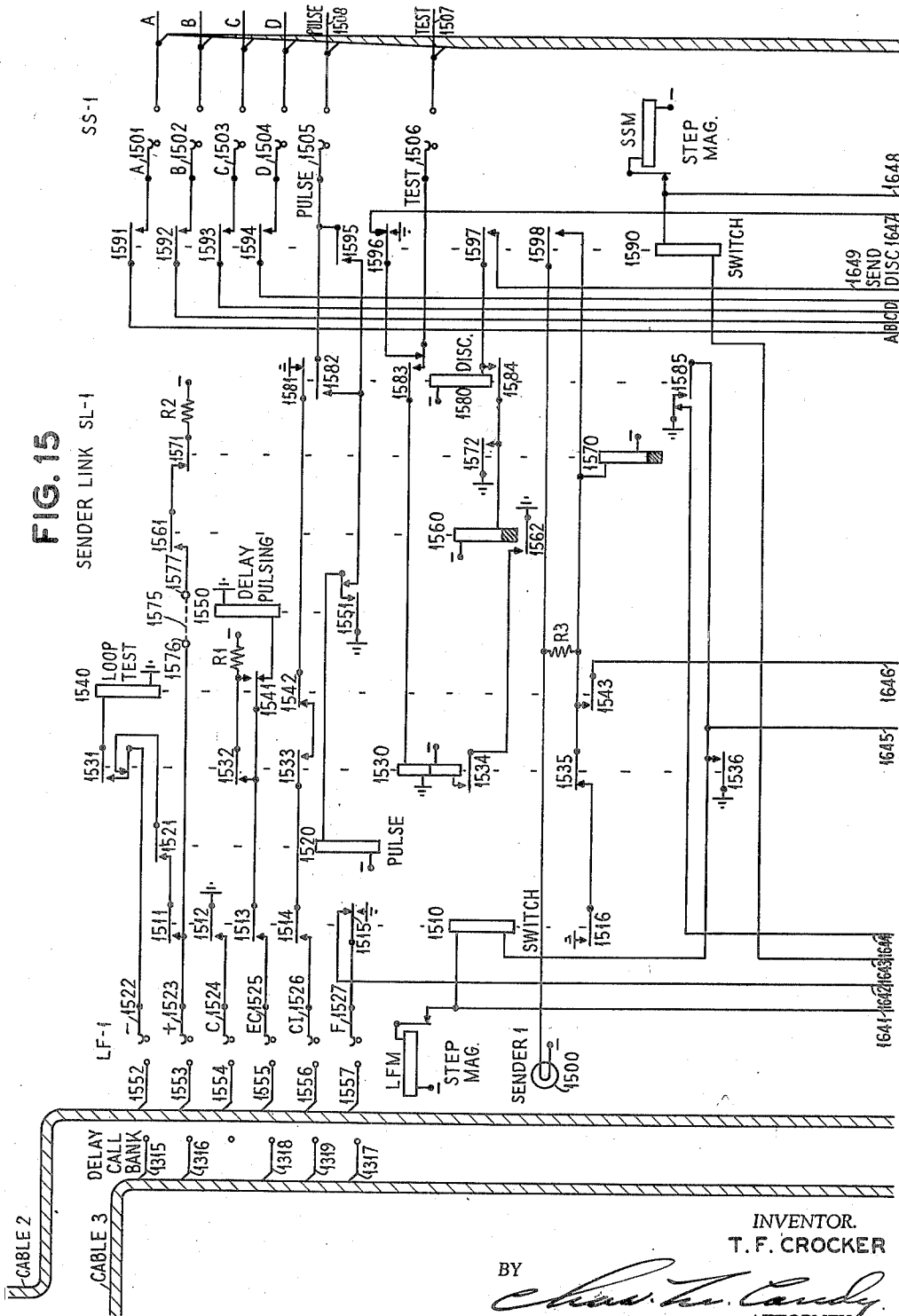
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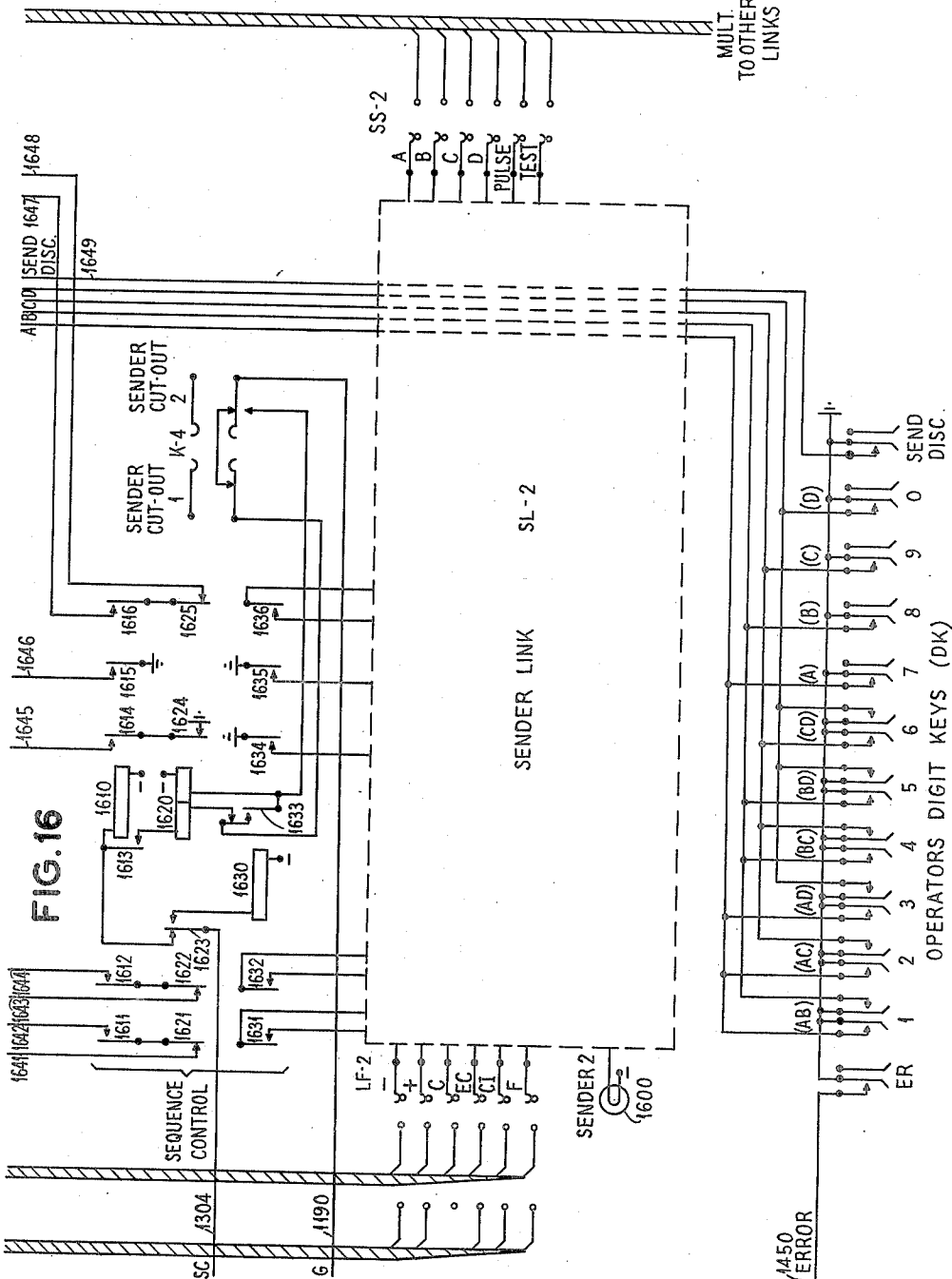
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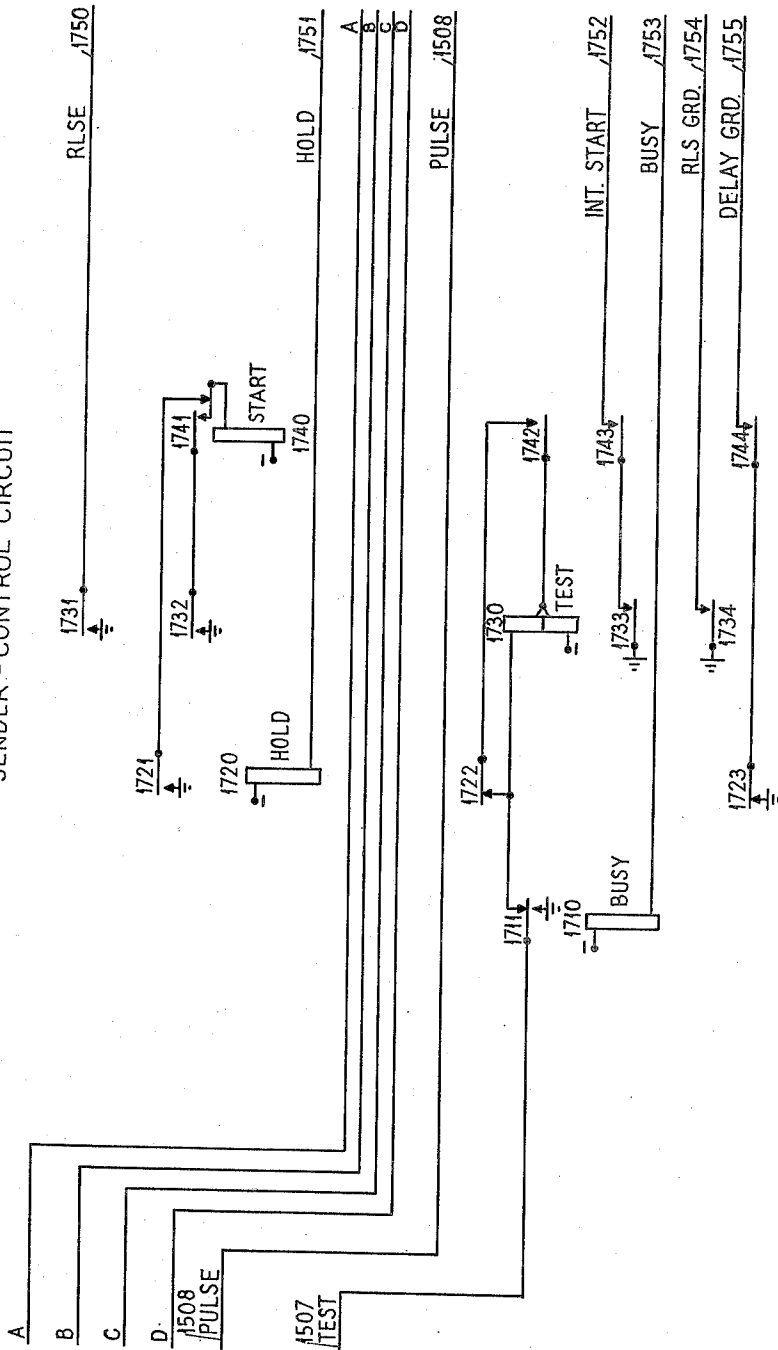
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FIG. 17

SENDER - CONTROL CIRCUIT



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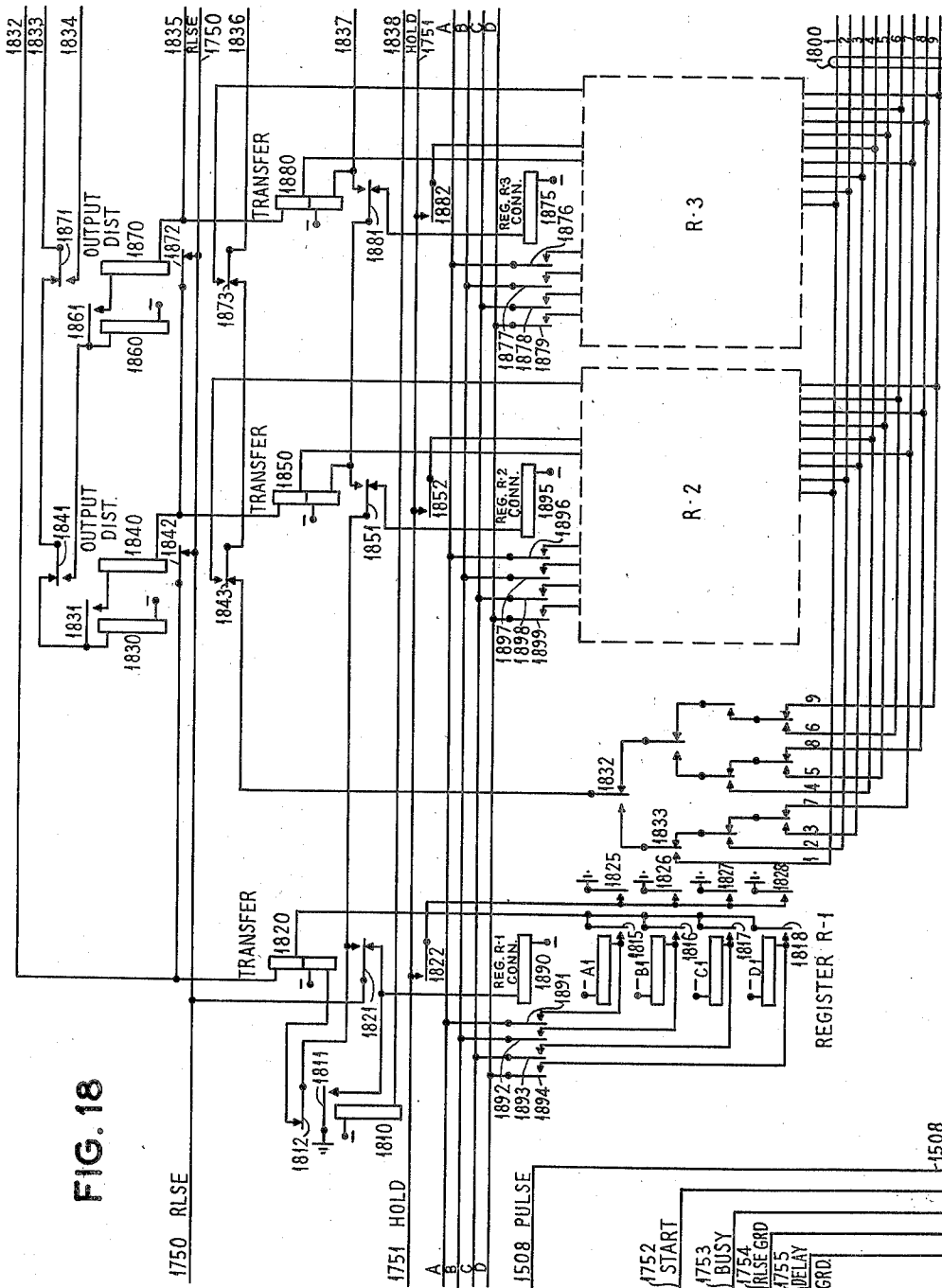
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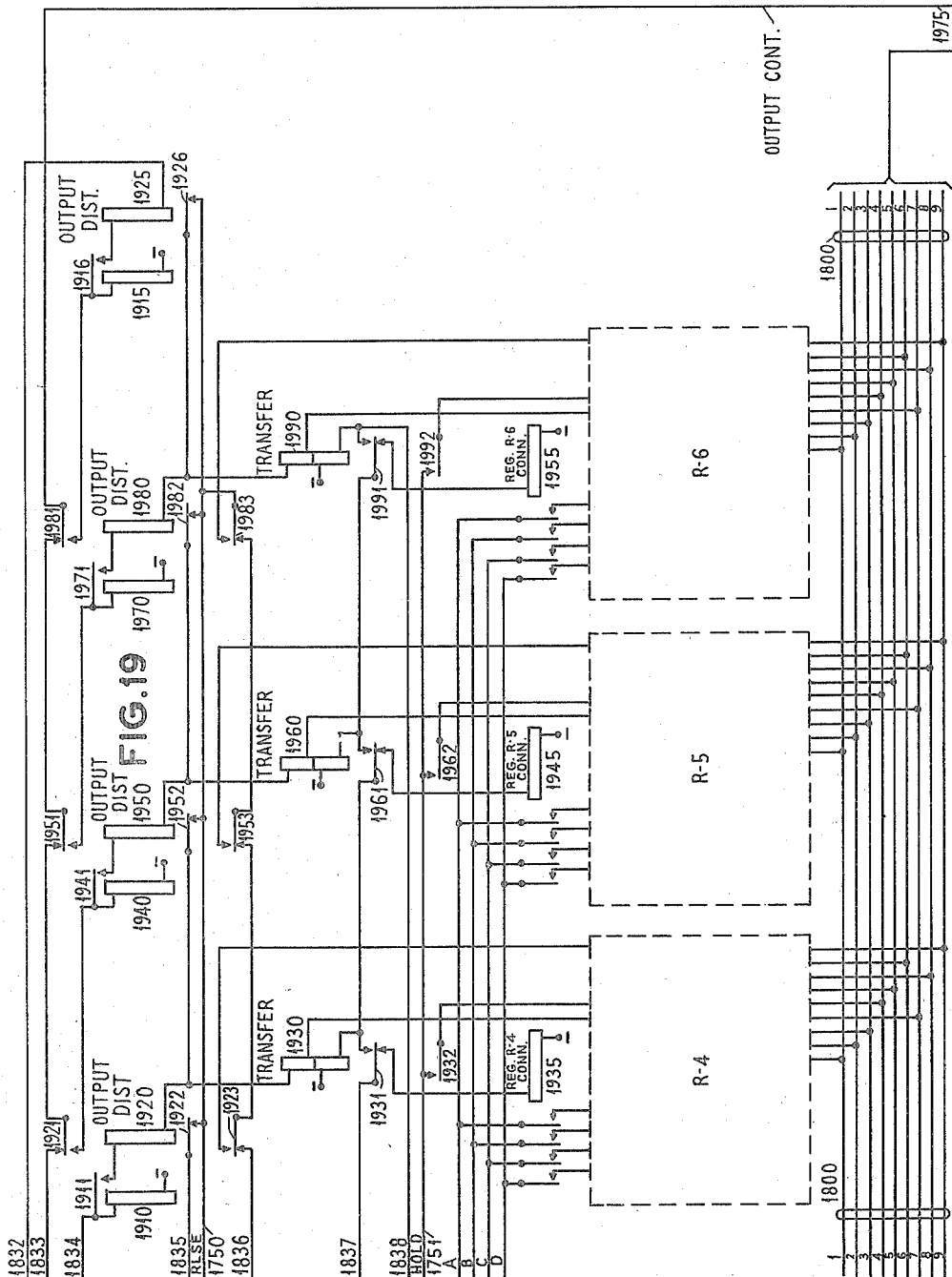
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21 Sheets-Sheet 17



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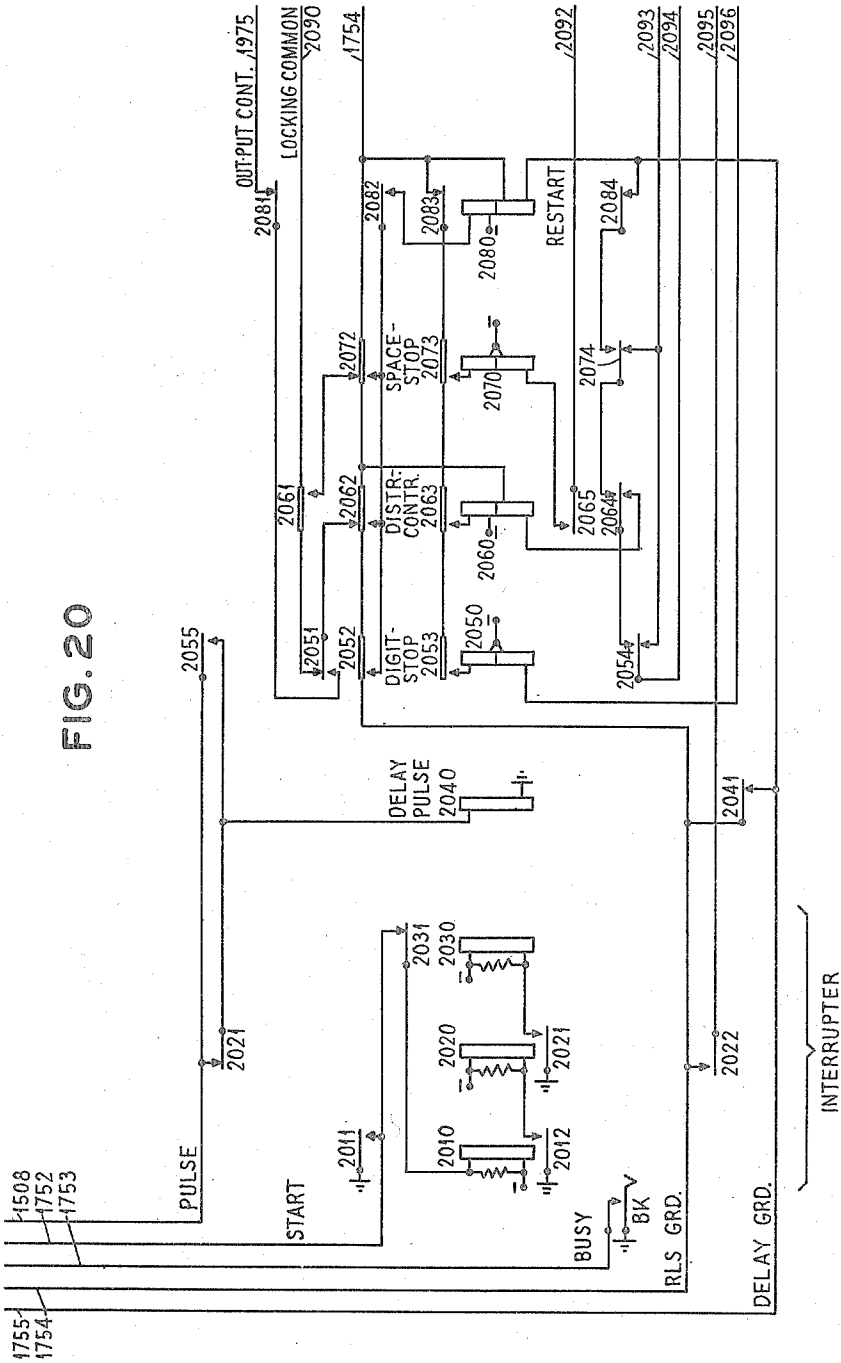
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FIG. 20



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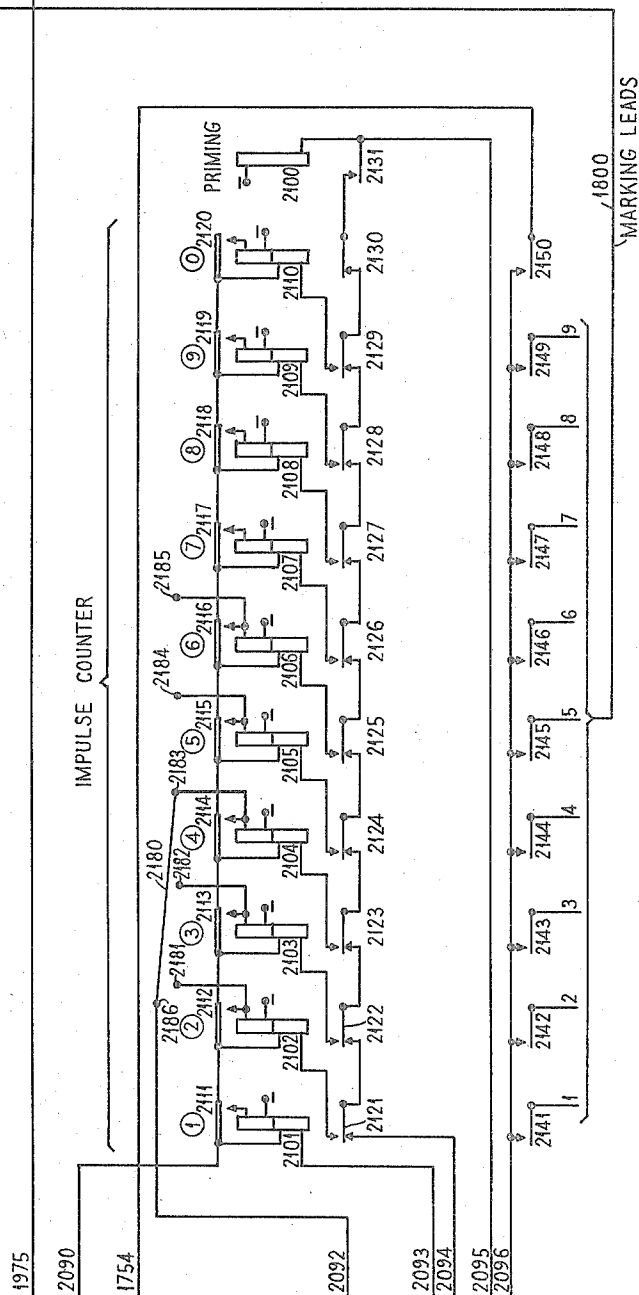
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FIG. 21



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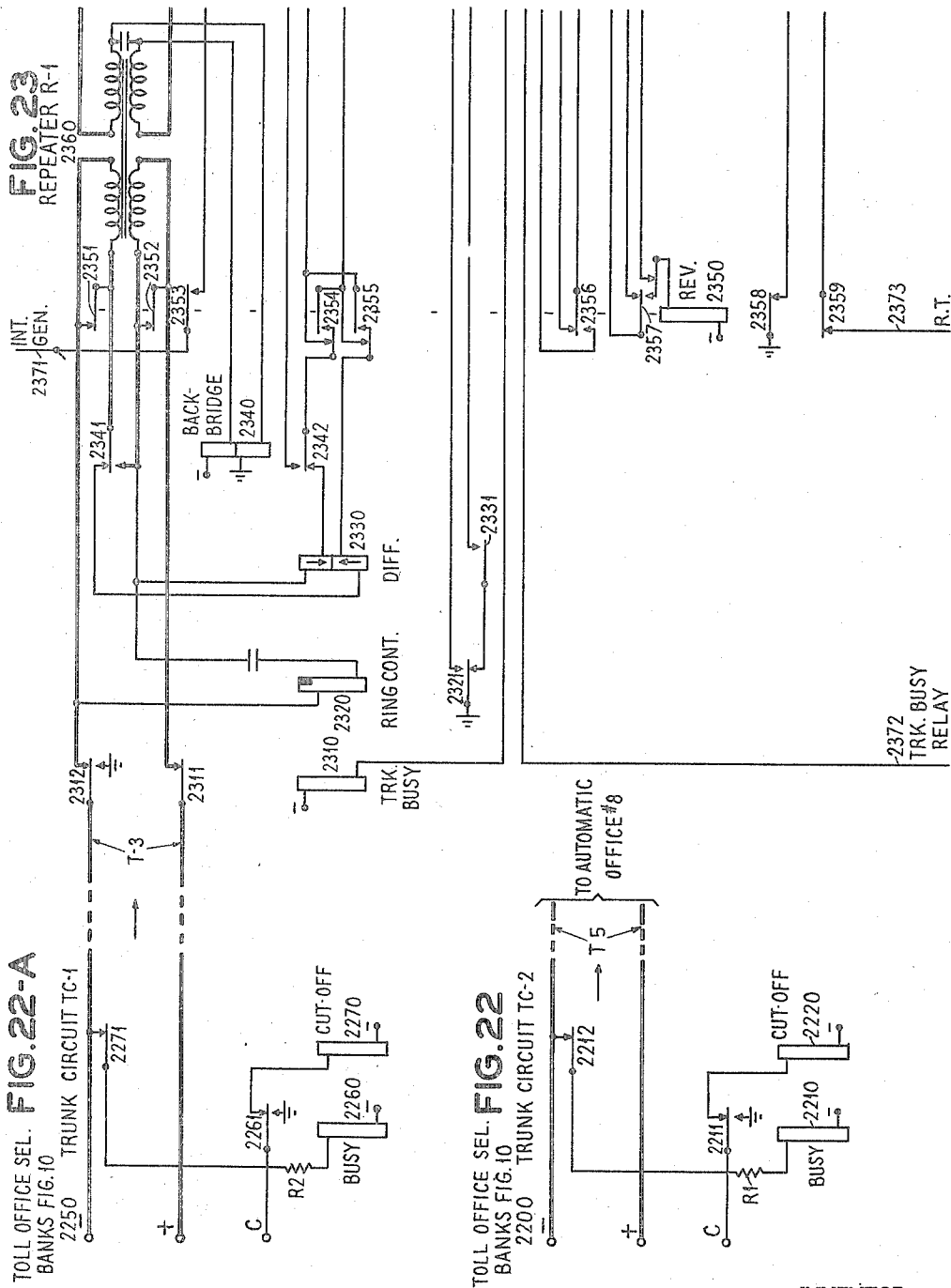
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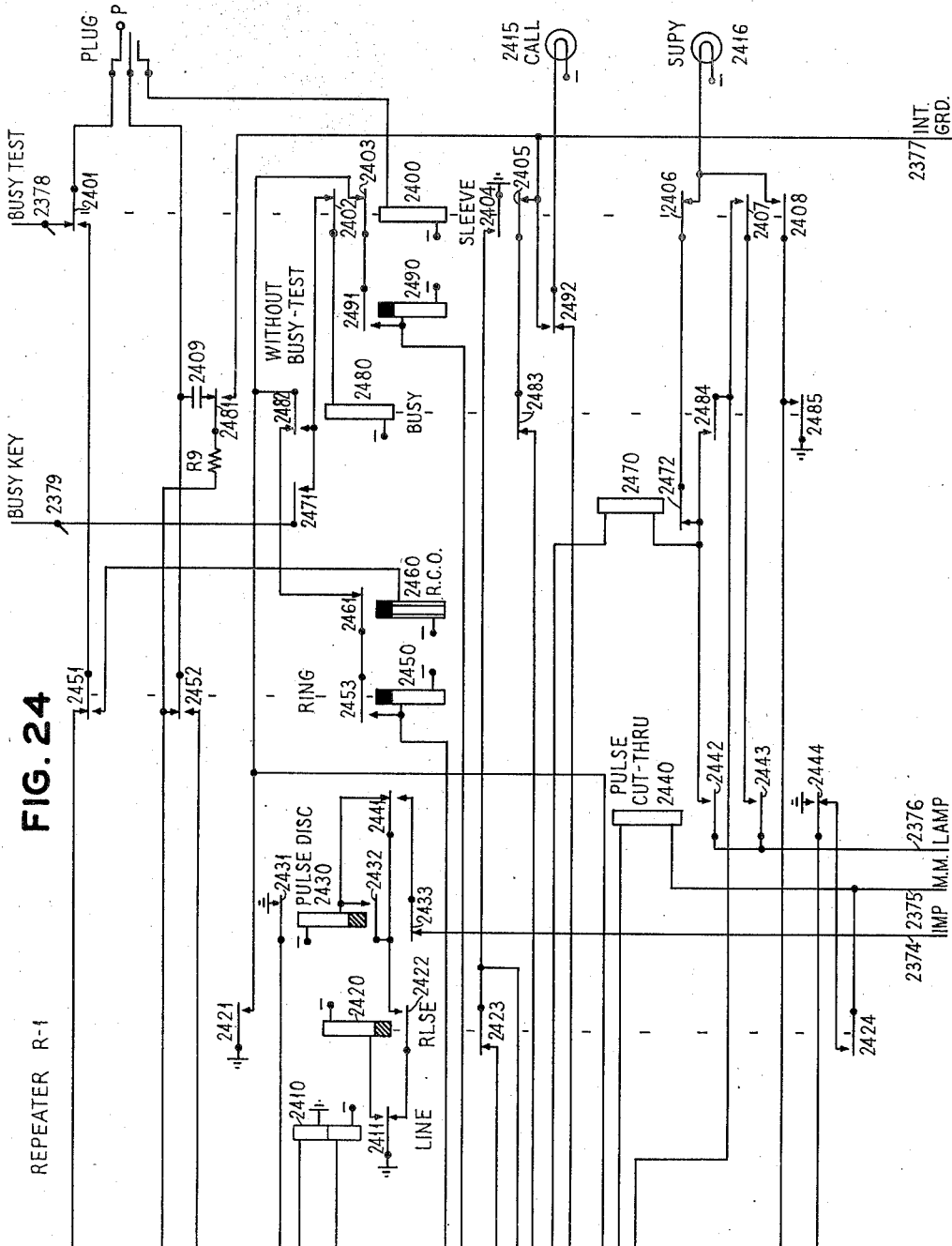
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UNITED STATES PATENT OFFICE

2,167,710

TELEPHONE SYSTEM

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Application May 14, 1937, Serial No. 142,558

40 Claims. (Cl. 179—27)

This invention relates to telephone systems in general, but is concerned more particularly with automatic switching arrangements for handling toll traffic in such systems. The main object of the invention is the provision of new and improved switching apparatus and operating methods for toll switchboards to enable toll operators to establish and supervise connections more efficiently.

GENERAL DESCRIPTION

The accepted practice for handling toll switching at a centralized toll switchboard in an exchange area having several local exchanges, ordinarily consists in dividing the several sections of the tollboard into three distinct groups, such as, inward, recording, and delay or point-to-point positions. Incoming calls to toll lines from other exchange areas are answered by switching operators at the inward position and are either completed directly or transferred to a delay or point-to-point position for completion. Through calls; that is, calls in which the switchboard serves as a tandem switching point, are handled at the inward position in much the same manner as incoming calls. Outgoing calls originating in either local automatic or local manual exchanges and destined to be trunked over toll lines leading to other exchanges, are answered by switching operators at the recording position of the toll board. The recording operators make out toll tickets for the calls and may either complete the calls directly or pass the ticket to a delay or point-to-point position for completion. In handling a delay or point-to-point call, the operator sets up a connection from her position to each of the lines involved. This type of connection is also referred to as a tail-to-tail connection.

One of the features of the switchboard disclosed herein is that an operator at a recording position can change her position, by the operation of a key, from a recording position to a delay or point-to-point position, and an operator at a delay position can convert her position to a recording position by restoring a key. Therefore, each recording and delay position is a universal position and can be changed from one class of service to the other at will, depending more or less, upon the traffic conditions.

Another feature of the invention relates to the method of handling toll calls from subscribers of a local manual exchange in a central office area. As is disclosed herein, the recording trunks from a local manual A-operator's switchboard are not arranged for CLR service (combined line

and recording service). Therefore, calls over these trunks are not extended to toll direct, but the calling subscribers are called back by the CLR (recording) operator via call indicator equipment at the local manual exchange, and an attempt is then made by the recording operator to complete the desired toll connection. The original connection set up by the local manual A operator is released by the recording operator as soon as the local manual subscriber is reached by way of the call indicator equipment. This arrangement is necessary in this case because the cord circuits at the local manual A operator's positions are not arranged to provide the necessary supervision to the CLR operators at the central office on toll calls, and it would be impracticable to change all the existing cord circuits to provide such supervision. Therefore, call indicating B operator's equipment is provided at the local manual exchange to give the CLR operator the usual switchhook supervision required on toll connections. A special flashing signal is also provided, which is controlled from the CLR operators' positions of the toll board, to indicate to a B operator that a particular connection is to be extended without making the usual tip busy test.

Another feature is the arrangement for controlling the transmission of ringing current. When a connection is extended from an inward position of the switchboard, ringing current is automatically transmitted after the connection is extended, and when a connection is extended from a universal (recording point-to-point) position of the switchboard, the transmission of the ringing current is controlled manually from a ringing key. All positions of the toll switchboard are arranged for manual control reringing.

Another feature is the arrangement provided whereby any toll operator can control the application of a trouble tone to defective toll lines in order to mark such lines "in trouble".

Another feature is the arrangement for delaying the transmission of additional digits by the register sender equipment when prolonged hunting time is required by level-hunting switches. This delay control is effective until the hunting switch seizes an idle trunk, thereby preventing further impulses from being transmitted before a succeeding switch is in a position to receive them.

Another feature is the transfer call arrangement by means of which any operator can transfer a received call to any other desired operator's position in the toll switchboard. The selected

operator receives a transfer call signal and is automatically connected to the calling operator's trunk. Other incoming calls are prevented from being received at the selected operator's position until the transfer call is set up.

Another feature is the arrangement whereby an operator (by operating an emergency key) can provide a starting ground potential for finder link circuits in the event that there is a failure in the distributor equipment.

Another feature is the provision of a series relay in the control (C) conductor of finders to control the supervisory lamp at the toll operator's position. The series relay may either be connected to give lock supervision of flash supervision, according to the class of service being handled at the particular toll operator's position that the finder is located.

Another feature is the provision of a disconnect key which is operated after the toll operator has controlled her digit key in accordance with the called number or toll line number, in order to automatically disconnect the register sender equipment when all the digits registered thereon have been retransmitted.

Another feature is the provision of a register sender having less registers than there are digits in a particular called number. This is accomplished by resetting the registers as many times as is required to transmit a called number. The sender portion of the register sender starts transmitting switch operating impulses as soon as a registration is made on the first register and continues transmitting impulses corresponding to the registrations on succeeding registers. Each of the registers in turn are restored to normal as soon as the sender has transmitted impulses corresponding to the registration thereon and can be reset to register subsequent digits of the called number while the sender is still transmitting impulses corresponding to the registrations on operated registers.

The foregoing features, together with others not specifically mentioned, will be understood best upon a further perusal of the description.

Description of drawings

Referring now to the accompanying drawings, comprising Figs. 1 to 25, inclusive, they show by means of the usual circuit diagrams, a sufficient amount of the apparatus involved in a toll switching system to enable the invention to be understood.

Fig. 1 shows a trunking diagram illustrating the local and toll trunking arrangements of a central office exchange area;

Figs. 2 to 24, inclusive, are circuit diagrams;

Fig. 25, drawn on the same sheet with Fig. 12, is a layout diagram showing how the various sheets of drawings, Figs. 2 to 24, inclusive, should be arranged to be best understood.

The toll line routes

Referring now particularly to Fig. 1, the toll line route between exchanges will be discussed. The toll line TL—1 represents one of several groups of toll lines extending between distant exchanges and the central or toll switching office.

The toll line TL—2 is one of a group of toll lines extending between a distant office and the central office. The distant office in this particular instance is of the type shown in Fig. 2, part 2, of the application of John Wicks, Serial No. 109,671, filed November 7, 1936, and the trunk is referred to therein as trunk line TL—4,

Toll traffic over trunk line TL—2, which is either tandemed through or originated in the central office, may be completed to the desired line terminating in the exchange at the distant end through the automatic switches thereat in response to the transmission of controlling voice frequency impulses transmitted over the toll line such as TL—2. Similarly, toll traffic arriving at or originating at the distant end of trunk line TL—2 may be completed to a desired line in the central office area through the automatic switches in the central office responsive to the transmission of voice frequency impulses over the toll line such as TL—2. In addition, toll traffic originating at the distant end of trunk line TL—2 which is destined to be trunked to distant toll offices over trunk line TL—1, are likewise set up by the medium of the switching arrangements at the central office responsive to the voice frequency impulses received over trunk line TL—2.

The central office exchange employs 2 six-digit numbering system, of which the first two digits designate the desired office in the exchange area, while the remaining four digits designate the desired line in the particular office selected. The various offices in the central office exchange area may be considered to be local offices and may be either manual or automatic exchanges. In the particular embodiment shown, a local automatic office, referred to as office #8, is accessible from the eighth level of the toll office selector TOS in the central office. In addition, a local manual office, referred to as office #4, is accessible from the fourth level of the toll office selector TOS in the central office and the inter-office trunks terminate in a call indicator or B-operator's positions at the local manual exchange. Each of the above local offices is housed in a separate office building, and the central office is accommodated in a still further building conveniently located with respect to serving as a terminus for inter-city toll lines. The Strowger switches in the central office exchange are indicated by a rectangle representative of the relays and mechanical equipment, below which the contact bank is indicated by ten short, heavy, horizontal lines, each of which indicates a separate level of the bank.

Referring now particularly to the automatic office #8 in the central office exchange area, represented by the dotted rectangle in the lower portion of Fig. 1, it will be noted that each line finder, such as finder F3, is paired with an office selector, such as office selector OS—1. When a call is initiated at a substation, such as substation A, a finder switch, such as finder F3, first searches for the level containing the calling line and then searches for the contact set in the level in which the line terminates. When the calling line is found, it is extended to the office selector OS—1. The office selector OS—1 responds to the first digit dialled by the calling subscriber, and raises its wipers (not shown) opposite the desired level of bank contacts and rotates them in search of an idle thousands selector in the called office. Levels two, three, and five, for example, are selected when calls are to be extended to local automatic offices #2, #3, and #5. If the call originated at substation A is a local call, the first digit dialled is the digit 8, resulting in the office selector OS—1 extending the calling line to an idle local thousands selector, such as the thousands selector MS.

The thousands selector MS, has access to the groups of hundreds selectors and if the second

digit dialled is the digit 4, the call is extended to one of the hundred selectors HS—1 by way of the fourth level of the thousands selector MS. The hundreds selectors in the group containing the selector HS—1 have access in common to ten groups of connectors, one of which is the group containing the connector C—1. Assuming that the third digit dialled by the calling subscriber is the digit 1, the hundreds selector HS—1 extends the calling line to the connector C—1, which is one of the connectors in the hundreds group 841.

Each of the connectors in the group including connector C—1 have access to one-hundred subscriber lines, one of which is the line of substation A. If the two final digits of a number dialled after the connector C—1 has been reached are "6" and "1", the line of substation A is the one selected as the number of this line is 84161, as indicated.

From the foregoing description of the trunking layout in office #8 of the central office area, it will be understood that the trunking arrangement used is the standard and well known trunking system laid out according to the numbering system commonly used in exchanges utilizing the step-by-step Strowger switches.

The toll thousands selector TMS is one of a group of selectors provided in office #8 for handling incoming calls to office #8 from the central office. This selector has access to ten groups of toll-hundreds selectors, of which the toll-hundreds selector THS is representative of the fourth group. The various levels of the toll-hundreds selector have access to connectors which are provided solely for the completion of toll calls and also to combination toll and local connectors. The connector C—1 is one of the combination toll and local connectors. The arrangement discussed is well known, the trunking system through which calls are extended from toll lines to called subscribers' lines being what is commonly referred to as a toll service trunking system.

Outgoing toll calls from office #8 are originated by the subscribers responsive to the dialling of the digit "0". The office selectors, such as OS—1, are provided with trunks extending from the tenth level thereof to the central office toll board, one of which is the trunk T1 extending by way of the trunk circuit TC to the combined line and recording circuit CLR, associated with the central office toll board.

An automatic toll board is employed at the central office and is represented by the rectangles PE—1 and PE—2. The position equipment PE—1 terminates at one end in a finder switch, such as F—1, and at the other end in a toll first selector, such as TFS—2. The finder F—1 receives calls over toll lines, such as toll line TL—1, and extends them to an inward operator's position, such as PE—1. The universal operator's position equipment represented by the rectangle PE—2 terminates at one end in a finder switch, such as finder F—2 and in the other end in a toll first selector, such as TFS—1. The finder F—2 receives calls from the local manual offices in the central office area, such as represented by office #4, over trunk lines, such as T—2, from an A operator at the local manual office switchboard. The local manual switchboards are not arranged for CLR service, in that a call is not extended to toll direct from this trunk, but the calling subscriber is called back by the CLR operator (universal operator) over trunk line T—3 and

the call indicator equipment. An attempt is then made immediately to extend the call through to the desired toll line. As is the usual practice in this type of service, the original connection completed through the A-operator's position is released. The universal operator at position PE—2 also receives calls from the local automatic offices by way of trunk lines, such as T—1 and the finder F—2. These calls are extended from the local automatic offices by way of the tenth level of the office selector in the various automatic offices in the central office exchange area.

The toll first selector TFS—1, in common with other toll first selectors, has access to toll line selectors, such as TLS—1, which toll line selectors have access by way of trunks such as trunk T—4 to various toll lines, such as TL—1. On another of its levels, toll first selector TFS—1 has access to toll office selectors, such as TOS—1, which toll office selectors have access to groups of trunks extending to various local offices in the central office exchange area by way of trunk circuits, such as TC—1 and TC—2. One of these trunk circuits, reached from the fourth level of the selector TOS—1 extends to the call indicator, or B-operator's position at the local manual office #4, by way of the trunk line T—3. Another of these trunk circuits, reached from the eighth level of the selector TOS—1 extends to the incoming toll thousand selector TMS in the local automatic office #8, by way of the trunk line T—5.

On another of its levels, toll first selector TFS—1 has access to toll line selectors, such as TLS—2, which toll line selectors have access to the automatic or dial toll lines, such as TL—2. The connections over toll trunk line TL—2 are completed by way of toll line TL—4 referred to in the above-mentioned Wicks application. The toll line selector TLS—2 is a level hunting selector, and adjacent levels are assigned to the group of toll lines extending to a given exchange. On a call to any one of the exchanges accessible to the selector TLS—2, the wipers of the selector are directed to the lowest level in which toll lines are accessible, and if all the lines accessible in the selected level are busy, the selector is automatically given an additional vertical movement to bring it into association with one or more of the higher levels in the group of lines until the level reached is one in which an idle toll line is available. It is to be noted that the digit 4 is transmitted to the toll first selector TFS—1 to cause it to select a selector in the group represented by the toll line selector TLS—2. If the digit 6 is then dialled, the call is directed by way of one of the levels 6—8, inclusive, to select an idle trunk line extending to the distant office by way of toll line TL—2.

Each toll line TL—2 is provided with an incoming selector, such as TFS—4, in order that incoming toll calls to the central office area can be handled automatically responsive to the voice frequency impulses received over the toll line in use. A group of selectors, such as selectors TFS—4, are assigned to the toll lines, such as TL—2, and the banks of these selectors are connected in multiple with the toll first selectors, such as TFS—1, TFS—2, and TFS—3, whereby digits received over these toll lines have the same trunking effect as digits received from the central office inward operators' positions, such as PE—1 and the universal operators' positions, such as PE—2.

It should be noted that the first level of the right-hand (lower) bank of the finder F—2 is set aside and connected directly to the toll first selectors, such as TFS—3. The trunks in this level are provided to enable the universal operators to make delay calls. Toll calls to certain towns or calls which cannot be immediately completed by one of the CLR operators are handled by the delayed method. Tickets for such calls are passed from the CLR operators to the so-called point-to-point operators. The point-to-point and CLR operators' positions are exactly alike, except that each point-to-point position is equipped with a delayed call key which is normally operated. However, each CLR operator's position is also provided with a delayed call key and a CLR operator can, by operating her delayed call key, make such delayed calls. Therefore, the CLR and point-to-point positions can be changed from one to the other class of service to meet the traffic being handled by means of the delayed call keys.

The transfer selectors, such as selector TS, are accessible from the ninth level of the toll first selectors TFS—1 to 4, inclusive, and are provided to enable the operators at either the inward or universal positions to transfer a call from one position to any other position by dialling the digit 9 plus the called position number. This operation applies particularly to an incoming toll call for a particular universal operator, which call is received via toll line TL—1 at an inward operator's position and is then forwarded to the called universal operator's position. The inter-position transfer circuits, such as ITC—1 and ITC—2, are accessible from various levels of the trunk selector, such as TS, and are provided for starting a finder at a selected operator's position, in operation in the well known manner.

Attention is called to the fact that the impulse repeater IR—2, the tone-unit TU—2, and the voice current repeater VCR, which are connected in the toll line TL—2, are exactly the same as those disclosed in the above-mentioned Wicks application. Since this equipment forms no part of this invention it has merely been shown to more clearly explain the connections between the central office and the distant office by way of toll line TL—2.

For the purpose of enabling the operators at the inward and universal positions to set up calls rapidly, a group of register senders is provided, of which the register sender RS is one. For the purpose of controlling these registers and associating them with the sender links over which their impulses are to be delivered, each operator is provided with two sender links, as indicated at SL—1 and SL—2 for inward position PE—1 and SL—3 and SL—4 for universal position PE—2. The digit keys at each of the operators' positions may be connected interchangeably to either of the two links associated with each position, the choice of the sender links being automatic, as will be pointed out later.

The sender link SL—1 has link finder LF—1 associated therewith, for connecting the sender link SL—1 to the finders, such as F—1 common to the operator's position. The sender selector SS—1, associated with the link SL—3 has access to the register sender RS and to other register senders, all of which are provided for the common use of all the operators. The sender links SL—2, SL—3, and SL—4 are similarly provided with link finders LF—2, LF—3, and LF—4, re-

spectively, together with sender selectors SS—2, SS—3, and SS—4, respectively.

General description of drawings

The trunking arrangement as disclosed in Fig. 1 having been described, further attention is directed to the circuit drawings shown in Figs. 2 to 24, inclusive:

Fig. 2 shows the toll line circuit TLC interposed between the two-way toll line TL—1 of Fig. 1 and the finder bank terminals 297 and the multiples thereof, of finder switch F1 shown in Fig. 6. This trunk circuit serves as a terminus for the trunk T—4 from the bank terminals 275 of selector TLS—1, Figs. 1 and 9, and multiples thereof in the banks of other selectors. The common start conductor 286 which extends to the distributor shown in Fig. 2, is also multipled to the level marking bank of the finder switch of Fig. 6 to mark the particular level in which the finder may find the calling toll line circuit. All incoming calls over toll line TL—1 are answered by an inward operator;

Fig. 3 shows the combined line and recording trunk CLR interposed between the two-conductor trunk T—1 incoming from the tenth level of the office selector OS—1 and the trunk circuit TC in the local automatic office #8, and the finder switch bank terminals 360 of the finder F—1 of Fig. 6, (F—2 of Fig. 1), and the multiples thereof in the banks of other similar finders. Incoming calls received over this trunk line are handled by the CLR operator at a universal position of the switchboard. Since the finder switches F—1 and F—2 together with the inward operator's equipment and the universal operator's equipment are similar, except for slight modifications that will be pointed out hereinafter, only one finder switch F—1, Fig. 6, and only one operator's position equipment PE—1 has been shown, in order to simplify the circuit diagram as much as possible. The common start conductor 313 is connected to the start relay of the distributor circuit shown in Fig. 12 and is multipled to the level marking bank of the finder switch of Fig. 6 and connected to the particular level of which the finder can find the calling trunk T—1;

Fig. 4 shows a manual recording trunk circuit MR interposed between the two-conductor trunk T—2, incoming from a local manual exchange #4 in the central office area and the bank terminals 460 of the finder F—1 of Fig. 6 (F—2 of Fig. 1), and the multiples thereof in the banks of other similar finders. The start conductor 445 is connected to the start relay of the distributor in Fig. 12 and multipled to the level marking bank of the finder F—1 to mark the level in the finder bank in which the manual recording trunk can be found;

Fig. 5 shows an inter-position transfer circuit ITC—2 interposed between the banks of the transfer-selector TS of Figs. 1 and 9 and the banks of the finder switch F—1 of Fig. 6 (F—2 of Fig. 1) and the multiples thereof in the banks of other finders. The inter-position transfer circuit is provided to enable a toll operator at one position to transfer a call to an operator at any other toll position. The common start conductor 524 is connected directly to the level marking bank of the finder F—1 of Fig. 6 (F—2 of Fig. 1), to mark the first level in the bank to enable the finder to find the calling inter-position transfer circuit. The emergency start conductor 515 is provided so that the finder will start immediately

regardless of the condition of the distributor circuit of Fig. 12;

Fig. 6 shows a finder F—1, associated with the position equipment of Figs. 11, 13, and 14. The finder switch is of the vertical and rotary Strowger type, having wipers which are moved first in a vertical direction and then in a rotary direction to find the contacts of the calling line. The wipers 618 of the finder are shown in the left-hand side of Fig. 6. Since in the present embodiment of this invention a finder of 200 line capacity is being used, the switch is provided with two complete sets of wipers, the wipers —1, +1, C1, and EC1, forming one set of wipers, and the wipers —2, +2, C2, and EC2, forming the second set. The set of wipers used in a connection being determined by the operation of the relay 610 or 620 over a circuit including one of the test wipers (C1 or C2) and the marking potential of the calling line. The finder circuit is provided with a talking key K1 and a monitoring key K2, and is connected directly through contacts of the monitoring key to an associated toll first selector TFS—1 of Fig. 7. The toll first selector TFS—1 of Fig. 7 is individually associated with the finder. The trunk conductors associating the finder F—1 with the toll first selector TFS—1 of Fig. 7, are multiplexed to the banks of the link finders such as LF—1 and LF—2 of Figs. 15 and 16, respectively. The finder circuits such as F1 are accessible to toll line circuits TLC of Fig. 2, to combined line and recording trunk circuits CLR of Fig. 3, to manual recording trunk circuits MR of Fig. 4, and by way of the first level of each bank, has access to inter-position transfer circuits ITC—2 of Fig. 5;

Fig. 7 shows a toll first selector TFS—1 which is directly associated with the finder F—1 of Fig. 6. This toll first selector TFS—1 is exactly the same as the other toll first selectors TFS—2, TFS—3 and TFS—4 shown in Fig. 1. These switches have access by way of their multiple bank contacts to various other switches, as is shown in Fig. 1;

Fig. 8 shows the toll line selector TLS—2 which is accessible from the fourth level of the toll first selectors TFS—1 to TFS—4, inclusive, and which has access to the voice frequency toll lines TS—2 by way of repeater IR—2, by way of levels 6, 7, and 8 of its banks, as shown in Fig. 1;

Fig. 9 shows a toll line selector TFS—1 which is accessible to the toll first selectors, such as TFS—1 to TFS—4, inclusive, and which has access to a toll line, such as TL—1, by way of various levels in its bank, as is shown in Fig. 1. The transfer selectors TS shown in Fig. 1 which are accessible from the ninth level of the toll first selectors, such as TFS—1 to TFS—4, inclusive, are the same as the toll line selector TLS—1 of Fig. 9, and have access, by way of its bank contacts to inter-position transfer circuits ITS—1 and ITC—2 of Fig. 5, as is shown in the trunking diagram, Fig. 1;

Fig. 10 shows the toll office selector TOS—1 which is accessible from the second level of the toll first selectors such as TFS—1 to TFS—4, inclusive, and which has access by way of the eighth level of its banks and the trunk circuit TC—2 to inter-office trunk lines extending to incoming toll thousands selectors, such as the toll thousand selector TMS in the automatic office #8, shown in the trunking diagram, Fig. 1. In addition, the toll office selector TOS has access by way of the fourth level of its banks and the trunk circuit TC—1 to trunk lines extending

to local manual office #4 call indicator positions. The trunk circuits TC—1 and TC—2 referred to in Fig. 1 are shown in detail in Fig. 22A and Fig. 22, respectively;

Figs. 11 and 13 together show the operator's position equipment and relays which are common to all of the finder circuits, such as F—1, at the same positions which are operatively connected thereto one at a time by the operation of the talking keys of the finder circuits;

Fig. 12 shows the start conductors 1200 (which are joined to the individual start conductors of line circuits such as shown in Figs. 2, 3, and 4, according to the finder bank levels through which these circuits are reached) for controlling the common start relay 1210, and for guiding the finders to the proper level as they search for calling lines. Fig. 12 also shows the distributor common to the various positions of the switchboard for distributing incoming calls to the various operators;

Fig. 14 shows the operator's position keys K—5 to K—16, inclusive, which are provided to take care of the various controlling operations;

Fig. 15 shows the sender link SL—1, together with the link finder LF—1 and the sender selector switch SS—1. The sender selector switch SS—1 associates an idle register sender with the sender link SL—1 and the link finder LF—1 associates the sender link SL—1 with a finder switch and its associated toll first selector such as F—1 of Fig. 6 and TFS of Fig. 7, respectively. When tail-to-tail connections are made the operator can control the link finder LF—1 to associate the sender link SL—1 with her position equipment in order to extend a connection by way of the answering end of the finders;

Fig. 16 shows the sender link SL—2 together with the associated equipment including the sequence control relays and the operator's digit keys DK. The sender link SL—2 is shown by means of a dotted rectangle and is exactly the same as the sender link SL—1 of Fig. 15. Each operator's position has two such sender links common to the position;

Fig. 17 shows the sender control circuit of the register sender;

Figs. 18 and 19 show the register controlling relays together with the registers R—1 to R—6, inclusive. Since the registers R—2 to R—6, inclusive, are identical with that shown for register R—1, they have been indicated by dotted rectangles;

Fig. 20 shows the interrupter circuit and the controlling relays for the sender;

Fig. 21 shows the impulse counter for controlling the retransmission of impulses indicative of the digits set up on the various registers;

Figs. 22 and 22A, which are shown in the same sheet with Fig. 23, show identical trunk circuits TC—2 and TC—1, respectively, which are accessible from different levels of the toll line selectors, such as TLS of Fig. 10. Trunk circuit TC—2 is connected in the trunk line T—5 extending to the automatic exchange #8 and trunk circuit TC—1 is connected in the trunk line T—3 extending to the manual exchange #4, as is shown in Fig. 1;

Fig. 23, on the same sheet with Figs. 22 and 22A, shows a portion of the repeater R—1 at the local manual office #4, which is associated with the call indicator equipment CI—1, as is shown in Fig. 1;

Fig. 24 shows the remaining portion of the repeater R—1 of Fig. 23 together with the super-

visory lamps and the plug at the B-operator's position;

Fig. 25, drawn on the same sheet with Fig. 12, is a layout diagram showing how the various sheets of drawings should be arranged to be best understood.

DETAILED DESCRIPTION

The disclosure having been described generally, a detailed description of the operation of the system will now be given.

Calling from local automatic exchange #8 to toll

In order to describe how connections are completed from the toll board at the central office to an exchange employing a manual toll board, it will be assumed that a subscriber in a local automatic exchange in the central office area (for example, the subscriber at substation A, Fig. 1, of automatic office #8) desires to converse with a subscriber reached by way of the trunk line TL-1 of Fig. 1.

Calling the central office toll board

In order to establish a connection with the central office toll board, the subscriber at substation A removes his receiver and thereby obtains connection with an office selector, such as OS-1, Fig. 1, by way of the finder F-3. When the subscriber dials the digit 0, assigned to the toll board, the office selector OS-1 selects an idle trunk extending to the toll board by way of a trunk circuit, such as TC. Assuming that the trunk circuit TC is the first one found to be idle, this trunk circuit is seized, whereupon it passes into a calling condition to extend the call over the trunk R-1 to the toll board by way of the CLR (combined line and recording) circuit CLR, Figs. 1 and 3.

In Fig. 3, it will be noted that the incoming conductors of the trunk T-1 extend to the line side of the repeating coil 300. Accordingly, when the calling condition is impressed on the trunk T-1 by the trunk circuit TC, Fig. 1, (which calling condition is characterized by a ground or positive potential on the negative conductor and a negative potential on the positive conductor of the trunk T-1). Line relay 340 in the circuit CLR operates, as its two windings (in series with the upper winding of supervisory relay 330) are connected in series with the conductors of the trunk T-1 by way of the line windings of the repeating coil 300. Due to the high resistance of the upper winding of line relay 340, supervisory relay 330 does not operate. At armature 341, line relay 340 places a negative potential on the C terminal 360 and the multiples thereof by way of contacts 331 of the supervisory relay 330 and the lower winding of the cut-off relay 320, shunting by the circuit including the resistance R and the upper winding of cut-off relay 320. This negative potential marks the line circuit CLR as calling in the banks of the finders having access to it.

At armature 342, line relay 340 closes a circuit for the lower or polarizing winding of the electro-polarized supervisory relay 330. A branch circuit extends through armatures 332 of supervisory relay 330, armatures 322 of cut-off relay 320, to the winding of start relay 310. The supervisory relay 330 does not operate at this time because the current flow in the upper winding of the relay is opposing the current flow through its lower winding. The start relay 310 operates, and at armature 311 opens a point in the answering supervisory circuit, while at armature 312 it places a ground potential on the common start

conductor 313 to mark the level in the banks of the finder F-1, Fig. 6, in which the CLR trunk is connected and to operate the start relay 1210 of Fig. 12.

When the common start conductor 313 is grounded by the operation of start relay 310 the distributor start relay 1210 operates. At armature 1211, start relay 1210 completes a circuit for lighting the answering pilot lamps at the various operators' positions. At armature 1212, start relay 1210 prepares a circuit for grounding the various start conductors extending to the various operators' positions under control of the distributor relays as will be subsequently described.

The finder starting system

As above mentioned, the start conductor 313 associated with the combined line and recording trunk CLR, has been grounded by start relay 310 to cause a finder to find the terminals of the calling line circuit CLR. The finder starting circuit will now be explained.

Upon referring to Fig. 12, which shows the common start leads and the distributor, it will be noted that there are ten start leads, indicated generally by the reference number 1200 and having the numbers 1 to 10 applied thereto. These latter numerals indicate the levels of the finders (Fig. 6) with which the start conductor 2000 are respectively associated. Conductors 2 to 9 in group 1200, it will be observed, extend to the contacts of the bank of vertical wiper 617 of the finder F-1 which are engaged by this wiper when the main wipers 618 of the finder are opposite the second to ninth levels, respectively. These leads are employed to stop the finder opposite the first calling level reached by the main wipers of the switch as they move upward in answering a call, and they are multiplied to all of the finders, as is indicated by the common-connection symbol near the contacts of the bank of the vertical wiper 617. It will be observed that the tenth contact in the vertical bank of wiper 617 is permanently grounded so as to stop the finder when the tenth and final level is reached. This accounts for the fact that the tenth one of the conductors 1200, Fig. 12, is not connected with the start leads extending to the vertical bank of the finder.

Upon referring to Fig. 1, it will be noted that the first level of the finders lead to either interposition transfer circuits such as ITC-1 or to the toll first selectors such as TFS-3 over which delayed calls are voluntarily extended by the operator, for which reason there is no conductor in the group 1200 of start conductors associated with the first level of the finder bank.

All of the line circuits accessible to a given level of finders all ground the corresponding one of start leads 1200, Fig. 12, by way of the various start leads shown in Figs. 2, 3, and 4.

The common start relay 1210, Fig. 12, upon energizing responsive to a ground potential on one of the start conductors 1200, at armature 1211 completes a circuit for lighting the answering pilot light in each of the positions, such as the pilot lamp 1204, associated with position 1. Start relay 1210, at armature 1212 closes a circuit to the position start conductor of one of the four positions that has been preselected by the distributor, or to the next one to be selected if none has been preselected.

The preselection of a position by a distributor of Fig. 12, takes place in a manner which will now be pointed out. When the operators are not engaged in putting through or attending to a

call, they are preferably instructed to operate the talking key of an idle finder selector link in readiness for the arrival of a call. By means of indicating lamps associated with her finders, an operator is able to know which finders are in use and those that are idle. The call, answering, and busy lamps, 601, 602, and 603, respectively, Fig. 6, inform the operator at position 1 of the condition of the finder link composed of the finder F—1, Fig. 6, and the toll first selector TFS—1, Fig. 7.

Preselecting a finder-selector link

Assuming now that the operator at position 1 is not engaged and wishes to preselect a finder for answering a call, and assuming further that the unlighted condition of the busy lamp 603 indicates that the finder F—1, Fig. 6, and the associated toll first selector TFS—1, Fig. 7, are not in use. The operator actuates the associated talking key K1, thereby completing a circuit, at spring contacts 696, over the associated common test conductor 604 for the lower winding of connecting relay 670. Test conductor 604 is one of the common conductors contained in cable 1 (which is one of the two multiplying cables which connect the equipment at position 1 with the group of finder selector links assigned to such position). Upon reference to Fig. 11, it will be observed that the test conductor 604 is normally grounded at armature 1133 of the normally restored talking relay 1130.

Upon operating, connecting relay 670 of the finder F—1 locks itself, by way of armature 679 and springs 695 of the talking key K—1, to hold conductor 605, which is also contained in cable 1. Connecting relay 670 at its several armatures, completes the association between the finder selector link and the position equipment, which association was partially effected by the operation of the talking key K1.

In the operator's position equipment, Fig. 11, talking relay 1130 now operates over the hold conductor 605 in the locking circuit of the connecting relay 670. Upon operating, talking relay 1130 disconnects ground potential from the test conductor 604, thereby preventing the inadvertent operation of an additional connecting relay, such as 670, in another finder. At the resting contacts of armature 1311 and 1312, talking relay 1130 disconnects the associated talking conductors from the windings of the repeating coil RC (used for monitoring purposes) and extends them to the operator headset equipment by way of the first contacts of the above-mentioned armatures. The talking relay 1130 also completes a circuit from ground at armature 1135, conductor 1185, armatures 1351 and 1343, respectively, conductor 1184, winding of distributor start relay 1170, springs on the delay key K3, to battery. Distributor start relay 1170 operates and prepares a circuit, at armature 117, for the call signal relays 1140, 1150, and 1160; it removes ground potential from the guard conductor 1188 at the resting contact of armature 1173; it places ground potential on the distributor start conductor 1189 at armature 1173 and its front contact; and it connects the position start conductor 1187 to start conductor 1186 at armature 1172, which conductor is connected, by way of armature 1334 of the answering pilot relay 1340, start conductor 1302, and cable 1, to the preselected finder link, Figs. 6 and 7.

Assuming the distributor, Fig. 12, to be in the normal position shown, the application of ground potential to the distributor start conductor 1189

(which is common to all positions in the group) results in the consecutive operation of relays 1240, 1250, 1260, and 1270, in which operation the relays test for the position in which a link has been preselected. The preselected position (the position 1) is characterized by the absence of ground potential on the guard conductor 1188.

When distributor relay 1240 responds to the closure of its circuit from the grounded distributor start conductor 1189 by way of armatures 1221 and 1231, and their lower windings, it extends the ground potential applied at armature 1212 by way of armature 1244, to the position start conductor 1187; it prepares a circuit at armature 1243 for the lower winding of relay 1250 associated with position 2, it completes a circuit for relay 1230 in series with its upper winding at armature 1242; and at armature 1241 opens the locking circuit for the upper winding of relay 1270. Relay 1230 operates in series with the upper winding of relay 1240 and at armature 1231 opens the initial operating circuit for the lower winding of distributor relay 1230.

In order to complete the description of operation of the distributor, Fig. 12, it will now be assumed that the finder F—1, Fig. 6, has "cut in" on the marked vertical bank associated with wiper 617 and that a relay in the operator's position equipment, Fig. 13, has operated to cause the release of the distributor start relay 1170, Fig. 11, as will be described in detail hereinafter. As a result of the deenergization of distributor start relay 1170, ground is removed from the distributor start conductor 1189 resulting in the deenergization of relays 1230 and 1240. In addition, ground potential is placed on the guard conductor 1188 which has no effect at this time. Accordingly, the relays of the distributor are restored to normal. On the other hand, if the operator, for example, at position 4 has her talking key, similar to key K1, Fig. 6, in its operated position, ground from the distributor start relay associated with that position maintains the locking circuit for relay 1230 and the upper winding of relay 1240 preventing their release at this time. Therefore, when the ground potential is placed on the guard conductor 1188, as a result of the deenergization of distributor start relay 1170 at position 1, a circuit is completed by way of armature 1234 and the lower winding of distributor relay 1250. Relay 1250 operates and at armature 1252 completes a locking circuit for its upper winding in series with relay 1230, and at the same time it opens the locking circuit for the upper winding of distributor relay 1240 at armature 1251.

Since the operator at position 2 does not have a talking key in its operated position, a ground potential is applied to the guard conductor connected to position 2 thereby causing the operation of the distributor 1261 by way of armature 1253. Relay 1260 operates and locks itself by way of its upper winding in series with relay 1230, in the same manner as relays 1240 and 1250. Since the ground potential on the start conductor, position 3, is now connected by way of armature 1263 to the lower winding of distributor relay 1270, relay 1270 operates and locks itself by way of its upper winding, and armature 1272 and armature 1241 in series with relay 1230. Responsive to the operation of relay 1270, ground potential is placed on the position start conductor similar to conductor 1187 which extends to the operator's position equipment of position 4. When the link finder associated with position 4 cuts in

on the marked vertical bank level, ground potential will be forwarded by way of the guard conductor (similar to conductor 1188) armature 1273 to the winding of relay 1220. Responsive to the operation of relay 1220, series holding circuit for relay 1230 and the upper winding of 1270 is opened at armature 1221, causing these relays to release. At armature 1273, relay 1270 opens the initial energizing circuit for relay 1220. Relay 1220, being slow to release, does not fall back and close the contact of armature 1221 until the slow-to-release relay 1230 has had sufficient time to fall back. The sequence of operation is now repeated, testing the various positions until the position is found at which the operator has operated her talking key and is in a position to answer incoming calls.

Finding the calling line

The finder F—1, Fig. 6, has been preselected as described hereinbefore. When the assumed call arrives over the incoming trunk T—1, Fig. 1, and the combined line and recording trunk CLR, Fig. 3, the grounding of start conductor 313, and the resultant actuation of the common start relay 1210 over the corresponding one of the level start leads 1200, results in the placing of a starting ground potential, by way of armature 1244 of the distributor relay 1240, on the position start conductor 1187. The ground potential thus placed on conductor 1187 is extended by way of armature 1172, conductor 1186, armature 1344, start conductor 1302, in cable 1; armature 677 of operated connecting relay 670 (finder F—1, Fig. 6), to the winding of the individual start relay 660 and battery.

Start relay 660 operates and completes an energizing circuit for the upper winding of supervisory relay 650 at armature 662; it opens a point in the circuit for the release magnet RLSE at armature 661; it completes a circuit for the polarizing windings of electro-polarized relays 610 and 620 at armature 663, it prepares a supervisory circuit at armature 664 which circuit includes conductor 606, cable 1, armature 1382, and supervisory relay 1370 of the operator's position relays, Fig. 13; and at armature 665 it prepares a circuit for the supervisory answering lamp 602. Referring again to the circuit completed at armature 663, it will be noted that one branch of the circuit is completed for the polarizing winding of the electro-polarized switching 2 relay 620; another branch of the circuit is extended by way of armature 625 to the polarizing winding of the electro-polarized switching 1 relay 610; and a third branch of the circuit is extended by way of armature 615, armature 641, and armature 635, to the winding of the vertical magnet VERT. to battery. As a result of the application of ground potential to the last mentioned branch circuit, the vertical magnet VERT. operates and starts the vertical movement of the finder in search of the level in which the calling line is located. When the vertical magnet VERT. operates it completes a circuit at armature 698 for the stepping relay 640, which relay, upon operating, opens the initial energizing circuit for the vertical magnet at armature 641. Responsive to the opening of its initial energizing circuit, vertical magnet VERT. falls back and opens the circuit for the stepping relay 640 at armature 698. Stepping relay 630 deenergizes and again closes the energizing circuit for the vertical magnet VERT. at armature 641.

The above cycle of operation is repeated until

the vertical wiper 617 comes into engagement with the previously grounded vertical bank contact. Since the vertical wiper 617 and the switch wipers 618 are on the same shaft, the vertical stepping, under control of the vertical magnet VERT. raises the wiper 617 and the wipers 618 to the level of bank contacts in which the called line is located.

When the wipers of the finder reach the level containing the calling line, vertical wiper 617 encounters ground potential on the associated vertical test or start conductor. Since relay 640 is reoperated following the operation of the vertical magnet VERT. which brought the wipers to the calling level, it is now locked in its energized position over a circuit including the grounded start conductor of the calling level engaged by the vertical wiper 617, lower winding of change-over relay 640, armature 633, winding of stepping relay 640, and battery. Change-over relay 630 operates in series with stepping relay 630 over the above traced circuit. Relay 630 is somewhat slow to operate and in addition is designed so that its armature 632 operates first and completes a locking circuit for its upper winding as follows: from ground, upper winding of relay 630, off normal springs 645 (closed on the first vertical step of the switch), overflow springs 646, armature 632, resistance R4, to battery. This locking circuit is completed before armature 633 opens its initial energizing circuit including the lower winding and relay 640. At armature 631 change-over relay 630 opens a point in the circuit for release magnet RLSE; prepares a locking circuit at armature 634 for the electro-polarized switching relays 610 and 620; and at armature 635 transfers the operating circuit of the vertical magnet VERT. to the rotary magnet ROT.

Referring again to the locking circuit for the upper winding of change-over relay 630 it will be noted that battery through resistance R4 and armature 632 is now extended by way of armature 676, release answer conductor 608, cable 1, winding of the answering pilot relay 1340, Fig. 13, to ground. The functions of relay 1340 will be explained subsequently.

Referring to the above described operation of relay 630, which resulted in the deenergization of relay 640, it is to be noted that when relay 640 falls back and closes armature 641 and its resting contact, that an operating circuit is now completed for the rotary magnet ROT. The rotary magnet ROT. operates to advance the wipers 617 and 618 in a rotary direction over the selected level of the finder bank. The operation of the rotary magnet ROT. is accompanied by the operation of the stepping relay 640 in the same manner as was described in connection with the stepping of the vertical magnet VERT. It may be well to mention that the vertical wiper 617 is rotated out of engagement with the bank of vertical contacts on the first rotary step of the switch.

The rotary movement continues until the wipers 618 come into engagement with the bank terminals of the calling line, in this case the terminals 360 shown on the right of the combined line and recording trunk (CLR), Fig. 3. It will be recalled that the C lead of the line circuit CLR has a battery potential placed thereon through the lower winding of the cut-off relay 320, armature 331 and armature 341, to mark the line as calling. Therefore, when the C terminal of the CLR trunk, Fig. 3, is engaged by either of the wipers C—1 or C—2 of the finder F—1, Fig. 6, a circuit is closed through the C lead of the CLR trunk circuit for

the upper test windings of one of the electro-polarized switching relays 610 or 620. The other end of the circuit for these relays being completed by way of armatures 613 or 623, lower winding of the supervisory relay 650, to ground at armature 634 of change-over relay 630.

The finder F—1 has two complete sets of wipers, one set comprising wipers —1, +1, C1, and EC1, adapted to engage contacts in one set of banks, and another set of wipers, comprising wipers —2, +2, C2, and EC2 adapted to engage contacts in another set of banks. The set of wipers to be used is determined by a marking battery potential encountered by the test wiper C—1 or C—2, when the bank contact of the calling line is found. Accordingly, if the C—1 wiper encounters a battery potential in its bank the switching —1 electro-polar relay 610 is operated and connects up the No. 1 set of wipers, whereas, if the C—2 wiper encounters a battery potential switching —2 electro-polar relay 620 is operated and connects up the No. 2 set of wipers.

For the purpose of this description, it will be assumed that the test wiper C—1 encounters the battery potential when the calling line bank contacts are reached and the following circuit is completed: from battery, lower winding of cut-off relay 320 of the CLR trunk, Fig. 3, armature 331, armature 341 of the operated line relay 340, C conductor and bank contact of terminals 360 engaged by the wiper C—1 of the wiper set 618, Fig. 6, operating winding of the switching —1 elector-polar relay 610, armature 623, lower winding of supervisory relay 650, armature 634 of the operated change-over relay 630, to ground.

Upon operating, relay 610 completes an assisting or holding circuit for its middle winding, at armature 614 from ground at armature 634, while at armature 615 it immediately opens the circuit to the rotary magnet ROT. to terminate the rotary movement with the wipers 618 in engagement with the terminals 360. At armatures 611 and 612, relay 610 connects up the negative (—) and positive (+) wipers of wiper set 618; at armature 613 it short circuits the operating winding of relay 610, thereby connecting the ground from armature 634 through the lower winding of the supervisory relay 650 and armature 613, directly to the associated C—1 wiper, thereby placing a guarding potential on the C lead of the CLR trunk, Fig. 3, in order to guard the trunk circuit effectively against seizure by subsequently operated finders, and in order to afford a direct circuit for the cut-off relay 320 of the CLR trunk, Fig. 3, in series with the supervisory relay 650, of finder F—1, Fig. 6.

In the CLR trunk, Fig. 3, cut-off relay 320 operates over the associated C lead when the finder engages terminals 360. Upon operating, cut-off relay 320 opens the circuit of start relay 310 at armature 322, and at armature 321 is prepared a circuit for shunting the high resistance upper winding of line relay 330. Start relay 310 subsequently falls back and at armature 311 completes the shunt circuit of the upper winding of relay 340, and at armature 312 removes the starting ground potential from conductor 313. The above-traced shunting or by-pass circuit around the high resistance upper winding of line relay 340 causes the current flow over the conductors of the trunk T—1 to become sufficient to impress a holding condition on the trunk circuit TC, Fig. 1, and to enable the connection to be held from the central office toll board. Relay 330 does not operate, because the potential over conductors of

the trunk T—1 is applied in the reverse direction at the trunk circuit TC, Fig. 1, upon seizure, whereby a positive potential is now applied to the upper or negative conductor of trunk T—1 and a negative potential is applied to the lower positive conductor. The current flow in the lower winding of relay 330 and the current flow in the upper winding of the relay oppose each other and thereby prevent the relay from operating at this time.

In the calling office #8 of Fig. 1, the increased current flow over the conductors of the trunk T—1, in addition to the locking up of the connection under control of the central office operator, causes the application of class tone normally made upon the seizure of the circuit to be discontinued after an interval sufficiently long to enable the central office toll operator to take note of the class to which the calling line is assigned. Relay 350 is provided to reopen the supervisory bridge at the will of the central office toll operator responsive to a manipulation of her ring answering key so as to cause the class tone to be momentarily reapplied in the event that the operator wishes to hear the class tone again. The circuit for controlling the reapplication of class tone to the toll trunk conductor T—1 is brought about by removing the short circuit or supervisory bridge by operating the start relay 310 from armature 351 or relay 350. Start relay 310 operates over this circuit and opens the shunt circuit from around the high resistance upper winding of line relay 340, at armature 311. This inserts the high resistance upper winding of line relay 340 in the circuit including the conductors of the trunk T—1 which causes the necessary operations in the trunk circuit TC of Fig. 1, to reapply the class tone to the trunk conductors of trunk T—1.

In the finder F—1, Fig. 6, when the switching —1 relay 610 operates a circuit is completed from ground at armature 663, armature 616, normally closed contacts of the normal post springs NP, wiper EC1 of the wiper set 618, EC terminal 360 of the CLR trunk, Fig. 3, group identity lamp 360, to battery. The lighting of this lamp over the above-traced circuit indicates to the toll operator the line group or trunk group over which the call is received, there being a separate one of these lamps at each operator's position for each group of lines through which calls may be received.

Referring again to the operation of the change-over relay 630 of finder F—1, Fig. 6, it was previously mentioned that the locking circuit for the upper winding of change-over relay was completed at armature 632 and that the battery potential was applied to the release answering conductor 608 by way of armature 676 of the operated connecting relay 670 and by way of cable 1 to the operator's position equipment in Fig. 13. The resistance R4 included in this circuit is provided primarily to enable the change-over relay 630 to be shunted and thereby released under control of the position equipment, Fig. 13. Referring to the release answering conductor 608, Fig. 13, it will be noted that the application of battery to this conductor causes the circuit to be completed to the answering pilot relay 1340. When the answering pilot relay 1340 operates, it opens the previously described circuit for the distributor start relay 1170, Fig. 11 (closed as previously described upon the operation of the talking relay 1130). The distributor start relay 1170 is slow acting, as is indicated, and remains

energized a short interval after its circuit is opened. A circuit is now completed from ground at armature 1341 of the operated answering pilot relay 1340, conductor 1183, armature 1171 of the still operated distributor start relay 1170, normally closed contacts of armature 1162, through the winding of the call signal relay 1140, to battery.

When call signal relay 1140 operates, it disconnects the operator's headset equipment from the tip conductor 1180 and places a ground potential on the ring conductor 1181 and extends the tip conductor of the operator's headset to the common call tone conductor 1181 by way of armature 1141 and normally closed contacts controlled by armature 1142. A distinctive high frequency tone is therefore transmitted by way of the front contact of armature 1141, front contact of armature 1131, through the right-hand winding of the induction coil I, artificial line resistance AL, front contact of armature 1132, to ground at armature 1142. The operator's receiver is associated with the secondary or right-hand windings of the induction coil I in the usual anti-side tone arrangement including the artificial line AL.

Call signal relay 1140 completes a circuit for signal interrupter relay 1150 at armature 1143. Relay 1150 operates, interrupting the flow of call tone current at armature 1151, and at the same time completing a circuit for relay 1160 from ground at armature 1152. Relay 1160 now operates and reapplies the call tone current at armature 1161, at the same time locking itself to the grounded conductor 1183 at armature 1162, and in doing so opens the initial energizing circuit for the call signal relay 1140 at normally closed contacts controlled by armature 1162. The call signal relay 1140 restores after a slight interval and terminates the two short applications of the high-frequency call tone (commonly referred to as a zip-zip tone) to the connected operator. The deenergization of call signal relay 1140 again connects the operator's headset to the tip and ring conductors 1180 and 1181 at armatures 1141 and 1142, respectively, and opens the energizing circuit for signal interrupter relay 1150 which subsequently deenergizes and opens the initial energizing circuit for signal interrupter relay 1160, at armature 1152. However, signal interrupter relay 1160 remains in its energized position by way of the locking ground on conductor 1183 until the slow-acting distributor start relay 1170 restores and opens the locking circuit for relay 1160 at armature 1171.

When distributor start relay 1170 restores, it disconnects the position start conductor 1187 from conductor 1186 at armature 1172, but this is of no particular concern, because the operation of the answer pilot relay 1340 applies ground potential at armature 1344 to the start conductor 1302 to maintain start relay 660 of finder F—1, Fig. 6, operated. The deenergization of distributor start relay 1170 also removes ground potential from the distributor start conductor 1189 and places a ground potential on the guard conductor 1188. The removal of ground from the distributor start conductor 1189 permits the release of relays 1230 and 1240 of the distributor, Fig. 12. However, if some other operator is maintaining a ground potential on the distributor start conductor, the above mentioned relays will remain operated and the distributor proceeds to pre-select another position.

Upon the termination of the above-mentioned

distinctive application of call-signal current to the operator's receiver, the operator may converse immediately with the calling subscriber at substation A of the automatic exchange #8 over the tip and ring conductors 1180 and 1181, armatures 1311 and 1312 of the split answering relay 1310, tip and ring answering conductors 653 and 654, cable 1, armatures 674 and 672 of the operated connecting relay 670, armatures 612 and 611, positive —1 and negative —1 (tip and ring) wipers of the wiper set 618 and the repeater 308 in the CLR trunk, Fig. 3, connected to trunk T—1 seized by the calling subscriber. At this point it may be mentioned that the finder F—1 being the answering switch, and the toll first selector TFS—1, Fig. 1, being the calling switch, conductors and other equipment having to do particularly with the finder are referred to as answer conductors, and conductors having to do particularly with the portion of the connection to be extended by way of the toll selector TFS—1 are referred to as calling conductors.

The subscriber at substation A in the automatic office #8 and the central office toll operator at position 1 may now converse over the trunk line T—1, Fig. 1. It may be conveniently assumed that a subscriber at a distant toll office is desired and that the toll office is at the distant end of the trunk line TL—1, Fig. 1.

Upon ascertaining the number (exchange and subscriber's number) of the wanted subscriber, the toll operator proceeds to set this number up on a selected register sender by operating her digit key DK, Fig. 16.

Selection of an idle register sender

The way in which the automatic selection of an idle register sender is accomplished will now be considered. As previously pointed out, the operator at position 1 has two sender links for her exclusive use, SL—1 and SL—2, Figs. 15 and 16, respectively. These sender links have access, by means of link finders LF—1 and LF—2, to the plurality of finder selector links at the #1 position, of which the finder F—1, Fig. 6, and the toll first selector TFS—1, Fig. 7, is one. These sender links also have access, by means of the sender selectors SS—1 and SS—2, to a group of register senders provided for the common use of all the operators.

The sequence control relays 1610, 1620, and 1630, operate automatically to render the sender links SL—1, Fig. 15, and the sender link SL—2 effective alternately.

Returning now to the point at which the answering pilot relay 1340, Fig. 13, operated responsive to the operation of the change-over relay 630 of the finder F—1, Fig. 6. Relay 1340, upon operating, extends the ground potential applied to conductor 1185 by way of armature 1135 of the talking relay 1130, to the sequence control relays, by way of armatures 1351, 1343, 1362, 1393, conductor 1304, armature 1632 of relay 1620, Fig. 16, winding of relay 1610, to battery. Assuming that the sequence control relays 1610, 1620, and 1630 are all restored, when conductor 1304 is grounded the above-traced circuit is completed for relay 1610. Relay 1610 thereupon operates and closes a locking circuit for itself in series with the left-hand winding of relay 1620 over the following circuit: battery, winding of relay 1610, armature 1613, left-hand winding of relay 1620, normally closed contacts controlled by armature 1633 of relay 1630, normally closed contacts of the sender cut-out 1 75

and 2 keys, key K4, conductor 1190, to ground at armature 1111 of the operated transmitter supply relay 1110. The start or transmitter supply relay 1110 being energized as long as the operator has her transmitter and receiver plugged into the illustrated jack provided for this purpose. Relay 1620 (the left-hand winding of which was included in the holding circuit of relay 1610) does not operate in this locking circuit for the time being, since its left-hand winding is shunted by the initial operating ground potential applied to relay 1610 by way of conductor 1304.

With the sequence control relay 1610 operated and sequence control relay 1620 not operated, circuits are completed for starting the link finder LF—1, Fig. 15, to find the preselected finder F—1, Fig. 6, and for starting the sender selector switch SS—1, Fig. 15, to find an idle register sender, as will now be explained.

When sequence control relay 1610 operates it closes a circuit from test wiper 1506 of the sender link SL—1, Fig. 15, normally closed contacts controlled by armature 1583, armature 1596, conductor 1647, armature 1616, armature 1625, conductor 1648, self-interrupting contacts of the stepping magnet SSM, winding of stepping magnet SSM, to battery. In the event that the register sender on which the wipers of the sender selector SS—1 are standing is busy, the test conductor, such as test conductor 1507, will be grounded, and the above circuit is completed for operating the rotary magnet. The magnet SSM operates in a buzzer-like manner to advance the wipers of the sender selector SS—1 until an idle register sender is found.

Simultaneously with the above-described circuit for the stepping magnet SSM, a test circuit is also completed, responsive to the operation of the sequence control relay 1610, for the switching relay 1590 which will operate in series with the stepping magnet SSM, as soon as the test wiper 1506 encounters an idle register sender. This circuit may be traced from ground at the normally closed contacts controlled by armature 1585 of the disconnect relay 1580, Fig. 15, conductor 1644, armature 1612 of the operated sequence control relay 1610, armature 1622, conductor 1643, winding of the switching relay 1590, self-interrupting contacts of the stepping magnet SSM, winding of magnet SSM, to battery. It will be noted that the switching relay 1590 is shunted by the operating ground for the stepping magnet SSM as long as the test wiper 1506 of the sender selector SS—1 encounters ground potential on the associated test conductors. However, when the idle register sender is found, (for example, the register sender shown on Figs. 17 to 21, inclusive), switching relay 1590 is no longer shunted by this operating ground potential and therefore operates in series with the stepping magnet SSM. Due to the high resistance of switching relay 1590, stepping magnet SSM will not operate and the wipers of the sender selector SS—1 will be brought to rest in engagement with the conductors of an idle register sender.

When switching relay 1590 operates, it disconnects the test wiper 1506 from the test circuit and connects it to ground at armature 1596, thereby grounding the test conductor 1507 of the seized register sender to mark the register as engaged. In addition, switching relay 1590 closes various circuits by way of its armatures 1591—1598 thereby connecting the operator's digit keys DK, Fig. 16, to the seized register send-

er and preparing circuits in the sender link SL—1 that will be described hereinafter.

As a further result of the operation of sequence control relay 1610, an outgoing circuit is completed for the stepping magnet LFM of the link finder LF—1 at armature 1611 and a testing circuit is completed at armature 1614 for the switching relay 1610 in series with the winding of the stepping magnet LFM. Attention is called to the fact that the finders, such as the finder F—1, Fig. 6, accessible in the banks of the link finders, such as LF—1, normally place a ground potential on test conductors, such as 1557, and when a finder is preselected by the operation of a talking key, such as key K1, the ground potential is removed from the associated test conductor. Therefore, when the circuit is closed from the test wiper 1527 of the link finder LF—1 through the winding of the stepping magnet LFM, the ground potential encountered by the test wiper 1527 causes the stepping magnet LFM to operate in a buzzer-like manner to advance the wipers 1522—1527, inclusive, of the link finder LF—1. As is the case of the switching relay 1590 of the sender selector SS—1, the switching relay 1510 of the link finder LF—1 is shunted during the hunting action of the stepping magnet LFM by the ground potential encountered by wiper 1527. This stepping action of the magnet LFM continues until the wipers arrive on the set of terminals associated with the link composed of finder F—1 of Fig. 6 and the toll first selector TFS—1, Fig. 7, which finder selector link has been preselected by the operation of the talking key K1. At this time, the test wiper 1527 does not encounter the ground potential on the test conductor 1557 and the switching relay is no longer shunted, permitting it to operate in series with the stepping magnet LFM. This circuit may be traced as follows: ground, armature 1624 of the sequence control relay 1620, Fig. 16, armature 1614 of the operated sequence control relay 1610, conductor 1645, winding of the switching relay 1510, self-interrupting contacts of the stepping magnet LFM, winding of the stepping magnet LFM, to battery. Switching relay 1510 operates in series with the stepping magnet LFM, but stepping magnet LFM does not operate because of the high resistance on the switching relay 1510, thus terminating the stepping action of the link finder LF—1.

Responsive to the operation of the switching relay 1510 a circuit is completed from ground at armature 1515, test wiper 1527, conductor 1557, cable 2, armature 675 of the operated connecting relay 670, out over the C conductor 773 extending to the toll first selector TFS—1, Fig. 7. In addition, at armature 1512 ground potential is applied to wiper 1524 and is extended by way of conductor 1554, cable 2, to conductor 1554 which is also connected to the C conductor 773 extending to the toll first selector TFS—1, Fig. 7. By referring to Fig. 7 it will be noted that when ground potential is applied to the C conductor 773 a circuit is completed by way of off-normal springs 750, and the upper winding of series relay 730, to battery. Series relay 730 of the toll first selector TFS—1 energizes when the wipers of the link finder LF—1 find the preselected finder selector link of Figs. 6 and 7, but without any particular effect at this time.

In addition to the above-mentioned circuits completed by the operation of switching relay 1510, a loop circuit is prepared for operating the link relay 710 of the toll first selector TFS—1, Fig. 75

7 at armature 1511; it prepares a delayed pulsing and supervisory signal circuit at armature 1513; it prepares a circuit for operating the cut-through relay 680 of Fig. 6, and at armature 1514; and at armature 1516 it completes a circuit, from ground at armature 1516, armature 1535, armature 1598 of the operated switching relay 1590, sender pilot lamp 1500. The sender pilot lamp 1500 lights when this circuit is completed, thereby indicating to the operator that she may now set up the digits of the desired number by means of the digit keys DK. It will be understood, of course, that the above described operations are ordinarily completed before the operator can obtain the necessary number information from the calling subscriber.

Referring again to the circuit completed by the armature 1516 of switching relay 1510, it will be noted that a circuit is also completed for relay 1570, which upon operating, completes an operating circuit for relay 1560 and prepares a holding circuit for disconnect relay 1580 at armature 1572. Upon operating, relay 1560 prepares a locking circuit for relay 1530 at armature 1562, while at armature 1551 it prepares a circuit which is held opened, at armature 1571, by the operation of relay 1570. The purpose of the last mentioned armatures of these two relays is for controlling the automatic ringing circuit, when that type of service is required, as will be explained fully hereinafter.

The conductors A, B, C, and D coming from the operator's digit keys DK, Fig. 16, are extended by way of armatures 1591-1594, inclusive, of the switching relay 1590, and wipers 1401-1504, inclusive, of the sender selector SS-1, to corresponding conductors leading to the register sender, Figs. 18 and 19.

Referring again to the operation of the switching relay 1590 of the sender link SL-1, Fig. 15, which relay operated when the switch SS-1 seized an idle register sender, and connected ground potential to the test wiper 1506. In the sender control circuit, Fig. 17, test relay 1730 is operated responsive to the application of ground potential to the test wiper 1506 over the following circuit: test conductor 1507, armature 1711, upper and lower windings of test relay 1730, to battery. In addition, at armature 1595, switching relay 1590 a pulsing circuit is completed from battery at the pulse relay 1520, normally closed contacts of armature 1551, armature 1595, wiper 1505 of the sender selector SS-1, pulsing conductor 1508, extended through Figs. 17, 18, and 20, armature 2021, winding of the delay pulsing relay 2040, to ground. Relays 1520 and 2040 energize over this circuit; pulse relay 1520 completes a loop circuit, at armature 1521, for line relay 710 of the toll first selector TFS-1, Fig. 7, which circuit will now be traced. Starting at the winding of line relay 710 of the toll first selector TFS-1, Fig. 7, the circuit is as follows: battery, upper winding of line relay 710, armature 741, negative conductor 771, conductor 1552 of cable 2, negative wiper 1522 of the link finder LF-1, normally closed contacts controlled by armature 1531, armature 1521 of the pulse relay 1520, armature 1511, positive wiper 1523 of the link finder LF-1, conductor 1553, and cable 2, positive conductor 772, armature 742, lower winding of line relay 710, to the previously grounded C conductor 773. Line relay 710 of the toll first selector TFS-1 operates and prepares the switch for further operations as will be explained hereinafter. The operation of the delay

pulse relay 2040 in series with the pulse relay 1520 disconnects the release ground conductor 1754 and the delay ground conductor 1755.

Since all the registers in the register sender are duplicates, the registering relays A1, B1, C1, and D1 of register R-1 only, have been shown. The registers R-2 to R-6, inclusive, which are exactly the same as register R-1, have been represented by dotted rectangles. Obviously, six digits can be registered, however, by means of a reflex circuit, controlled by the operation of the last register, the registers are provided to be reused to register as many digits as desired. This reflex action of the registers will be described in detail hereinafter.

Registration of the desired number

As mentioned above, the association of the register sender and the finder selector link, by means of the sender link SL-1, Fig. 15, causes the sender pilot light 1500 to light, thereby informing the central office toll operator that she may start to depress her digit keys DK, Fig. 16, in accordance with the digits in the desired number.

The wanted subscriber is located in a distant office which is accessible to the toll operator at the central office by way of trunk line TL-1. At the distant office, the trunk line TL-1 terminates in a toll board, from which point the connection is extended to the desired subscriber by the distant manual operator. In order for the toll operator to extend a connection to the distant operator over a trunk line TL-1 she operates her digit keys DK to register the digits of the number assigned to the distant office in which the wanted subscriber may be reached. It will be assumed that the wanted exchange trunk number is 13 and that the toll operator accordingly depresses the digit keys of her key set DK to extend the connection. It will be noted that the four conductors associated with the operator's digit keys DK are labeled A, B, C, and D. The operation of a digit key results in the placing of ground potential on one or more of these conductors. As an aid in reading the drawings, the conductors grounded responsive to the operation of each key have been noted in parentheses above each key.

As has been previously mentioned, the seizure of the register sender caused the operation of test relay 1730, Fig. 17. At armature 1731, relay 1730 applies ground potential to the release conductor 1750. This ground potential extended by way of armature 1821 of transfer relay 1820, to the winding of the register R-1 connecting relay 1890. In addition, the ground potential on conductor 1750 prepares a holding circuit for various relays as will be apparent later. Register R-1 connecting relay 1890 operates at armatures 1891-1894 extend the digit registering conductors A, B, C, and D associated with the operator's key set with the corresponding relays A1, B1, C1, and D1, respectively, of the register R-1. The operator may now set up the digits 1 and 3 of the desired exchange trunk number on the registers by operating the corresponding digit keys shown at the bottom of Fig. 16.

When the operator depresses the digit key 1 to set up the first digit, the A and B conductors are grounded, causing the operation of relays A1 and B1 of register R-1, Fig. 18. Upon operating, relays A1 and B1 complete locking circuits for themselves at armatures 1815 and 1816, by way of the upper winding of the transfer relay 1820, armature 1842, and the grounded release con-

ductor 1750. Transfer relay 1820 does not operate for the time being, because it is short circuited by the initial application of ground potential over conductors A and B. As soon as the depressed digit key 1 is released, however, the shunt is removed from around the winding of relay 1820, and this relay operates in series with relays A1 and B1 of the register R—1.

Transfer relay 1820, upon operating, completes a locking circuit for itself by way of its lower winding, armature 1812, armature 1821, and the grounded release conductor 1750. In addition to this locking circuit, a branch circuit is also completed by way of armature 1851 and the winding of register R—2 connecting relay 1895. Relay 1895 operates over this circuit and connects the key conductors A, B, C, and D, by way of armatures 1896—1899, to register R—2. At the back contact of armature 1821 relay 1820 opens the energizing circuit for the register R—1 connecting relay 1890 causing relay 1890 to restore and disconnect the key conductors A, B, C, and D from the register R—1. At armature 1822, relay 1820 completes a circuit from ground at armatures 1825 and 1826 of the operated register relays A1 and B1, armature 1822, hold conductor 1751, winding of hold relay 1720, to battery. The operations that take place responsive to the operation of hold relay 1720, Fig. 17, will be explained shortly. It should be noted that the operation of the hold relay is responsive to the registration of the first digit of the number, and that the digit registered will immediately be transmitted in the form of pulses to the sender link SL—1, Fig. 15, and retransmitted therefrom to cause the necessary operations for setting the toll first selector TFS—1, Fig. 7.

Referring again to the operation of the register R—1 (relays A1 and B1) it will be noted that at armatures 1832 and 1833 and their respective front contacts a marking ground potential is applied to conductor 1 of the marking conductors 1800, which conductors extend to the impulse counting relays, Fig. 21. Tracing the circuit back from the armature 1832 of the register A1 relay, it will be found that the armature is grounded by way of a circuit including armatures 1843, 1873, conductor 1836, armatures 1923, 1953, 1983, and the grounded release conductor 1750. The effect of this marking ground on conductor 1 of the marking conductors 1800 will be explained in connection with the operation of the impulse counting relays, Fig. 21.

When the operator depresses the digit key 3 of the digit keys DK to register the second digit of the trunk number, conductors A and D are grounded and accordingly cause the operation of relays A2 and D2, of register R—2 (which relays are the same as those comprising register R—1) by way of armatures 1896 and 1899 of the operated register R—2 connecting relay 1895. Relays A2 and D2, upon operating, lock in series with the upper winding of the transfer relay 1850, by way of armature 1872 and the grounded release conductor 1750. Transfer relay 1850 remains short circuited as long as the digit key is depressed and operates as soon as the key is released. Transfer relay 1850 completes a locking circuit at its lower winding at armature 1851, and at its front contacts, from the grounded release conductor 1750 by way of armature 1821 of the operated transfer relay 1820. In addition, the locking ground for the lower winding of 1850 is also extended by way of armatures 1881 of transfer relay 1880, causing the operation of the reg-

ister R—3 connecting relay 1875. At the back contact of armature 1851, relay 1850 opens the circuit of the register R—2 connecting relay 1895, which relay releases and opens the initial energizing circuit of the register relays of register R—2. At armature 1852, of the operated transfer relay 1850, ground is extended from the armatures of the operated register relays A2 and D2 (not shown) to maintain a holding ground on conductor 1751. Attention is called to the fact that conductor 3 of the marking conductors 1800 is not marked by the application of ground potential thereon due to the fact that relay 1840 has not operated and completed the marking circuit by way of the front contact of armature 1843. Relay 1840 does not operate until the impulses corresponding to the registration set up on register R—1 have been transmitted with the operation of the impulse counting relays, Fig. 21.

In the particular connection being described it is only necessary for the operator to register two digits to cause the selection of a toll line, such as TL—1, extending to the distant office toll board. However, when it is necessary for the operator to set up the digits of a number made up of more than six digits, she will continue to operate the digit keys DK in accordance with that number, causing the register relays of the registers R3 to R6, Figs. 18 and 19, to be set up and locked in their operated position in series with the associated transfer relays such as 1930 and 1990. Since only six registers will have been operated under this assumed condition, the seventh digit will be registered on the register R—1 after the first registration thereon has been transmitted and the associated register relays released. This reflex action of the register of Figs. 18 and 19 will now be explained.

In order to describe the reflex action of the register sender of Figs. 18 and 19, it will be assumed that the toll operator has operated her digit keys DK to register six digits. When the last register (R—6) is operated the transfer relay 1990 is locked up to the grounded release conductor 1750, by way of armature 1991 and its front contact. In addition, this ground potential is also extended by way of conductor 1838, to the winding of relay 1810 and battery. Relay 1810 operates, and at armature 1812 it opens the locking circuit for the lower winding of transfer relay 1820. Since the first digit registered will have been transmitted by the impulse sender, relay 1820 is prepared to release because the circuit including its upper winding is opened responsive to the restoration of the operated relays of register R—1 under control of the output distributor relay 1840.

When relay 1820 falls back, the locking circuit for the lower windings of all transfer relays is opened at armature 1821 and its front contact, and at the back contact of armature 1821 a circuit is completed from the grounded release conductor 1750 for reoperating the register R—1 connecting relay 1890. In addition, the restoration of transfer relay 1820 also opens the energizing circuit of relay 1810. Relay 1810 falls back and again prepares the locking circuit for the transfer relay at armature 1912. This locking circuit, however, is not completed until the transfer relay 1820 is again operated. Relay 1890 operates and connects the relays of the register R—1 to the control conductors A, B, C, and D in the same manner as previously explained.

When the locking circuit for the lower winding of the transfer relays is opened, the transfer relays of the registers that have been released under

control of the associated output distributor relays, will immediately restore, and the transfer relays of the registers that are still operated, remain energized over a circuit including the operated register relay or relays, the upper winding of the associated transfer relay, and the grounded release conductor 1750. It should be noted that as soon as the impulse sender transmits impulses corresponding to the registration on one of the operated registers, the associated output control relay opens the circuit including the upper winding of the transfer relay and the operated register relay or relays. Since the locking circuit for the lower winding has been opened (responsive to de-energization of transfer relay 1820) the transfer relay will then restore. The remaining registers and transfer relays will each be restored to normal in turn.

At the same time the impulse sender is transmitting impulses corresponding to the registration on the registers that have not been restored, the operator can operate her digit keys to register digits on the restored registers a second time. The transfer relay 1820 (of register R-1) will operate in series with the operated register relay or relays in the same manner as previously described. The remaining registers can be reoperated in succession and, when the last register is reoperated, the same cycle of operation can be repeated. Accordingly, the register sender composed of registers R-1 to R-8, inclusive, can be used to register as many digits as desired. This arrangement is of particular importance in a system using tandem dialling.

It may be well to mention at this time that the impulse sender, Fig. 21, will lag behind the register relays slightly, therefore, a continuous ground potential is placed on the hold conductor 1751 by operated register relays. When the impulse sender catches up with the operated registers, the ground potential is removed from the hold conductor 1751, thereby causing the release of hold conductor 1720, Fig. 17, in order to delay further impulse transmission by the impulse sender until the next register has been operated.

In the event that the operator discovers an error in her operation of the digit keys, she may clear out the portion of the number which has been registered by an operation of the error key ER. This results in an operation of the error relay 1360 in the operator's position equipment, Fig. 13, by way of conductor 1450. Error relay 1360 opens the initial circuit of sequence control relay 1610, whereupon relays 1610 and 1620 operate in series from the grounded conductor 1190. Relay 1620 upon operating releases the sender link SL-1 and prepares a circuit at armature 1623 for operating relay 1630. The release of the sender link SL-1 permits the release of the selected register sender equipment and any operated switches controlled by the register sender. When the error relay 1360 is permitted to restore, upon the release of the error key, the sender link SL-2, Fig. 16, is seized. When error relay 1360 reoperates and closes the circuit at armature 1362, the ground potential applied to conductor 1304 completes the circuit of sequence control relay 1630, thereby causing the sender link SL-2 to start the link finder LF-2 and the sender selector SS-2 to operate in the same manner as described in connection with the operation of sender link SL-1, Fig. 15.

Starting the sender

As mentioned hereinbefore, relay 1720, of the

sender control circuit, Fig. 17, is operated when ground potential is applied to hold conductor 1751 by way of armatures of the operated register relays, such as A1-B1 of register R-1. Responsive to the energization of hold relay 1720, a circuit is completed at armature 1721 causing the operation of start relay 1740. Upon operating, relay 1740 completes a locking circuit for itself by way of armature 1741, and at the same time opens its initial energizing circuit. At armature 1723, hold relay 1720 opens a point in the circuit of the delay ground conductor 1755, and at armature 1722 it opens a point in a circuit which is subsequently used to short circuit the high resistance upper winding of test relay 1740. At armature 1743 relay 1740 places a ground potential on the interrupter start conductor 1752 thereby completing a circuit for interrupter relay 2010, Fig. 20. This ground potential starts the interrupter, comprising relays 2010, 2020, and 2030, operating to retransmit the impulses of the registered digits. Since the retransmission of the registered digits takes place immediately upon the registration of the first digit, the registration of succeeding digits continues while the impulse sender retransmits impulses corresponding to the registered digit on each register in turn.

Responsive to the operation of the interrupter relay 2010, a locking circuit is completed for itself at armature 2011, and at armature 2012 a circuit is completed for operating interrupter relay 2020. Relay 2020 completes an energizing circuit for interrupter relay 2030 at armature 2021. Upon operating, interrupter relay 2030 opens the initial energizing circuit for interrupter relay 2010, at armature 2031. Relay 2010 falls back and opens the circuit of relay 2020 which relay upon falling back opens the circuit of relay 2030. Upon falling back relay 2030 again restores the initial circuit of relay 2010. This cycle of operation is continued until the interrupter start lead 1752 is no longer grounded.

During the time that the interrupter relay 2020 is operated the series circuit, including the delay pulse relay 2040 and the pulse relay 1520 of the sender link, Fig. 15, is opened at armature 2021. The momentary restoration of pulse relay 1520 opens the loop circuit of line relay 710 of the toll first selector TFS-1, Fig. 7. When the pulse relay 2020 falls back, the series circuit of the pulse relay 1520 and the delayed pulse relay 2040 is again completed, thereby closing the loop circuit of the line relay 710 again at armature 1521. Furthermore, the first time interrupter relay 2020 energizes the grounded release conductor 1754 is extended, by way of armature 2022, conductor 2095, to the winding of priming relay 2100 and battery. The priming relay 2100, associated with the impulse counting relays 2101-2110, constituting the impulse counter for counting the transmitted impulses and terminating them when the number transmitted coincides with the value of the digit registered, operates and at armature 2131 completes a locking circuit for itself by way of armatures 2121-2130, inclusive, of the above mentioned counting relays, conductor 2094, armature 2054, conductor 2093, lower winding of counting relay 2101, locking common conductor 2090, armature 2051, armature 2062, to the grounded release ground conductor 1754.

No current flows in the locking circuit of priming relay 2100 as long as the initial circuit of this relay remains established. However, when inter-

rupter relay 2020 restores and thereby terminates the first pulse being delivered at armature 2021, counting relay 2101 operates in series with priming relay 2100 to connect up the conductor 1 of the marking conductors 1800. Relay 2101 completes a locking circuit for itself at armature 2111 from the grounded locking common conductor 2090. In addition, relay 2101 opens its initial energizing circuit including the lower winding at the back contact of armature 2121, thereby releasing priming relay 2100 and at the front contact of armature 2121 prepares the circuit for the second counting relay 2102.

Since the conductor 1, of the marking conductors 1800, is marked by the register R—1, digit stop relay 2050 energizes over a circuit including its lower winding, conductor 2096, and armature 2141. Responsive to the energization of digit stop relay 2050, a circuit is completed at armature 2055 to prevent the pulse lead 1508 from being opened by armature 2021 of interrupter relay 2020. This shunting circuit completed around the circuit through armature 2021 prevents the transmission of a further impulse (circuit opening) upon the next operation of the interrupter relay 2020. The impulse constituting the digit 1 as registered on the register R—1 is accordingly terminated.

In addition to the above-mentioned shunting circuit for the pulse lead 1508, digit stop relay 2050 locks itself over a circuit including its upper winding, armatures 2053 and 2083, and the grounded release ground conductor 1754. At armature 2154, digit stop relay 2050 prepares a circuit for the distributor control relay 2060; at armature 2051 and its resting contact it removes the ground potential from the locking common conductor 2090, permitting the impulse counting relay 2101 to release; and at the front contacts of armature 2051 it extends the grounded release ground conductor 1754 by way of armature 2062, 2051, 2081, to the output control conductor 1975. The ground potential applied to the output control conductor 1975 is extended by way of armatures 1981, 1951, and 1921, conductor 1833, armatures 1871 and 1831, to the winding of relay 1830 and battery. Relay 1830 operates and at armature 1831 prepares a locking circuit for itself in series with output distributor relay 1840. As long as the ground potential is maintained on conductor 1975, the circuit for the output distributor relay 1840 is shunted by the grounded release conductor 1750. However, when the ground is removed from the output control conductor 1975, relay 1840 energizes in series with relay 1830.

Due to the fact that the hold conductor 1751 is grounded by operated register relays, start relay 1740 maintains a ground potential on the interrupter start conductor 1752, thereby maintaining the interrupter relays 2010, 2020, and 2030 operating as previously described. Therefore, upon the next operation of interrupter relay 2020 (there being no impulses transmitted over the pulse conductor 1508 because of the shunting of interrupter contacts 2021 by priming relay 2100 again operates over the circuit including the grounded release conductor 1754, armature 2022 and conductor 2095. When the interrupter relay 2020 falls back and opens the circuit, priming relay 2100 completes a locking circuit for itself in series with the lower winding of distributor control relay 2060. This locking circuit is from battery, winding of relay 3100, armature 2131, armatures 2121-2130 of the impulse count-

ing relays, conductor 2394, armature 2054, armature 2064, lower winding of distributor control relay 2060, to the grounded release ground conductor 1754. It will be noted that this locking circuit is completed upon the energization of the priming relay 2100, but due to the fact that the lower winding of distributor control relay 2060 is short-circuited by the initial operating ground for relay 2100, does not operate until the interrupter relay 2020 falls back and removes ground potential from conductor 2095.

Distributor control relay 2060, upon operating, locks itself to the grounded release ground conductor 1754 over a circuit including its upper winding, armature 2063 and armature 2083; it prepares a circuit for the space stop relay 2070 at armature 2065, to enable this relay to operate at the end of the predetermined time interval or digit space between the sending of the first and second digits; it extends the grounded release ground conductor 1754 to the locking common conductor 2090 by way of armatures 2072 and 2061; it opens its initial energizing circuit at the back contacts of armature 2064, thereby releasing relay 2100; at the front contact of armature 2064 it prepares a new circuit by way of armatures 2074 and 2054 for starting the operation of the impulse counting relays in order to count a predetermined number of operations of the interrupter relay and thereby time the inter-digit spacing; and at armature 2062 it disconnects ground potential from the output control conductor 1975. When ground potential is removed from conductor 1975 the winding of the output distributor relay 1840 is no longer shunted and it operates in series with relay 1830. Responsive to the operation of the output distributor relay 1840, the output control conductor 1975 is transferred to the winding of relay 1860 associated with the output distributor relay 1870. The next time that the output control conductor 1975 is grounded, relay 1860 will operate and when the ground potential is removed, relay 1870 will operate in series with relay 1860 in order to connect register R—3 to the marking conductors 1800. In addition, at armature 1842, relay 1840 opens the holding circuit for transfer relay 1820 and the operated register relays of register R—1. The operated register relays will restore, but the transfer relay 1820 remains in its energized position by way of the lockout circuit including its lower winding and the grounded release conductor 1750. The deenergization of the A1 and B1 register R—1 relays does not remove ground potential from the holding conductor 1751, because the conductor 1751 is not grounded by way of armature 1852 and lock-up register relays in the register R—2.

It may be well to mention at this time that if the operator has not set up the registers of the second register (R—2) by means of her digit keys DK, the hold ground from the register relays would be removed from the hold conductor 1751 by the release of register relays in register R—2 and thereby cause the deenergization of hold relay 1720. Relay 1720, upon falling back, places a ground potential on the delay ground conductor 1755 at armature 1723, the function of which will be explained later.

Referring again to the energization of the output distributor relay 1840, it will be noted that at armature 1843 and its back contact, that ground potential is removed from the marking conductors 1800 and transferred by way of the front contact of this armature and by way of arma-

tures on operated register relays of register R—2 (which register relays in this case would be relays A2 and D2, since the digit 3 has been registered thereon) to ground the conductor 3 of the marking conductors 1800.

With the digit stop relay 2050 and the distributor control relay 2060 locked up in their energized position and with the counting relays 2101–2110 restored, the circuit is now prepared to count the spacing time between transmission of registered digits. The next time priming relay 2100 is operated by the interrupter relay 2020, it energizes when the circuit is completed at armature 2022 and locks itself up in series with the lower winding of impulse counting relay 2101 when the interrupter relay 2020 again falls back, over the following circuit: battery, winding of the priming relay 2100, armature 2131, armatures 2121–2130 of the impulse counting relay 2101–2110, inclusive, conductor 2094, armature 2054, armature 2064, armature 2074 of the deenergized space stop relay 2070, conductor 2093, lower winding of impulse counting relay 2101, to the grounded locking common conductor 2090. The locking common conductor 2090 being grounded from the ground release conductor 1754 by way of armature 2072 and 2061. Relay 2101 completes a locking circuit for its upper winding by way of armature 2111 and the grounded locking common conductor 2090; at armature 2121 it opens its initial energizing circuit and the locking circuit for priming relay 2100; and at the front contact of armature 2121 it prepares a circuit for energizing the impulsing counting relay 2102. Therefore, the next time priming relay 2100 operates, it locks itself in series with the lower winding of the impulse counting relay 2102 when its initial energizing circuit is opened. Relay 2102 completes a locking circuit for its upper winding at armature 2112, it opens the circuit for the priming relay 2100 at the back contact of armature 2122 and at the front contact prepares the circuit for the lower winding of the impulse counting relay 2103. It will be noted that the counting relays complete the testing circuits for the marking conductors 1800 at armatures 2141, 2142, etc., but due to the fact that the digit stop relay 2050 is energized a ground potential encountered on any one of the marking conductors 1800 has no effect at this time. The succeeding counting relays are operated successively, responsive to successive operations of the priming relay 2100, until the space stop relay 2070 is caused to operate. The point at which the space stop relay 2070 is operated depends upon the position of the jumper 2180. As shown, jumper 2180 interconnects the terminal 2186, associated with the space stop relay 2070 by way of conductor 2092 and armature 2065, and terminal 2183 connected to the upper winding of counting relay 2104. Under this condition, when the fourth counting relay 2104 operates and locks itself to the locking common conductor 2090, a circuit is closed by way of jumper 2180, conductor 2092, armature 2065 of the operated distributor control relay 2060, to the lower winding of space stop relay 2070. Relay 2070 operates and prepares a circuit for starting the transmission of impulses for the digit as registered on the register R—2, Fig. 18. It will be noted that the jumper 2180 may be connected to either of the terminals 2181 and 2182 if less time is required between impulse series, and that it may be connected to either of terminals 2184 and 2185 to increase the time interval between impulse series.

Upon operating space stop relay 2070 completes

a locking circuit for its upper winding at armature 2073, and it prepares a circuit, at armature 2074, for operating the restart relay 2080 upon the next operation of the priming relay 2100. In addition, space stop relay 2070 removes the ground potential from the locking common conductor 2090 at armature 2072 thereby permitting the operated counting relays to again restore. With all of the counting relays 2101–2110, inclusive, restored, and with the relays 2050, 2060, and 2070 operated, upon the next operation of the priming relay 2100 (by means of armature 2022 on the interrupter relay 2020) a locking circuit is closed for the priming relay 2100 (when its initial energizing circuit is opened) in series with the lower winding of the restart relay 2080. This locking circuit may be traced from battery winding of the priming relay 2100, armature 2131, armatures 2121–2130, conductor 2094, armatures 2054, 2064, and 2074 of the operated relays 2050, 2060, and 2070, respectively, armature 2084, lower winding of restart relay 2080, to the grounded release ground conductor 1754. Restart relay 2080 completes a locking circuit for its upper winding at armature 2082 in multiple with armatures 2052, 2062, and 2072 to the grounded release trunk conductor 1754. At armature 2084, restart relay 2080 opens its initial energizing circuit to permit the priming relay 2100 to restore and at armature 2081 it opens a point in the circuit for the output control relays over output control conductor 1875. At armature 2083, relay 2080 opens the locking circuit for the relays 2050, 2060, and 2070 to permit all these relays to clear out. When relays 2050, 2060, and 2070 restore they disconnect the grounded release ground conductor 1754 from the upper winding of restart relay 2080 permitting the restart relay 2080 to restore. The shunt (maintained at armature 2055 by the digit stop relay 2050) around the impulsing springs 2021 and the interrupter relay 2020 is removed upon the restoration of the digit stop relay 2050.

With relays 2050, 2060, 2070 and 2080 again restored, and with impulse counting relays 2101–2110 also in restored condition, the sending apparatus may now transmit and count the impulses constituting the second digit registered on the register R—2 by the toll operator.

Since the second digit registered is the digit 3, three impulses are transmitted at armature 2021 of relay 2020 over the pulse conductor 1508, by which time two of the counting relays 2101 and 2102 have been operated to test the marking conductors 1 and 2 of the marking conductors 1800, and the locking circuit of priming relay 2100 includes the lower winding of the third counting relay 2103. Then, when interrupter relay 2020 falls back to terminate the third transmitted impulse of the series and at the same time opens the initial circuit for the priming relay 2100, counting relay 2103 operates in the locking circuit of relay 2100 and connects up the third conductor of the marking conductors 1800 to the lower winding of the digit stop relay 2050. Since the conductor 3 of the marking conductors 1800 has been grounded by means of the register relays of the register R—2, Fig. 18, digit stop relay 2050 is operated with the same results that have hereinbefore been described. However, at this time the grounding of the output control conductor 1875, by means of armature 2051 of the digit stop relay 2050, completes an energizing circuit for relay 1860. Relay 1860 in turn prepares a circuit for the output distributor relay 1870. When the ground potential is removed from the output con-

trol conductor 1975 by the subsequent operation of the distributor control relay 2060, output distributor relay 1870 energizes in series with relay 1860 over a circuit including conductor 1835, armature 1922, and the grounded release conductor 1750. The operation of output distributor relay 1870 transfers the marking ground potential from register R—2 to register R—3 at armature 1873, in order to prepare for the marking of the conductors 1800 in accordance with the digits registered on the register R—3. At armature 1872, output distributor relay 1870 opens the circuit for relays 1830 and 1840, which relays accordingly restore and by the same action the locking circuit for the operated register relays of register R—2 is opened, permitting the register relays to restore to normal. Transfer relay 1850 remains energized over the holding circuit including its lower winding and armature 1851.

In a similar manner the digits registered on registers R—3 to R—6 are transmitted with suitable spacing between the impulse series constituting the digits.

It will be remembered that the operator at the toll board was only required to set up two digits (13) on her digit keys DK, which resulted in the setting of the registers R—1 and R—2, Fig. 18. The impulses, indicative of the digits registered on these registers and the required spacing time between the first and second digits, are transmitted under control of the pulsing relay 1520 of the sender link SL—1. At armature 1521, relay 1520 controls the loop circuit for operating the toll first selector TFS—1, Fig. 7, and any subsequent switches to be controlled by impulses transmitted from these contacts. After the toll operator has operated the digit keys 1 and 3 indicative of the trunk number 13, she immediately operates her sender disconnect key as an indication that no more digits are to follow.

When the sender disconnect key, of the operator's digit keys DK, is depressed, the sender disconnect conductor 1649 is grounded, thereby causing the operation of disconnect relay 1580. Responsive to the operation of disconnect relay 1580, a locking circuit is completed for itself by way of armature 1583 and ground at armature 1572 of the operated relay 1570. In addition, at armature 1581, relay 1580 opens a point in the circuit including the cut-in wiper 1526 of the link finder switch LF—1 (this circuit is also opened at armature 1533); at armature 1582 it closes a multiple circuit for the pulse relay 1520; at the normally closed contacts controlled by armature 1585, it opens the locking circuit for the switching relay 1590, while at the front contacts of this armature a second holding circuit is completed for switching relay 1510 in series with the stepping magnet LFM of the line finder FL—1; and at armature 1583 it transfers the test conductor 1507 (connected by way of wiper 1506 of the sender selector SS—1) from the grounded armature 1596 to the upper winding of relay 1530. The upper winding of 1530 is now connected by way of armature 1583, wiper 1506, test conductor 1507, armature 1711, both winding of test relay 1730, to battery. The test relay 1730 remains energized over this circuit, but due to the high resistance of the upper winding of relay 1730, relay 1530 will not operate.

Referring now to the deenergization of switching relay 1590 of the sender selector SS—1, it will be noted that at armatures 1591–1594, inclusive, the operator's digit keys DK are disconnected from the sender switch wipers 1501–1504,

inclusive. In addition, relay 1590 opens a point in the pulsing lead circuit at armature 1595, which circuit is now closed at armature 1532; it again prepares the circuit for the stepping magnet SSM of the sender selector SS—1 at armature 1596, (this circuit is now held opened by armature 1583 of the disconnect relay 1580); it disconnects the sender disconnect conductor 1649 of the operator's digit keys DK at armature 1597; and it opens a point in the circuit of the sender 1 pilot lamp 1500 at armature 1598, thereby causing the lamp to be dimmed somewhat because the circuit now includes the resistance R—3. The dimming of the pilot lamp 1500, by the insertion of resistance R3, is an indication to the toll operator that the impulses from the register sender are still being transmitted over the pulsing circuit.

Referring again to the operation of output distributor relay 1870, Fig. 18, attention is called to the fact that at armature 1872 the circuit for holding the transfer relay 1850 energized in series with register relays A2 and D2 of register D—2 (operated and locked in this circuit by the operation of the digit keys by the toll operator) is opened, thereby causing the operated registers A2 and D2 to fall back and remove the holding ground, applied by way of armature 1852, from the hold conductor 1751. Since no other registers have been operated by the manipulation of the operator's digit keys DK the hold conductor 1751 is now void of any ground potential and hold relay 1720 restores. Responsive to the deenergization of hold relay 1720, ground at armature 1723 is applied to the delay ground conductor 1755 thereby providing a shunting circuit for the restart relay 2080, in order to prevent the relay from operating to restart the impulse counting relays of Fig. 21. The impulsing circuit over the pulse lead 1508, controlled by armature 2021 of the interrupter relay 2020, is short circuited at armature 2055 by the energized digit stop relay 2050. Hold relay 1720 opens a point in the initial energizing circuit for the start relay 1740 at armature 1721, and at armature 1722 is placed a short circuit around the high resistance upper winding of the test relay 1730. This shunting circuit around the high resistance upper winding of relay 1730, completed by way of armature 1722 and armature 1742 of relays 1720 and 1740, respectively, permits relay 1530, of the sender link SL—1, Fig. 15, to operate in series with the lower winding of test relay 1730. Test relay 1730 remains in its energized position and relay 1530 completes a locking circuit for itself by way of its lower winding and armature 1534. At armature 1531, relay 1530 opens the loop circuit including wipers 1522 and 1523, and connects the winding of loop test relay 1540 to the negative side of the trunk line by way of negative wiper 1522 of the link finder LF—1, conductor 1552 and cable 2, and the negative trunk conductor 771; at armature 1523 it places battery on the EC conductor by way of resistance R1, armature 1513, EC wiper 1535, conductor 1555, and the EC conductor 774; and at armature 1533 it prepares a circuit for placing ground potential on the cut-in conductor 1556 in order to operate the cut-through relay 680 of Fig. 6. At armature 1535, relay 1530 opens the circuit for the sender 1 pilot light 1500, causing the lamp to become extinguished as an indication to the operator that the digits registered by her have all been transmitted. As a further result of the opening of the circuit at armature 1535, slow-to-release relay 1570 also deenergizes. After a slight interval

relay 1570 falls back and at armature 1572 opens the circuit for the slow-to-release relay 1560, which also falls back. In addition to opening the circuit for slow-to-release relay 1560, armature 1572 opens the locking circuit for the disconnect relay 1580.

When disconnect relay 1580 falls back a circuit is completed from ground at armature 1581, armature 1532, armature 1533, armature 1514, cut-in wiper 1526, conductor 1556, and cable 2, through the upper winding of cut-through relay 680. It should be noted, however, that this circuit for the cut-through relay 680 is not completed if loop test relay 1540 is operated and the circuit is open at armature 1542. Cut-through relay 680 operates and at armature 685 completes a locking circuit for itself in series with the call pilot relay 1350, Fig. 13, as will be described hereinafter.

In addition, relay 1580, upon restoring, opens the series circuit including relays 1520 and 2040 at armature 1582 and both relays fall back; at armature 1581 it disconnects the upper winding of relay 1530 from the test conductor 1507 thereby permitting relay 1730 to restore, and by this same action it again prepares the circuit for the stepping magnet SSM; and at armature 1585 it opens the holding circuit for switching relay 1510 and the relay falls back.

The restoration of test relay 1730 removes ground potential applied to conductors 1750, 1752, and 1754, thereby releasing operated relays in Figs. 18-21, inclusive. In addition, relay 1730 opens the locking circuit for start relay 1740 which relay also falls back.

The busy key BK shown on Fig. 20 is provided so that a register sender can be made busy in the banks of the sender selectors, such as SS1, Fig. 15, in case it is necessary to remove the register equipment from service temporarily. When the busy key BK, Fig. 20, is operated, ground potential applied to conductor 1754 causes the operator to busy relay 1710. At the back contact of armature 1711, relay 1710 disconnects the test relay 1730 from the test conductor 1507, and at the front contact of armature 1711 it applies ground potential to test conductor 1507, thereby preventing the seizure of the register sender, comprising Figs. 17 to 21, inclusive, by a sender selector, such as SS-1, Fig. 15.

Due to the slow release action of relays 1560 and 1570, relay 1570 will fall back first and close a circuit at armature 1571 before relay 1560 has had time to fall back. These relays may be referred to as the automatic ringing relays and are arranged to connect battery, by way of resistance R2, to the positive conductor of the loop circuit, to cause a relay in the toll line circuit, such as TLC, Fig. 2, to automatically transmit ringing current over the toll line TL-1 to signal a distant operator. However, since the call being described is being handled by an operator at a so-called universal position, at which position the sender links, such as SL-1, Fig. 15, are not provided with straps, such as strap 1575, between terminals 1576 and 1577, the closure of the automatic ringing circuit of armatures 1561 and 1571 has no effect at this time. The universal toll operator will manually control the ringing over the toll line TL-1 by the operation of a ring call key as will be described hereinafter.

As has been described above, after all the digits that have been registered on the register sender have been transmitted, ground potential applied to the cut-in conductor 1556 caused the operation of the cut-through relay 680. Cut-through relay

680, upon operating, completes a locking circuit by way of its lower winding, armature 685, armature 680 of the operated connecting relay 670, release call conductor 1355 and cable 1, upper winding of the call-pilot relay 1350, and battery. Relay 1350 energizes in series with the cut-through relay 680. Responsive to the operation of the call-pilot relay 1350, ground potential is removed from the sender control conductor 1304 at armature 1351. When ground is removed from conductor 1304, sequence control relay 1620 energizes in series with relay 1610 over a circuit including the grounded conductor 1100. At armature 1623, sequence relay 1620 prepares a circuit for operating the sequence control relay 1630, which circuit is completed when the next call is extended by the operator. Relay 1620 also opens the various controlling circuits for the sender link SL-1, Fig. 15, thereby permitting the sender link SL-1 and the register sender connected thereto to be restored to normal. As a further result of the operation of cut-through relay 680, a multiple circuit is completed for link busy lamp 603 at armature 686. Relay 680 also places a direct ground potential on the C conductor 773 of the associated selector TFS-1; at armatures 681 and 682 it closes the talking circuit; and at armature 684 it connects the call supervisory lamp 601 to the EC conductor 774 of the associated selector.

When the sender link SL-1, Fig. 15, is cleared out, the wipers of the link finder LF-1 are disconnected, and the bridge across the negative and positive talking conductors of the link shown in Figs. 6 and 7 is opened.

Operation of the toll first selector TFS-1

The setting up of the connection responsive to the transmission of the number 13 by the register sender will now be described.

Referring now to the toll first selector TFS-1, Fig. 7, it will be recalled that the C conductor 773 was grounded responsive to the operation of switching relay 1510 of the sender link SL-1, Fig. 15. The application of ground potential to the incoming C conductor results in the application or ground potential to the lower terminal of the lower winding of line relay 710 and in the operation of series relay 730 whose upper winding is normally connected to the C conductor through off-normal contacts 750. Series relay 730 prepares a circuit for the vertical magnet VERT. and also a locking circuit for its lower winding at armature 732; it opens the circuit of the rotary magnet ROT. at armature 733; and at armature 731 it connects the C wiper of the wiper set 770 to the lower winding of the electro-polar switching relay 740.

When the pulse relay 1520 of the sender link SL-1, Fig. 15, completes the loop circuit at armature 1521 line relay 710 operates. This circuit may be traced as follows: battery by way of the upper winding of relay 710, Fig. 7, armature 741, negative talking conductor 771, conductor 1552 and cable 2, negative wiper 1522 of the link finder LF-1, normally closed contacts controlled by armature 1531, armature 1521 of the operated pulse relay 1520, armature 1511 of the operated switching relay 1510, positive wiper 1523, conductor 1553 and cable 2, positive talking conductor 772, armature 742, lower winding of line relay 710, to the grounded C conductor 773. Line relay 710 completes a circuit at armature 711, for the slow-to-release relay 720, from ground at armature 746. Release relay 720 operates over this circuit and at armature 723 makes an additional

application of ground potential to the C conductor 773; it opens a point in the circuit of the release magnet RLSE at the back contact of armature 724, while at the front contact of armature 724 it prepares a circuit for the lower winding of series relay 730 and the vertical magnet VERT.; it energizes the lower or polarizing winding of the electro-polar switching relay 740 at armature 722; and at armature 721 it prepares a test circuit for the upper or operating winding of the electro-polar switching relay 740. The switch is now in a position to respond to impulses delivered by the pulse relay 1520, Fig. 15.

The response of the automatic switches to the impulse trains transmitted by the register sender will now be considered. Returning now to the point at which the first series of impulses (interruptions) is transmitted, the circuit of the line relay 710 is momentarily interrupted by the impinging contacts 1521 of the pulse relay 1520. It will be remembered that the operator has set up the digit 1 as the first registration on the register sender, therefore, the circuit of the line relay 710 will be opened only one time at impinging contacts 1521. Since the impinging contacts 1521 are only momentarily opened, line relay 710 is deenergized only momentarily. When line relay 710 falls back, a circuit is completed from ground at armature 746, armature 711, armature 724 and its front contacts, armature 732 of the operated series relay 730, winding of the vertical magnet VERT. to battery, and a branch of the circuit extending through the lower winding of the series relay 730, to battery.

By the operation of the vertical magnet VERT. the wipers 770, of the toll first selector TFS-1 are raised one step and come to rest opposite the desired level of the associated bank contacts. It should be understood from the foregoing description that if the circuit of the line relay had been momentarily interrupted a number of times by the impinging contact 1521 of the pulse relay 1520, that the vertical magnet VERT. would raise the wipers 770 of the selector step by step until they come to rest opposite the level of the bank contacts corresponding to the number of impulses received by the line relay. Off-normal contacts 751 and 752 prepare circuits for the rotary magnet ROT. and release magnet RLSE., respectively, while off-normal contacts 750 open the initial circuit of the upper winding of series relay 730 so as to enable relay 730 to restore upon the termination of the series of impulses being delivered to the vertical magnet VERT., the lower winding of the relay sufficing to maintain the relay operated throughout this series of impulses.

When series relay 730 restores upon the termination of the first digit (which in this case is the digit 1), it disconnects its own lower winding and the vertical magnet VERT. at armature 732, it extends the test winding of relay 740 to the C wiper at armature 731, while at armature 733 it completes a self-interrupting circuit for the rotary magnet ROT. through off-normal contacts 751, armature 711 of the operated line relay 710, and ground at armature 746 of the electro-polar switching relay 740. Rotary magnet ROT. now operates in a buzzer-like manner to rotate the wipers 770 over the terminals in the selected level (the first level in this case) in search of an idle trunk leading to a desired toll line selector, such as the toll line selector TLS-1, Figs. 1 and 9.

Operation of the toll line selector TLS-1

When an idle selector is reached, which selector

may be assumed to be the selector TLS-1 of Fig. 9, the test winding (top winding) of the electro-polarized switching relay 740 of the selector TFS-1, encounters a negative potential by way of the C wiper of the 770 wiper set and the C conductor 914 of the selector TLS-1, Fig. 9, which negative potential is obtained through off-normal contacts 991 and the upper winding of the vertical series relay 930. To describe the operating circuit of the electro-polar switching relay 740 in detail, the battery potential applied to the C wiper of the 770 wiper set, is extended by way of the normally closed contacts controlled by armature 731, armature 721 of the operated release relay 720, upper winding of switching relay 740, to the grounded C conductor 773. Upon operating, relay 740, at armature 746 opens the circuit of the rotary magnet ROT. to terminate the rotary movement of the switch, also opening the circuit of the slow-to-release release relay 720. In addition, relay 740 extends the incoming EC conductor 774 to the EC wiper of the 770 wiper set; at armature 743 it forwards ground potential over the C wiper of the 770 wiper set by way of the normally closed contacts of armature 731, and by this same action short circuits the upper or test winding of the switching relay 740; while at armature 745 it completes a circuit for the middle or holding winding to lock the relay in its energized position from the incoming grounded C conductor 773; and at armatures 741 and 742 it disconnects the talking conductors 771 and 772 from the line relay 710 and extends them to the negative and positive wipers of the 770 wiper set. Line relay 710 now restores and prepares a circuit for the release magnet RLSE. at armature 711. The slow-releasing release relay 720 subsequently restores to normal, opening the previously shunted test winding (top winding) of switching relay 740; opens the energizing circuit of the polarizing winding of relay 640 at armature 722; and removes the locally applied ground potential from the incoming C conductor at armature 723, leaving the conductor grounded by armature 1512 of the switching relay 1510, Fig. 15.

The toll line selector TLS-1, Fig. 9, having been selected by the stopping of the wipers 770 on the terminals shown to the left of Fig. 9, to which the conductors 912-915, inclusive, are connected, vertical series relay 930 is energized over the grounded C conductor 914 through the off-normal springs 991 and its upper winding, and the line relay 910 is energized over the circuit including the negative and positive conductors 912 and 913, respectively, and the impinging contacts 1521 of the pulse relay 1520, Fig. 15. Release relay 920 operates responsive to the operation of line relay 910 over the following circuit: ground at armature 987 of the switching relay 980, armature 911 of the operated line relay 910, and the winding of the slow-releasing release relay 920, to battery. Responsive to the operation of series relay 930, a circuit is completed at armature 932 for operating the sequence relay 940. This circuit is completed from the grounded C conductor 914, by way of the normal post spring contacts 997, armature 932, and the winding of the sequence relay 940, to battery. In addition, vertical series relay 930 prepares a circuit at armature 933 for its lower winding in multiple with the vertical magnet VERT. Responsive to the operation of release relay 920, a circuit is prepared at armature 921 for the test winding (upper winding) of the electro-polar switching relay 75

988; a circuit is completed at armature 922 for energizing the polarizing winding of the switching relay 980; at armature 923 an additional ground potential is applied to the C conductor 914; and at armature 924 the multiple circuit for the lower winding of vertical series relay 930 and the vertical magnet VERT. is prepared.

Referring again to the energization of sequence relay 940, it will be noted that at armature 941 it opens the circuit of the C-wiper of 990 wiper set; at armature 942 it completes a multiple circuit for itself by way of armature 961, which circuit is independent of the original circuit completed by way of armature 932; at armature 943 it disconnects BC wiper of the 990 wiper set from the operating winding of the group busy relay 970; and at armature 944 prepares a point in the circuit for the rotary magnet ROT. With relays 910, 920, 930, and 940 operated, the toll line selector TLS-1 is prepared for further operation.

The toll lines accessible to the toll line selector TLS-1 are in relatively small groups. When a group of trunk lines assigned to a particular level accessible to the selector TLS-1 are sufficient in number to utilize the entire level, one-digit numbers are required to raise the wipers of the switch to the selected level and the switch automatically rotates to find an idle toll line in the selected level. However, it may be advisable when the trunk groups are particularly small to assign two or more groups of trunks to a single level. In which case, two-digit numbers are assigned to each trunk group in which two or more groups of trunks may appear in a single level of bank contacts. When two-digit numbers are required to select a particular group of trunks in a single level, the first digit will raise the wipers of the switch to the particular level, and the second digit will directly operate the wipers of the switch to the first trunk in the selected group and the wipers will then automatically rotate over the trunk lines in the selected group to find the first idle one. Since the trunk group in which the call being described requires an entire level of the toll first selector TLS-1, only a single digit is required to select an idle trunk in the group. Therefore, the operation of the switch when controlled by a single digit will now be described.

When the second digit registered (digit 3) is transmitted, the pulse relay 1520, Fig. 15, is deenergized momentarily three times, and momentarily opens the loop circuit of the line relay 910 three times under control of the impulse springs 1521. Vertical magnet VERT., Fig. 9, responds each time the line relay 910 momentarily falls back and closes the back contact of armature 911. The lower winding of slow-releasing vertical series relay 930 maintains the relay operated after the upper winding has been disconnected at off-normal contacts 991 upon the first vertical step of the switch. Off normal contacts 992 and 993 also are closed on the first vertical step of the switch to prepare the circuit for the release magnet RLSE. and the rotary magnet ROT. In response to the three impulses transmitted to the line relay 910 wiper set 990 are raised step by step until they are opposite the third level of the associated bank contacts.

At the end of the series of impulses, vertical series relay 930 restores and opens the initial energizing circuit of sequence relay 940 at armature 932. However, relay 940 remains operated by way of its locking circuit including armature

942, armature 961, normal post spring contacts 997, and the grounded C conductor 914.

Since the trunk group over which the call being described is to be extended requires only a single digit to cause the selector TLS-1 to select the first idle trunk in the group, the normal post spring contacts 997 are opened when the wipers 990 are raised to the third level (these contacts are opened only at levels assigned to trunk groups reached by a single digit) and remain closed on all levels in which trunk groups are selected by a two-digit number.

Therefore, normal post spring contacts 997 open the locking circuit of the sequence relay 940. Relays 940 deenergizes and prepares a circuit for the rotary magnet ROT. at armature 944. Sequence relay 940 also connects the test winding of the electro-polarized group busy relay 970 to the BC wiper of the wiper set 990; it opens the circuit of the rotary series relay 950 at the front contact of armature 944; and at armature 941 connects the C wiper of the 990 wiper set to the test winding (top winding) of the electro-polarized switching relay 980.

As soon as the sequence relay 940 falls back and closes the back contacts of armature 944, a self-interrupting circuit is completed for the rotary magnet ROT. over the following circuit; from ground, armature 987 of the switching relay 980, armature 911 of the operated line relay 910, closed contacts of the off-normal springs 993, self-interrupting contacts 996 of the rotary magnet ROT., armature 944, normally closed contacts controlled by armature 964, winding of the rotary magnet ROT., to battery. The rotary magnet operates in buzzer-like manner and rotates the wipers 990 across the bank contacts of the desired toll line group.

Assuming now that the toll line TL-1, Figs. 1 and 2, is idle when the wipers 990 arrive on terminals 275 in the bank associated with the toll selector TLS-1 in the selected level. When wiper C of the 990 wiper set engages the bank terminal 275 to which C conductor 278 is connected, the electro-polarized switching relay 980 will energize over the following circuit: battery, winding of cut-off relay 290 of Fig. 2, armature 283, armature 245, C conductor 278 of the terminal set 275, wiper C of the 990 wiper set, Fig. 9, armatures 971, 965, 951, 941, normally closed contacts controlled by armature 931, armature 921 of the operated release relay 920, test winding (top winding) of the electro-polarized switching relay 980, to the grounded C conductor 914. Upon operating, switching relay 980 terminates the rotary movement of the wipers by opening the automatic stepping circuit for the rotary magnet ROT. at armature 987, and by this same action opens the energizing circuit of the slow-releasing relay 920; it completes a holding or locking circuit for its middle winding at armature 986 from the grounded C conductor 914; it disconnects the busy control wiper BC from the group-busy relay 970 at armature 985; it extends the incoming EC conductor 915 to the EC wiper of the 990 wiper set at armature 984; it applies a direct ground potential to the C wiper of the 990 wiper set at armature 983; and it transfers the incoming negative and positive conductors 912 and 913, respectively, from the windings of the line relay 910, to the negative and positive wipers of the wiper set 990 at armatures 981 and 982, respectively. It will be noted that the grounding of the C wiper and consequently the C conductor 278 of the toll line circuit TLC prevents the toll line cir-

cuit, Fig. 2, from being seized by other toll line selectors, such as TLS—1. The same ground potential from armature 983 also places a shunt around the test winding of the switching relay 980. However, switching relay 980 remains in its energized position by means of the locking circuit including its middle winding.

Line relay 910 now restores and closes a point in the circuit for release magnet RLSE. The toll line selector TLS—1 is held in its operated position by the ground potential supplied over the C conductor 914 from the preceding toll first selector TFS—1, Fig. 7.

Operation of the toll-line circuit TLC

In the toll line circuit TLC, Fig. 2, the cut-off relay 290 is energized over the above-traced circuit including the C conductor 278. At armature 293, relay 290 extends the grounded C conductor 278 to the C terminal 297 and multiples thereof in the banks of the finder switches, such as the finder switch F—1, Fig. 6, thereby busying this toll line circuit to any other switches having access to it. In addition, relay 290 opens a point in the start circuit at armature 295, and at armature 294 it opens a point in the circuit through which the start relay 280 becomes locked locally in an incoming call, thereby preparing the start relay for the transmission of supervisory pulses over the EC conductor 279. It is to be noted that the EC conductor 279 now extends through the lower winding of start relay 280 to open contacts, while the negative and positive conductors 276 and 277, respectively, extend to ground potential by way of the windings of the pad control relay 220, the negative conductor by way of the upper winding of retard coil 250, lower winding of guard relay 240, and the winding of pad control relay 220 to ground, while the positive conductor 277 extends by way of the lower winding of the retard coil 250, armature 244, winding of the ring relay 230, and the pad control relay 220 to ground. This is the condition under which the calling loop tests "dry"

Loop-test

Referring to the sender link SL—1, Fig. 15, it will be remembered that relay 1530 was operated after the last digit registered on the register equipment had been transmitted. The operation of relay 1530 results in the talking conductors being tested for a "dry" loop.

When relay 1530 operates, it connects ground potential through the winding of the loop test relay 1540 and armature 1531 to the negative talking conductor in order to test for a negative potential. In the above described connection, the negative and positive talking conductors have been extended to ground through the winding of the pad control relay 220, Fig. 2. Therefore, the loop test relay does not operate.

However, if the line relay of toll first selector TFS—1, Fig. 7, or toll line selector TLS—1, Fig. 9, is still bridged across the talking conductors, the negative talking conductor will have a negative battery potential applied to it through the winding of the connected line relay. When this condition occurs, loop test relay 1540 energizes in series with the connected line relay, and at armature 1542 prevents the cut-in conductor from being grounded. Cut-through relay 680 is accordingly prevented from operating and the associated switch train cannot be connected to the finder F—1, Fig. 6. In addition, at armature 1543 ground potential is applied to the winding of re-

lay 1570 to prevent its release and also to light the sender 1 pilot lamp 1500. The operator is informed of the incomplete connection and restores her talking key K—1, thereby releasing the sender link SL—1, Fig. 15, and the operated switches controlled by the register sender equipment.

Referring again to the sender link SL—1, Fig. 15, it will be remembered that after all the digits have been sent out by the pulse relay 1520 of the sender link equipment and the cut-through relay 680 of the finder F1, Fig. 6, has been operated, that the call-pilot relay 1530, Fig. 13, locked in series with the lower winding of cut-through relay 680 and the closed contacts of armature 669 of the connecting relay 670. Responsive to the above operations, the sender control relays of Fig. 16 were operated causing the sender link SL—1, Fig. 15, to be disconnected (released). In addition the sequence control relays, Fig. 16, prepared the sender link SL—2, Fig. 16, for operation. Furthermore, it will be remembered that the sender 1 pilot lamp 1500 was lighted when the sender link SL—1 was connected to the register sender equipment, that the sender pilot lamp was dimmed during the transmission of the impulses by the register sender equipment, and that when these impulses were completely transmitted the sender 1 pilot light 1500 was extinguished.

Manual ringing

When the toll operator is informed by the extinguishing of the sender 1 pilot lamp 1500, Fig. 15, that the connection has been set up to a toll line of the desired group (toll line circuit TLC, Fig. 2), she momentarily operates her non-locking ring call key K—13, thereby causing the following operation. When the operator throws the ring call key K—13 a circuit is completed at contacts 1422 for operating the split call relay 1320, Fig. 13. At armatures 1321 and 1322, split-call relay 1320 extends the tip and ring call conductors 656 and 655, respectively, to contacts 1421 and 1420, respectively, of the ring call key K—13. Therefore, when contacts 1421 of the key K—13 is closed, a momentary ring-control pulse is transmitted from the negative pole of exchange battery through the resistance R7, contact 1421 of key K—13, conductor 1446, armature 1321 of the operated split-call relay 1320, conductor 656 and cable 1, armature 673 of the operated connect relay 670, armature 682 of the operated cut-through relay 680 to the positive talking conductor 772. At the same time this application of negative potential to the positive talking conductor takes place, it is to be noted that ground potential is impressed on the negative talking conductor by way of contacts 1420 of key K—13, conductor 1447, armature 1322 of the operated split-call relay 1320, conductor 655 and cable 1, armature 671 of the operated connect relay 670, armature 681 of the operated connect relay 680, to the negative talking conductor 771. This latter condition prevents any possibility of an undesired operation of the guard relay 240 over the negative talking conductor by induction through the condenser associated with the switchboard windings of repeating coil 200.

In the toll line circuit TLC, Fig. 2, the momentary ring control pulse (the described momentary application of negative potential to the positive talking conductor) results in the operation of ringing relay 230 through the lower winding of retard coil 240 and armature 244 of relay 240. Upon operating, ringing relay 230 applies ring-

ing current of the chosen frequency to the toll line TL—1 from the common ringing lead 296 in order to signal the operator in the distant exchange, to which the toll line TL—1 extends.

Controlling the toll line pad

It is common practice to provide a so-called pad at each exchange terminal of a repeated toll line, such as the pad 214. This pad is composed of two series, center-tapped resistors and a shunt resistor connected between the center taps in series with an insulating condenser. As is well understood, the purpose of a pad is two-fold: it introduces a definite loss when the toll line is connected through the exchange to a subscriber line, which loss is not present when the toll line is interconnected with another toll line, whereby the transmission level is more nearly uniform independent of the length of the toll connection built up, and introduces a necessary circuit loss which tends to balance the artificial line network at the repeater nearest the exchange regardless of the transmission characteristics of the local line.

When the toll line TL—1, Fig. 2, is in use and cut-off relay 290 is therefore operated, a circuit is closed at armature 291 by way of armature 221 of the pad control relay 220 through the winding of the pad cut-off relay 210 to battery. This pad cut-off relay 210 operates unless the pad control relay 220 is operated to prevent the operation of the pad cut-off relay. The pad control relay 220 is operated from the switchboard extension of the toll line over a simplex circuit, provided there is a connection made to the talking conductors connected to the toll line. Each of the circuits used for connecting the toll line with a local line is provided with a 44,000 ohm center path resistor through which the current is applied for operating the pad control relay. One of these pad control resistors is connected with the switchboard windings of the repeating coil 300 of circuit CLR, Fig. 3. The current which flows through pad control relay 220 and supplied through one of the center-tapped resistors above mentioned is insufficient to operate the guard and ringing relays 240 and 230, respectively, neither of which is as sensitive as the pad control relay and each of which receives only one half the current which flows through the pad control relay 220.

The toll operator may actuate the cut-off answering key K—5 to disconnect the answering end of the connection while she is talking over the toll line TL—1, if desired. Likewise, she may actuate the cut-off call relay K—15 if she desires to converse over the answering end of the connection without being overheard over the calling end of the connection.

It is to be noted that a 44,000 ohm pad-control resistor is connected with the position talking conductors 1180 and 1181 to supply a battery potential to the answering and calling end of the connection while the position talking conductors are connected thereto. This connection insures that the toll line pad is inserted while the toll operator is conversing over the toll line.

When the operator operates her ring call key K—13 and the split-call relay 1320 operates, the tip and ring call conductors 656 and 655, respectively, are disconnected from the position talking conductors 1180 and 1181, respectively, to prevent the battery potential through the 44,000-ohm pad-control resistor 2 from being connected to the tip and ring call conductors 656 and 655, respectively. Accordingly, the pad control relay 220

is not operated at this time. It is to be noted that the pad cut-out relay 210, Fig. 2, is operated from ground at armature 291 of the operated cut-off relay 290. At armatures 211, 212, and 213, pad cut-out relay 210 disconnects the pad 214 from the talking conductors of the trunk. The ringing current is now transmitted over the toll line TL—1 by way of the repeating coil 200, thereby resignalling the operator at the distant end of toll line TL—1.

The toll operator at the central office operates the key K—13 only momentarily, therefore, the ring control pulse, transmitted over the positive conductor of the trunk, only causes a momentary operation of ring relay 230. In addition, the split call relay 1320, Fig. 13, again connects the tip and ring call conductors 656 and 655, respectively, to the position talking conductors 1180 and 1181, respectively, of the operator's telephone set. Battery potential through the 44,000-ohm pad-control resistor, is again connected across the tip and ring call conductors 656 and 655, respectively, by way of the closed contacts of armatures 1321 and 1322 of the deenergized split call relay 1320. When this occurs, the pad control relay 220 of the toll line circuit, Fig. 2, is energized over this simplex circuit as described above. At armature 221, pad control relay 220 opens the circuit of pad cut-out relay 210 which immediately falls back. Responsive to the deenergization of pad cut-out relay 210, the pad 214 is again connected to the talking conductors of the trunk. The above-described pad circuit of the pad control relay 220 insures that the toll line pad 214 is inserted while the toll operator is conversing over the toll line.

In the event that the first application of ringing current transmitted over the toll line TL—1 is not successful in securing a response from the distant operator, the toll operator may again cause ringing current to be transmitted over the toll line by momentarily actuating her ring-call key K—13 again. The pad control relay 220 will deenergize due to the operation of the split call relay 1320 and the pad cut-out relay 210 will again operate to remove the pad 214 from the toll line while the ringing current is being transmitted.

When the distant operator responds, she may converse with the originating operator (the central office toll operator) who informs the distant operator of the number of the wanted subscriber. The distant operator completes the connection in the usual manner and when the central office toll operator hears the wanted subscriber answer the call, she stamps the toll ticket to indicate the starting time of the conversation between the calling and the called subscribers.

The central office toll operator now restores her talking key K1 to normal, thereby opening the holding circuit for the connecting relay 670 at contacts 695; opening the initial energizing circuit of the connecting relay 670 at contacts 696; and at the normally open contact 694 disconnects the call supervisory pilot lamp 601 from the FL conductor 1358 and connects it to exchange battery by way of the normally closed contact 694.

When the connect relay 670 falls back, talking relay 1130 in the operator's position equipment, Fig. 11, also restores. Responsive to the deenergization of the connecting relay 670, the talking conductors of the calling subscriber are extended to the called subscriber through the normally closed contacts controlled by armatures 672 and 674, thereby disconnecting the operator's tele-

phone circuit from the calling and called lines. At armature 676, connecting relay 670 disconnects the battery potential, applied by way of resistance R4 and armature 632 of the operated change-over relay 630 from the release answering conductor 608, thereby causing the release of the answering pilot relay 1340, Fig. 13; at armature 677 it opens the circuit of the start relay 660; and at armature 669 it opens a point in the circuit over the release call conductor 1355 for the call pilot relay 1350. It will be noted that the call pilot relay 1350 was energized in series with the lower winding of the cut-through relay 680, however, the cut-through relay remains locked up in the circuit including the resistance R5 and battery by way of armature 685 and relay 1350 falls back. Start relay 660, upon falling back opens the circuit for the upper winding of supervisory relay 650 at armature 662. At armature 661, start relay 660 prepares a point in the circuit for the release magnet RLSE.; it disconnects ground potential from the polarizing windings of the electro-polar relays 610 and 620 and by this same action causes the calling trunk group identity lamp 360 of the CLR trunk, Fig. 3, to be extinguished. At armatures 664 and 665, start relay 660 transfers the answering supervisory lamp 602 from the control of the relay 1370 in the operator's position relays Fig. 13, to the lower winding of the supervisory relay 650 and the C-1 conductor of the wipers 618. Relay 650 remains energized in series with the lower winding of cut-off relay 320, Fig. 3.

Responsive to the deenergization of talking relay 1130 in the operator's position, Fig. 5, and answering pilot relay 1330, call pilot relay 1350, and supervisory relay 1370 of the operator's position relay 13, the operator's position equipment is restored to normal and may be used to extend other incoming calls by way of finder-selector links, similar to finder F1 and toll selector TFS-1 of Figs. 6 and 7, respectively, common to her position equipment.

It may be well to mention at this time that after the talking key K1 has restored with the resulting deenergization of the connecting relay 670, pad control relay 220 of the toll line circuit of Fig. 2 is held operated from the 44,000-ohm pad control resistor and battery bridging the switchboard windings of the repeating coil 300 of the CLR trunk of Fig. 3.

Attention is called to the fact that the calling and the called subscribers may converse with each other even though the toll operator has not restored her talking key K1 to normal. With the connecting relay 670 operated, the talking conductors of the calling line include the armatures 672 and 674 of the connecting relay 670, ring and tip answering conductors 654 and 653, respectively, cable 1, position talking conductors 1181 and 1180, respectively, armatures 1312 and 1311, armatures 1322 and 1321, respectively, ring and tip call conductors 655 and 656, respectively, cable 1, armatures 671 and 673, armatures 681 and 682, over the negative and positive conductors 771 and 772, to the toll line circuit of Fig. 2 by way of the toll first selector TFS-1, Fig. 7, and the toll line selector TLS-1 of Fig. 9. Therefore, the calling and the called subscribers' talking circuit is looped by way of the operated contacts on the connect relay 670 through the operator's position relay of Fig. 13, before the talking key K1 is restored to normal position and after the talking key K1 is restored to normal the talking conductors of the trunk are cut through

normally closed contacts controlled by the connecting relay 670.

Switchhook supervision from the local automatic subscriber

Assuming that the local calling subscriber at substation A, automatic office #8, of Fig. 1, desires to attract the attention of the toll operator at the central office. The subscriber may do so by depressing the switchhook momentarily one or more times. Each time the switchhook is depressed, the trunk circuit TC of Fig. 1, operates in the well known manner to reverse the application of the potential to the two conductors of the trunk T-1, thereby reversing the current flow through the lower winding of line relay 340 and the upper winding of the electro-polarized supervisory relay 330 of the CLR trunk, Fig. 3. Each time the current flow is reversed, electro-polarized supervisory relay 330 operates to insert the high resistance R in the circuit of the cut-off relay 320 and the associated C conductor extending to terminals 360 of the finder switch banks, Fig. 6, for the duration of the reversal. It should be noted that the resistor R and the resistance of the upper winding of cut-off relay 320 is normally shunted by armatures 331 of the electro-polarized supervisory relay 330. Therefore, when relay 330 operates, battery by way of both windings of the cut-off relay and the resistor R is connected by way of the armature 341 to the C conductor extending to the terminals 360 of switch banks of the finder, Fig. 6, thereby reducing the current flow sufficiently to cause the marginally adjusted answering supervisory relay 650 to fall back. Upon restoring, answering supervisory relay 650, Fig. 6, completes a circuit from ground at armature 634 of the operated change-over relay 630, armature 652, normally closed contacts controlled by armature 664 of the deenergized start relay 660, answering supervisory lamp 602, to battery. The dotted jumper 653 including the armature 651 shunted around the lower winding of the marginal supervisory relay 670 is not used at the CLR or point-to-point operator's position (commonly referred to as universal position) and has no bearing on the operation of the circuit at this time. When the current flow over trunk line T-1 is reversed back to the direction normally obtained during conversation, electro-polarized supervisory relay 330 is caused to restore and again shunt the resistance R and upper winding of cut-off relay 320 at armature 331. When this occurs, the answering supervisory relay operates in series with the lower winding of the cut-off relay 320 and opens the circuit for lighting the answering supervisory lamp 602 at armature 652. The operator may respond to the flashing condition of the lamp 602 by again actuating the talking key K-1 to bring about the operation of the talking relay 1130, the connecting relay 670, and the start relay 660, to connect her position talking conductors 1180 and 1181 to the calling line by way of tip and ring answering conductors 653 and 654, respectively. When the operator has answered the signal and conversed with the calling subscriber, she may again restore the talking key K-1 to permit talking relay 1130, connecting relay 660, and starting relay 660 to again restore and disconnect her position talking conductors, or she may break down the extended connection and re-extend it in the event that it is found that the connection has not been completed to the desired called line.

Ring-down supervision from the called toll line

In the event that the operator at the distant end of the toll line TL—1 desires to get in touch with the originating central office toll operator, she causes ringing current to be momentarily applied to the toll line TL—1, thereby causing the shaded-pole alternating current ring-up relay 270 to operate and open the normally closed circuit of the slow-to-release signal relay 260. The momentary deenergization of the signal relay 260 completes a circuit from ground at armature 246, armature 261, through the upper winding of the combined start and recall relay 280. Relay 280 closes a locking circuit for its lower winding at armature 284 in series with the EC conductor 279 connected to the toll line selector bank contacts 275, EC wiper of the wiper set 990 of toll line selector TLS—1 of Fig. 9, armature 984 of the operated switching relay 980, armature 962, EC conductor 915 and bank contact of the preceding toll first selector, EC wiper of the 770 wiper set of toll first selector TFS—7, Fig. 7, armature 744 of the operated switching relay 740, EC conductor 774, armature 684 of the operated cut-through relay 680 of the finder F—1, Fig. 6, calling supervisory lamp 601, contact 694 of the restored talking key K1, to battery. The calling supervisory lamp 601 becomes lighted steadily in this locking circuit, including the lower winding of the combined start and recall relay 280, to signal the operator. When the operator responds by throwing her talking key K—1, the talking relay 1130, connecting relay 670, and start relay 660, together with other relays in the operator's position relay circuit of Fig. 13 will operate and connect the position talking conductors 1180 and 1181 to the tip and ring call conductors 656 and 655, respectively, extending to the called operator over the toll line TL—1. The disconnection of the calling supervisory lamp 601 by the operation of the key K—1 opens the locking circuit for the combined start and recall relay 280 which immediately falls back, and the calling supervisory lamp 601 is extinguished.

Responsive to the operation of combined start and recall relay 280, a circuit is completed at armature 281 for holding the cut-off relay 290 in its energized position, and for maintaining a ground potential on the C conductor extending to the banks of the finder switch, Fig. 6; and at armature 283 ground potential is applied to the C conductor of trunk T—4 to busy the trunk in the banks of the selectors, such as toll line selector TLS, Fig. 9. When the operator throws her key K—1 to connect her position talking conductors to the talking conductors of the toll line TL—1, the circuit of the calling supervisory lamp 601 is transferred from battery at the normally closed contacts 694 of the key K—1 to the normally open contacts 694 thereby placing the lower winding of the start and recall relay 280 and the calling supervisory lamp 601, in series with the high resistance 1303 and the winding of relay 1300. The additional resistance of resistor 1303 and the winding of relay 1300 causes the marginally operated holding winding of relay 280 to have insufficient current to maintain the relay in its operated condition and the relay restores. When the distant operator has completed her conversation with the central office toll operator, the central office toll operator restores her key K—1 to normal.

Clearing out the connection

When the conversation has been completed, the restoration of the receiver at the local calling substation A, Fig. 1, results in the previously discussed operation of the electro-polarized supervisory relay 330 to insert the resistance R and the resistance of the upper winding of the cut-off relay 320 in the C conductor. Answering supervisory relay 650 of the finder, Fig. 6, is thereby restored to light the answering supervisory lamp 602 steadily as a disconnect signal. The toll operator may now stamp the toll ticket so that the calling subscriber may be charged for the completed toll call. In order to clear out the calling end of the connection, the operator momentarily throws the non-locking release answering key K—2, as will be subsequently described.

The distant operator rings on the toll line TL—1, thereby causing the above-described operation of the lighting of the calling supervisory lamp 601, as an indication that the subscriber at the distant office has replaced his receiver and the trunk is available for additional calls, the toll operator at the central office may operate her talking key K1 to connect her position talking conductors 1180 and 1181, respectively, to the talking conductors of the toll line TL—1 and challenge the line, or she may momentarily throw her release call key K—12 to disconnect the calling end of the link, as will be subsequently described.

Clearing out the calling end of the connection

When the conversation has been completed, restoration of the receiver at the local calling substation A of local automatic exchange 8, results in the previously discussed operation of the electro-polarized relay 330 to insert the resistance R and the resistance of the upper winding of the cut-off relay 320 in the C lead connected in the banks of the finder switch F—1 of Fig. 6. The answering supervisory relay 650 of the finder F—1 of Fig. 6, is thereby restored to light the answering supervisory lamp 602 steadily as a disconnect signal.

It should be understood that when the operator is releasing a finder such as finder F1 of Fig. 6, that all the talking keys, such as K—1, of other finders associated with her position must be in normal position while the talking key K—1 of the finder being released must be operated at the same time that the release-answering key K—2 is operated, or the talking key K—1 may be operated prior to and during the time that the release-answering key K—2 is operated. When the talking key K—1 is operated, connect relay 670 is operated from the grounded test conductor 604 (grounded from armature 1133 of the talking relay 1130, Fig. 11) and locks by way of its upper winding in series with the winding of the talking relay 1130. A further result of the operation of the connecting relay 670, the tip and ring answering conductors 653 and 654 are connected to the position talking conductors 1180 and 1181; the change-over relay 630 is held operated in series with the answering-pilot relay 1340; the start relay 660 is operated from the grounded start conductor 1302 (grounded by the operation of the answering pilot relay 1340 at armature 1344); and the call pilot relay 1350 operates in series with the lower winding of the cut-through relay 680. Start relay 660 completes an obvious circuit for energizing supervisory relay 650.

The operator now momentarily operates the nonlocking release answering key K—3 causing the operation of the split answering relay 1310 from the grounded contacts 1409 of key K—3. The split answering relay 1310 disconnects the tip and ring answering conductors 653 and 654, respectively, from the position talking conductors 1180 and 1181 at armatures 1311 and 1312 and by this same action disconnects the tip and ring answering conductors from the tip and ring calling conductors 656 and 655, respectively, to prevent the operator and the called subscriber from receiving disagreeable clicks in their receivers during the release action of the switches connected to the calling (answering) end of the connection. At contacts 1408, release answer key K—3 grounds conductor 608 which results in the shunting down of answering pilot relay 1340 and the shunting out of the upper winding of the change-over relay 630. The locking circuit for change-over relay 630, which includes ground by way of its upper winding, off normal springs 635, overflow springs 646, armature 632, resistance R4, and battery, is short circuited when the release answering conductor 608 is grounded by the operation of the key K—3. The call pilot relay 1350 remains operated, however, and when answering pilot relay 1340 falls back the circuit completed at armature 1343 for operating the distributor relay is not closed because its circuit is opened at armature 1351 of the operated call pilot relay 1350. Thus, additional incoming calls are prevented from being received and further operation of the sender control relays is prevented because the sender control conductor 1304 cannot be grounded to select a sender link as long as the call-pilot relay 1350 is maintained energized.

It will be recalled that the answering supervisory relay 650 was held in its operated position from ground at armature 643 of the operated change-over relay 630 in series with the winding of the cut-off relay 320 of the CLR trunk, Fig. 3, and that when the additional resistance is placed in the circuit by the operation of the electro-polarized supervisory relay 630, the answering supervisory marginal relay 650 was released and lighted the answering supervisory lamp 602 to indicate to the toll operator that the calling subscriber has hung up his receiver. Furthermore, when the operator actuated the talking key K—1 with the resultant circuit operations which caused relay 650 to be again operated over its upper winding, the answering supervisory lamp 602 was extinguished. When answering pilot relay 1340 deenergizes the ground at armature 1344 is removed and the start relay 660 falls back. When start relay 660 restores it prepares a circuit at armature 661 for the release magnet RLSE., it removes ground from the polarizing winding of the switching relays 610 and 620, and by this same action removes ground from the EC—1 wiper of the wiper set 618, causing the trunk identity lamp 360 to become extinguished. At armature 662, relay 660 opens the energizing circuit for the upper winding of supervisory relay 650, thereby causing the relay to restore. Responsive to the deenergization of the change-over relay 630, the ground at armature 634 is removed from the middle or holding winding of the switching 1 relay 610 and from the C—1 wiper of the wiper set 618, permitting relay 610 to restore. At armature 631, change-over relay completes a circuit from ground, armature 631, armature 661 of the deenergized start relay 660, off-

normal springs 647 (closed when the wiper shaft of the switch was raised from its normal position), winding of release magnet RLSE., to battery. Responsive to the operation of the release magnet RLSE., the wipers of the shaft are restored to normal in the well known manner.

When the release answering key K—3 is restored to normal after the momentary operation, split answering relay 1310 is restored to normal, and again connects the tip and ring answering conductors 653 and 654 to the position talking conductors 1180 and 1181, which has no effect on the circuit at this time, because the calling end of the connection has been released by the restoration of the finder F—1 of Fig. 6. The answering pilot relay 1340 has been restored as explained, and the call pilot relay 1350 remains energized in series with the cut-through relay 680 as long as the talking key K—1 remains in its operated position.

In the CLR circuit of Fig. 3, cut-off relay 320 restores when ground potential is removed from the conductor and at armature 321 removes the shunt around the high resistance upper winding of line relay 340. The insertion of the high resistance upper winding of the line relay 304 in the holding bridge across the conductors of the trunk T—1, gives a disconnect supervision to the trunk circuit TC, Fig. 1, connected at the distant end of trunk line T—1. It is to be noted that start relay 310 is not operated at this time, because it is maintained disconnected at armature 332 of the electro-polarized supervisory relay 330. As soon as the usual relay operation has taken place in the trunk circuit TC, the switches OS—1 and F—3 (shown in Fig. 1) clear out, and the conductors of the trunk T—1 are disconnected so as to terminate the flow of current thereover. When this occurs, line relay 340 restores. Supervisory relay 330 restores when its polarizing circuit is opened at armature 342 by the deenergization of the line relay 340.

Before clearing out the called end of the connection, responsive to the disconnect signal indicated by the lighting of the call supervisory lamp 601, lighted by the transmission of ringing current over the toll line TL—1 from the distant operator, as has been described hereinbefore, the toll operator at the central office toll board may momentarily project ringing current over the toll line TL—1 by operating her ring call key K—13, as has previously been discussed. This will signal the distant operator to give a ring-off relay.

The clearing out of the called end of the connection will now be discussed. If the called subscriber at the distant toll office has hung up his receiver and the operator thereat has received a disconnect signal, she will cause ringing current to be transmitted over the toll line TL—1 and thereby cause the operation of the ring-up relay 270 of the toll line circuit shown in Fig. 2. The operation of the circuit responsive to the transmission of the ringing current from the distant operator, ultimately results in the lighting of the call supervisory lamp 601, as has been described hereinbefore. Upon noting the disconnect signal (the lighting of the call lamp 601) the toll operator can either talk to the distant operator or she can assume that the lighting of the call lamp 601 is a disconnect signal and operate her release call key K—12 to restore the called end of the connection to normal.

The called end of the connection is cleared out responsive to the momentary operation of the

non-locking releasing call key K—12. Responsive to the closing of contacts 1419, by the momentary operation of the call key K—12, ground potential is connected, by way of conductor 1348 to the winding of the split call relay 1320, which relay, upon operating, disconnects the ring and tip call conductor 655 and 656, respectively, from the position talking conductors 1180 and 1181, thereby preventing the operator from receiving disagreeable clicks in her receiver. At contacts 1418, release call key K—12 connects ground potential by way of conductor 1355 to hold the call pilot relay 1350 in its energized position, and to place a shunt around the holding or lower winding of the cut-through relay 680 of the finder F—1, Fig. 6. It should be understood that the talking key K—1 is operated during the time that the toll operator is disconnecting the calling and the called ends of the connection and is restored after the called end of the connection is released. Cut-through relay 680 falls back when the holding or lower winding is shunted, thereby disconnecting the talking conductors 771 and 772 at armatures 681 and 682; it removes the holding ground from the C-conductor 773 extending to the toll first selector TFS—1, Fig. 7, at armature 683, and it disconnects the call supervisory lamp 601 from the EC conductor 774 at armature 684; and at armature 686 opens the circuit for the link busy supervisory lamp 603 to extinguish the lamp and thereby indicate that the finder F—1, Fig. 6, is available for additional calls. When the release call key K—12 is restored to normal, the split call relay 1320 and the call pilot relay 1350 are restored to normal.

In the event that the toll operator desires to clear out the called end of a connection before she has received a disconnect signal from the distant operator, she may first momentarily operate her ring call key K—13 to cause ringing current to be transmitted over the toll line TL—1 as previously discussed, in order to give the distant operator a ring-off signal. The toll operator then operates the release call key K—12 to release the equipment as discussed previously.

If the toll operator is not busily engaged at completing other connections she may leave the talk key K—1 in its operated position in order to make the finder F—1, Fig. 6, available for additional calls. If this is the case, the deenergization of the call-pilot relay 1350 results in the reoperation of the distributor start relay 1170 by way of the previously described circuit. The operation of the distributor start relay 1170 removes the busy ground potential from conductor 1188 to mark the operator's position idle at the testing relays of the distributor, Fig. 12, and places ground potential on the distributor start conductor 1189 to start the distributor to connect the operator's position and selected finder to an idle register sender by means of an idle sender link.

Referring now to the toll first selector TFS—1, Fig. 7. Responsive to the deenergization of cut-through relay 680, the electro-polarized switching relay 740 deenergizes because the locking circuit for its middle winding is disconnected by the removal of ground from C conductor 773. Responsive to the deenergization of switching relay 740, a circuit is closed from ground at armature 746, armature 711 of the deenergized line relay 710, armature 724 of the deenergized release relay 720, off normal contacts 752 (closed on the first vertical step of the switch), winding of release magnet RLSE., to battery. The operation of the

release magnet RLSE. results in the restoration of the wipers 770 in the well known manner. It should be noted, however, that at armatures 741 and 742 switching relay 740 opens the circuit of the negative and positive wipers of wiper set 770, and at armature 743 removes the ground potential from the C wiper of the wiper set 770, which subsequently results in the release of the toll line selector TLS—1, Fig. 9.

In the toll line selector TLS—1, Fig. 9, the switching relay 980 restores when the preceding selector (in this case the toll first selector TFS—1, Fig. 7) removes ground potential from the C conductor 914. Upon restoring, switching relay 980 disconnects the negative, positive, and EC wipers of the wiper set 990 and removes ground from the C wiper at armature 983. At armature 987, switching relay 980 completes an operating circuit for the release magnet RLSE. by way of armatures 911 and 924 of the deenergized relays 910 and 920, and off-normal contacts 992. Responsive to the operation of the release magnet RLSE., the wiper set 990 of the switch are restored to normal position.

In the toll line circuit TLC, Fig. 2, the removal of ground potential from the C conductor 278 by the preceding switch, (the toll line selector TLS—1, Fig. 9), renders the circuit accessible to other selectors and permits the cut-off relay 290 to restore and place the circuit in normal condition.

Overflow condition at the toll first selector

The handling of overflow conditions at certain of the switching stages will be discussed briefly. In the event that the toll first selector TFS—1, Fig. 7, is unable to find an idle trunk on a desired level, the rotation of the wipers 770 as previously described continues until the wipers have been advanced to the overflow position, one step beyond the last trunk. Overflow contacts are provided in the bank of the C wiper of the wiper set 770 and a meter is preferably connected to each of these contacts to record the number of unsuccessful attempts to find an idle trunk in a group. The upper or test winding of switching relay 740 is actuated in series with this meter and operates just as though an idle trunk were found and applies ground potential to the C wiper to bring about an effective operation of the overflow meter. At the same time, overflow contacts 753 are closed and connect the upper winding of series relay 730 in the circuit in order to supply an effective source of operating potential for the test winding of switching relay 740, in the event that the overflow meter is of high resistance, thereby insuring operation of relay 740 upon the eleventh rotary step of the switch wipers. When switching relay 740 by-passes its upper test winding to apply ground potential directly to the C wiper, series relay 730 is operated and at armature 731 alters the connection of ground potential to the C wiper from armature 743 to armature 722 of relay 720. By this arrangement, when release relay 720 restores responsive to the operation of switching relay 740 and the restoration of line relay 710, ground potential is disconnected from the C wiper of the 770 wiper set in order to leave the overflow meter free from subsequent actuations before the selector TFS—1 restores. Series relay 730 remains operated through the upper winding of switching relay 740 from ground on the incoming C conductor 773.

In addition, overflow contacts 754 connect the

associated 60-impulse-a-minute interrupter lead to the associated EC conductor 774 so as to form a characteristic all trunks busy flashing circuit for the calling supervisory lamp 601 when cut-through relay 680 operates. The toll first selector TFS—1 is cleared out in the hereinbefore described manner, responsive to the removal of ground potential from the incoming C conductor 773.

Overflow condition at the toll line selector

Referring now to the toll line selector TLS—1, Fig. 9, arrangements for handling a group busy condition at this selector will now be pointed out.

It has been previously explained that the wipers 990 of this selector are advanced step by step over the toll line of a group in search of an idle one, in the event that the first toll line of a group is busy. When a particular group is busy, the stepping operation continues until a final toll line of the particular group is reached. As indicated by the dotted strap connection 287, Fig. 2, the B and C terminals of the last toll line in the group are connected together in order to provide a circuit for operating the group busy relay 970 in the event that the last toll line in a particular group is also busy. When the last toll line of the group is also busy, the C lead thereof is grounded (for example the C lead 278 of trunk T—4, Fig. 2), thereby preventing the switching relay 980 from operating when the wipers 990 advance to the last trunk in the group. The test or upper winding of the electro-polarized group busy relay 970 is energized from this ground potential on the C conductor 278 and by way of the strap, indicated at 287, the BC wiper of the 990 wiper set, Fig. 9, armatures 985, 963, 943, of the deenergized relays 980, 960, and 940, respectively, to the upper or operating winding of the electro-polarized group busy relay 970. The polarizing winding (lower winding) of the group busy relay is energized from the grounded incoming C conductor 914. Upon operating, this busy relay 970 disconnects the C-wiper of the wiper set 990 to prevent a subsequent operation of switching relay 980 while the wipers are being rotated over toll lines of subsequent groups in the level. By this operation, it is insured that the self-interrupting circuit of the rotary magnet to move the wipers step by step will continue until the wipers are rotated into the eleventh rotary step position. When this occurs, overflow contacts 994 operate to insure the actuation of the switching relay 980 to terminate the operation of the rotary magnet ROT., and to bring about the operation of the vertical series relay 930 so that the momentary metering impulse will be delivered as explained in connection with the toll first selector TFS—1, Fig. 7. It should also be noted that the overflow contacts 995 are closed to connect the 60-impulse-a-minute interrupter lead to the associated incoming EC conductor 915 to produce an all-trunks busy flashing of the calling supervisory lamp 601.

This selector is cleared out in the usual manner upon the removal of ground potential from the incoming C lead 914, permitting relays 930, 970, and 980 to restore.

Attention is called to the fact that the upper or test winding of group busy relay 970 is of higher resistance than the upper or test winding of relay 980. Therefore, the upper winding of the group busy relay 970 has many more turns

of wire than the upper or test winding of relay 980. Accordingly, in the event that the final toll line of the group (assuming that all other lines in the group are busy) is being guarded by a relay, similar to guard relay 240 of toll line circuit TLC, Fig. 2, which relay opens the C lead conductor 278 for this purpose, the current flows through these two test windings in series upon the last trunk of the group being encountered, over the following circuit: battery by way of the upper winding of group busy relay 970, armatures 933, 963, and 985, of the deenergized relays 940, 960, and 980, respectively, the C wiper of the 990 wiper set, strap 287 of toll line circuit TLC, Fig. 2, wiper C in the 990 wiper set, armatures 971, 965, 951, 941, normally closed contacts controlled by armature 931, armature 921, upper winding of switching relay 980, to the grounded incoming C conductor 914. The current flow in this circuit builds up to an operating value in the winding of relay 970 before it reaches operating value in the upper or test winding of relay 980. Relay 970 operates quickly and disconnects relay 980 before relay 980 has had time to operate in series with the test winding of relay 970.

Guarding a defective toll line

In the event that the toll line TL—1 is seized as previously described and is found to be defective, the operator may cause this toll line to be guarded against further seizure by a toll line selector, similar to toll line selector TLS—1, Fig. 9, and cause the test desk to be signalled by throwing the non-locking transfer call key K—14 while the talking key K—1 is in an operated position. By the momentary operation of the transfer call key K—14, a circuit is completed from ground springs 1425, for operating the split call relay 1320 by way of conductor 1448. At armatures 1321 and 1322 the tip and ring call conductors 656 and 655 are disconnected from the position talking conductors 1180 and 1181 and from the calling subscriber's talking conductors 653 and 654. At springs 1424 of the key K—14, battery potential, by way of resistance R1, conductor 1447, ring call conductor 655, and cable 1, armature 671 of the operated connect relay 670, and armature 681 of the operated cut-through relay 680 is connected to negative talking conductor 771, toll first selector TFS—1, Fig. 7, negative conductor 912 of the toll line selector TLS—1, Fig. 9, negative conductor 276 of the toll line circuit, Fig. 2, upper winding of retard coil 250, lower winding of guard relay 240, and winding of the pad control relay 220 to ground. Responsive to the closing of this circuit, the guard relay 240 energizes and locks itself by way of its upper winding and armature 245, in series with the lamp 217 at the test panel 216. Guard relay 240 also disconnects the ringing relay 230 at armature 244; at armature 245 it opens the C lead of the trunk T—4 to guard against further seizure of the toll line circuit, Fig. 2, by a toll line selector, such as TLS—1, Fig. 9; at armature 246 it opens a point in the circuit through which start relay 280 is actuated by signal relay 260; and at armatures 241 and 242 it connects the common guard tone conductors to the talking conductors of the toll line TL—1 to impress a tone on this toll line which may be heard in the event that the toll line is seized at the distant end thereof, to warn an operator who seizes this toll line at the distant end, that it is defective and should be similarly guarded at the distant end. When

the toll line has been repaired, guard relay 240 may be restored by opening its locking circuit at key K—18 at the test panel 216, whereupon lamp 217 becomes extinguished.

5 Calling from toll to local automatic office #8

The operations involved in completing a call originating in a distant office to a desired subscriber's line in the central office area will now be explained. For this purpose it will be assumed that a subscriber in a distant exchange (inter-connected by means of toll lines, such as toll line TL—1) is calling the subscriber at substation A, Fig. 1, in the automatic office #8 of the central office area. It will be assumed further that the call is received over the toll line TL—1 which terminates in the toll line circuit TLC, Fig. 2.

When the toll line TL—1 is seized at the distant exchange and ringing current is projected thereover, the shaded pole, alternating current, ring-up relay 270 is actuated and thereby opens the energizing circuit for the slow-releasing signal relay 260. Upon restoring, relay 260 closes an energizing circuit for the upper winding of start relay 280. Start relay 280 completes a locking circuit for its upper winding from ground at armature 284, armature 294 of the deenergized cut-off relay 290, upper winding of start relay 280, to battery. This locking circuit for the start relay 280 is provided so that the relay will remain operated after the ringing current has ceased and the normally operated signal relay 260 has been permitted to operate again. As a further result of this operation, start relay 280 places a ground potential on the C lead of the branch trunk T—4 at armature 283, to busy the toll line in the banks of the selectors having access to it, and also to remove the idle indicating battery potential from the winding of the cut-off relay 290 at the back contacts of armature 283. At armature 282, start relay 280 connects battery potential, by way of the winding of cut-off relay 290, to the C conductor extending to the banks of the finder switch to mark the toll line circuit of Fig. 2 as the calling line; and at armature 285 applies ground potential to the start conductor 286 to start a finder to search for the calling line.

It will be assumed that an operator at the switchboard position, indicated in Fig. 11, has operated her talking key K—1 to select an idle finder, such as F—1, Fig. 6, and thereby has marked her position idle in the testing circuit of the distributor, Fig. 12, and her position has accordingly been selected by the operation of the distributor (as previously described) to respond to the present call. It should be understood that incoming toll calls are received at inward positions of the toll board. It will, therefore, be assumed that the equipment being used for this connection is under control of an inward operator. Under this condition, the finder F—1, Fig. 6, operates as previously described in search of the calling toll line circuit.

In the previous description of the finder F—1, Fig. 6, it was assumed that the set of wipers controlled by the switching 1 relay 610, namely, the negative 1, positive 1, C1, and EC1, wipers of the wiper set 618 were used in connecting the finder to the calling line. For the purpose of describing the operation of switching 2 relay 620, it will be assumed that the calling line is connected in the banks accessible to the negative 2, positive 2, C2 and EC2 wipers of the wiper set 618. Therefore, when these wipers contact the terminals 297, a circuit is completed for the test winding of the

switching 2 relay 620 in series with cut-off relay 290 of the toll line circuit, Fig. 2, over the following path; battery at the winding of the cut-off relay 290, armature 282 of the operated start relay 280, C terminal 297, C2 wiper of the 618 wiper set, upper or test winding of the switching 2 electro-polarized relay 620, armature 613, lower winding of the supervisory relay 650, armature 634 of the operated change-over relay 630, to ground. Relay 620 operates and extends the answering end of the operator's position equipment to the calling toll line circuit by way of the No. 2 wipers of the wiper set 618. Relay 620 completes a locking circuit for its middle or holding winding at armature 624, and at the front contact of armature 623 completes a shunt around its upper or test winding so that when ground is returned on the C2 wiper from the toll line circuit, this ground is placed directly on the lower winding of the supervisory relay 650.

In the toll line circuit TLC—1, cut-off relay 290 completes a locking circuit at armature 293 and armature 292, to ground at armature 281 of the operated start relay 280. It will be noted that the ground potential at armature 281 is directly connected, by way of armature 292, to the C terminal of the 297 terminals in the bank of the finder switch and to multiples thereof, to busy this toll line circuit in the banks of all other finder switches, similar to finder F—1. At armature 291, cut-off relay 290 prepares a circuit for the pad cut-out relay 210, the circuit being opened at armature 221 by the operation of the pad control relay 220 in a simplex circuit including the talking conductors of the trunk and the 44,000-ohm pad control resistors and battery, bridging the tip and ring answering conductors 653 and 654 by way of the back contacts of armatures 1311 and 1312 of the split answering relay 1310 in the operator's position relays, Fig. 13. At armature 295, cut-off relay 290 opens the start circuit, and at armature 294 it opens the locking circuit for the start relay 280 and the relay restores.

The ground potential now connected to the C2 wiper of the finder F—1, Fig. 6, by way of armature 634 of the change-over relay 630, lower winding of supervisory relay 650, armature 723 of the operated relay 620, and the wiper C2 of the wiper set 618, is extended by way of C conductor of the 297 terminal set, and armature 293 of the operated cut-off relay 290, over one branch completing a locking circuit for cut-off relay 290, and over another branch extending by way of armature 283 of the deenergized start relay 280, armature 245 of the guard relay 240, to the C conductor 278 of the terminal set 275 in the banks of the toll line selector of Fig. 9 and multiples thereof to busy the toll line circuit to all toll line selectors having access to it. The grounding of the C terminal in the banks of the finder switch also places a busy ground potential on the multiples of the C terminals in the banks of all other finder switches to prevent the toll line circuit, Fig. 2, from being seized by other finders.

The toll group identity lamp 215 lights when the wipers of the finder switch engage the terminals 297 to indicate the toll group over which the call is received, there being a separate one of these lamps at each operator's position for each group of toll lines from which calls may be received at these positions.

The toll operator receives the call tone (commonly referred to as zip-zip tone) responsive to the operation of the calling signal relay 1140 and

the subsequent operation of the signal interrupter relays 1150 and 1160 and converses with the distant operator over the toll line TL—1 and receives the information as to the destination of the call being extended.

Operation of sequence control relays

It will be recalled that when the sender link SL—1, Fig. 15, was released, after the digits registered on the register sender in the previously described connection were retransmitted, and the cut-through relay 680 of the finder, Fig. 6, had operated and locked in series with call pilot relay 1350, that at armature 1351 call pilot relay 1352 removed the ground potential from the sequence control conductor 1304 causing sequence control relays 1610 and 1620, of Fig. 16, to be energized in series, by way of the grounded conductor 1190. The operation of sequence control relay 1620 caused the release of the sender link SL—1, Fig. 15, and thereby caused disconnection of the link finder LF—1 from the finder selector link comprising finder F—1, Fig. 6, and the toll first selector TFS—1, Fig. 7, and also the release of the sender selector switch SS—1 from the register sender equipment.

The operation of the sequence control relays 1610 and 1620 prepares the sequence control equipment, so that when the operator at the position shown in Fig. 11 receives another call, the relay 1630 is operated responsive to the application of ground potential to the sequence control conductor 1304 in order to connect up the sender link SL—2 of Fig. 16, which sender link is identical to the sender link SL—1, Fig. 15.

When the sequence relay 1630 operates, it opens the locking circuit for the relay 1610 at the normally closed contacts controlled by armature 1633 and the relay accordingly falls back, and by this same action it completes a holding circuit for the right-hand winding of relay 1620 to prevent the relay from restoring while the sender link SL—2 is being used. Sender 2 pilot lamp 1600 will light to indicate to the operator that the sender link SL—2 is prepared for further operation, that is, that the link finder LF—2 has been connected to the preselected finder, such as finder F—1, Fig. 6, and that the sender selector SS—2 has been connected to an idle register sender.

The operator can then depress her digit keys DK in accordance with the called number; the register sender equipment will register and retransmit pulses in the manner previously described, and during this transmitting period the sender 2 pilot lamp 1600 will become dimmed and will be extinguished when the digits registered have all been retransmitted. The grounded sequence control conductor 1304 will subsequently become ungrounded, thereby causing the release of sequence control relay 1630 and the restoration of sequence control relay 1620, due to the opening of its locking circuit at the front contacts of armature 1633. Accordingly, the sender link SL—1 is again prepared for operation to connect an idle register sender set by way of sender selector SS—1 to a preselected finder link by way of the link finder LF—1.

Referring again to the connection being described, it will be noted that the operation of change-over relay 630 in the process of the operation of finder F—1, Fig. 6, in connecting the finder to the calling line, answering pilot relay 1340 operates and places a ground potential on the sender control conductor 1304. It will be as-

sumed, as has been described above, that the sequence control relay 1610 is again in position to operate when the sender control conductor 1304 is grounded, in order to start the sender link SL—1, Fig. 15, to select an idle register sender by way of the sender selector SS—1, and to connect the sender link SL—1 and the selected register sender to the finder selector link comprising finder F—1 and selector TFS—1, Figs. 6 and 7, respectively, by way of the link finder switch LF—1. Since the operation of the sender link SL—1, Fig. 15, has been described hereinbefore, the controlling operations in the present connection will only be briefly mentioned from time to time.

At the operator's switchboard position, the toll group identify lamp 215 of toll line circuit, Fig. 2, the link busy lamp 603 of the finder F—1, Fig. 6, and the sender 1 pilot lamp 1500 of sender link SL—1, Fig. 15, are all lighted to give the operator the necessary signals to indicate that she may proceed with extending the toll line connections.

The toll operator at the central office acknowledges the call and receives the order from the distant operator as to the destination of the call being extended.

Upon referring to the trunking layout in Fig. 1, it will be observed that the toll line TL—1 terminates in the toll line circuit TLC of Fig. 2, and that these toll line circuits are found by the finder F—1 of the inward operator's position equipment, and that the finder is tied directly to the toll first selector TFS—2. Since the toll first selectors TFS—1, TFS—2, TFS—3, and TFS—4 are exactly the same, only one detail circuit has been shown, that is, the toll first selector TFS—1, Fig. 7. It will be observed that the first digit to be set up on the digit keys by the toll operator is the digit 2 to cause the toll first selector TFS—2 (the selector TFS—1 of Fig. 7) to make connection with a toll office selector, such as the toll office selector TOS, Figs. 1 and 10. Since the call is to be extended to the automatic office #8, the toll office selector TOS responds to the second digit of the called number, namely, the digit 8, to extend the connection, by way of the trunk circuit TC—2 (which trunk circuit is the same as the trunk circuit TC—1 and is shown in Fig. 22) to the thousands selector TMS. The last four digits to be set up by the operator on the digit keys DK are the digits 4161, the digit 4 to cause the thousands selector TMS in the automatic office #8 to extend the connection to the toll hundreds selector TFS, the digit 1 to select the connector C—1 and the digits 61 to operate the connector C1 to the sixth level and then rotate its wipers into engagement with the first set of bank contacts, to which contacts the subscriber's line of substation A is connected.

When the operator notes the above-mentioned lighting of the sender 1 pilot lamp 1500, she depresses her digit keys DK to register the number 284161 on the registers R1-R6, inclusive, of Figs. 18 and 19. The registers R1-R6, inclusive, of Figs. 18 and 19, together with the interrupter and control relays of Fig. 20, impulse counting relays of Fig. 21, and the sender control relays of Fig. 17 cooperate in the manner previously described to control the pulsing relay 1520, of the sender link SL—1, Fig. 15, to retransmit impulses corresponding in number to the digits as registered on the registers R1-R6, inclusive. Immediately after she has depressed her digit keys to set up the desired number, the

operator then depresses the sender disconnect key in order to prepare the sender link SL—1 to release the selected register sender equipment after the digits registered have been retransmitted.

As soon as she has operated the disconnect key, the operator may restore her talking key K—1 and permit the position equipment to clear out. When the talking key K—1 is restored, connect relay 670 and start relay 660 are restored because the circuit for relay 670 is opened at contacts 695 of key K—1 and relay 670 opens the circuit of start relay 660 at armature 677. Relay 670 disconnects the talking conductors of the link from the position talking conductors and connects them through the armatures of the cut-through relay 680; and it disconnects position conductors 1355, 1356, 1302, and 608. Relay 670 extinguishes the group-identifying lamp 215 and disconnects the position conductors 606 and 607. Switching 2 relay 620, change-over relay 630 and supervisory relay 650 remain operated. In the position equipment of Figs. 11 and 13, talking relay 1130 restores when the talking key K—1 is restored, while answering pilot relay 1340 restores responsive to the the associated release answering conductor 608 being disconnected upon the restoration of the connect relay of the finder. The position equipment is now in normal condition in readiness for the operator to accept a further call. Ground potential is removed from the sender control conductor 1304 when relays 1130 and 1340 restore, whereby the initial circuit of the operated sequence relay 1610 is opened and the shunt is removed from the winding of relay 1620. Relay 1620 now operates in series with relay 1610 (from grounded conductor 1190) preparatory to the subsequent selection of sender link SL—2.

The setting up of the connection responsive to the transmission of the number 284161 by the register sender will now be described.

The toll first selector TFS—1 of Fig. 7 (TFS—2, Fig. 1) responds to the first set of impulses indicative of the first digit 2, by raising its wipers opposite the second level of its associated bank contacts and rotating the wipers in search of an idle toll office selector. Assuming that the toll office selector TOS of Fig. 10 is the first one found to be idle, this selector is seized by way of the terminals 1015 shown in Fig. 10.

Operation of the toll office selector TOS

When the toll office selector TOS of Fig. 10 is seized, the ground potential applied to the incoming C conductor, prepares the line relay 1010 for operation over the loop circuit including the negative and positive talking conductors, and completes energizing circuits for the upper winding of the series relay 1030 and the lower or polarizing winding of the switch-over control relay 1060. When the loop circuit including the negative and positive talking conductors is completed by the switching through operation of the preceding switch, line relay 1010 operates, and at armature 1011 completes an energizing circuit for the slow releasing relay 1020. The operation of the series relay 1030 prepares the circuit for the vertical magnet VERT. and a locking circuit for its lower winding at armature 1033. The operation of the release relay 1020 closes another point in the vertical magnet circuit at armature 1024. Since the number assigned to the line of substation A is 284161, the digit 2, necessary to extend the connection to the toll

office selector TOS, is followed by the subscriber's number 84161.

Responsive to the impulses retransmitted by the register sender equipment indicative of the digit 8, line relay 1010 is restored momentarily eight times. Each time the line relay 1010 restores, a circuit is completed from ground at armature 1046, armature 1011 and its resting contact, armature 1024 of the operated release relay 1020, armature 1033 of the operated series relay 1030, one branch of the circuit including the lower winding of series relay 1030 and battery, to maintain the relay energized during the vertical movement of the switch, and another branch of the circuit including the winding of the vertical magnet VERT. and battery. The vertical magnet VERT. responds each time this circuit is completed to raise the wipers 1016 opposite the eighth level of bank contacts. After the series of impulses have been delivered to the line relay 1010, the relay remains energized and at the back contact of armature 1011 opens the circuit for the lower winding of series relay 1030, which relay restores (the circuit including its upper winding being opened by the off-normal contacts 1091 on the first vertical step of the wipers) and opens the operating circuit for the vertical magnet VERT. at armature 1033, and at armature 1034 prepares the operating circuit for the rotary magnet ROT. by way of closed off-normal springs 1093. The operating circuit of the rotary magnet ROT. may be traced from ground at armature 1046, armature 1011 of the operated line relay 1010, off normal contacts 1093 (closed on the first vertical step of the switch wipers, armature 1034 of the deenergized series relay 1030, self-interrupting contacts of the rotary magnet ROT., winding of the rotary magnet ROT. to battery. Due to the action of the self-interrupting contacts on the rotary magnet ROT., the wipers 1016 are rotated across the bank contacts in search of an idle trunk circuit, similar to the trunk circuit TC—2 shown in Fig. 22, connected to an idle inter-office trunk line, such as the trunk line T—5 extending to the incoming toll thousands selector TMS, Fig. 2, in the called automatic office #8.

It will be assumed that the first idle trunk circuit reached by the wipers 1016 is the trunk circuit TC—2 of Fig. 22. When this occurs, the battery potential applied to the C terminal 2200 in the banks of the toll office selector TOS, by way of the winding of cut-off relay 2220 and the armature 2211, is encountered by the C-wiper of the wiper set 1016, causing the operation of the switching relay 1040. The switching relay 1040 and the cut-off relay 2220 energize in series in a circuit from battery, winding of the cut-off relay 2220, armature 2211, C terminal 2200, C wiper of the 1016 wiper set, the normally closed contacts controlled by armature 1031, armature 1021 of the operated release relay 1020, test winding of the electro-polarized switching relay 1040 to the grounded incoming C conductor. The operation of the cut-off relay 2220 removes the winding of the busy relay 2210 from the negative talking conductor at armature 2212, and the switching relay 1040 upon operating completes a locking circuit for its holding or middle winding by way of armature 1045 and the grounded incoming C conductor. Relay 1040 also applies a ground potential directly to the C wiper at armature 1043 to maintain the cut-off relay 2220 of the seized trunk circuit TC—2 in its operated position and to guard the trunk line against fur-

ther seizure by other toll office selectors. Relay 1040 also terminates the rotary movement of the switch at armature 1046, and it prepares a connection-holding circuit at the front contact of this same armature, the purpose of which will be discussed later; at armatures 1041 and 1042 it disconnects the incoming negative and positive talking conductors from the line relay 1010 and extends them, by way of normally closed contacts on relays 1050 and 1080 and the negative and positive wipers of the 1016 wiper set, to the negative and positive talking conductors of the trunk circuit TC—2, Fig. 2, and thence by way of the inter-office trunk line T—5 to the toll thousands selector TMS, Fig. 1. The operating winding of the electropolarized switchover control relay 1060 is connected in series with the positive talking conductor, however, the winding of the relay is so poled that the relay is not operated by current flowing over the line conductors in normal direction. Due to the above-mentioned operation of the switching relay and the disconnecting of the line relay 1010 from the talking conductors, the line relay 1010 falls back and opens the circuit of the release relay 1020 which also restores. The restoration of relays 1010 and 1020 prepares a circuit for the release magnet RLSE., the circuit being closed at the time the switching relay 1040 is restored to normal.

As the succeeding digits are retransmitted under the control of the pulse relay 1520 and its impulsing contacts 1521, the connection is further extended through operation of the toll thousands selector TMS, Fig. 1, the operation of the toll hundreds selector, such as THS, and by the operation of a combined toll and local connector, such as Cl, to extend the connection to the line of substation A.

After all the impulses have been sent out by the pulsing contacts 1521 of the pulse relay 1520, and relay 1530 of Fig. 15 operates from a circuit completed for its upper winding over the test conductor 1507 by the sender control circuit Fig. 17, and locks to ground by way of armature 1534 and armature 1562. Upon operating, relay 1530 grounds the negative talking conductor by way of the winding of loop test relay 1540 and armature 1531, and by this same action opens the loop circuit at the normally closed contacts of armature 1531; it connects battery by way of resistance R1, and armature 1532, to the EC conductor; at armature 1533 it connects ground to the cut-in conductor to operate the cut-through relay 680 of the finder; Fig. 6; at armature 1535 the sender 1 pilot lamp 1500 (which has been dimmed by the insertion of resistance R3 during the transmission of impulses) circuit is opened and the lamp 1500 is extinguished. At armature 1536 a holding ground is placed on the winding of the switching relay 1510 to prevent the release of the relay until after relay 1530 falls back. Referring to relay 1540 which is connected to the negative talking conductor by way of the armature 1531, it will be noted that if the call has not been completely extended by the operation of the various switches in the switch train, a battery potential will be applied to the negative talking conductor by one of the line relays of the switches in the switch train. When this occurs, relay 1540 will operate (if an incomplete call has been made) and at armature 1542 will prevent the application of ground potential to the cut-in conductor to operate the cut-through relay 680 of the finder (Fig. 6), thus preventing

the switch train from being connected to the associated finder circuit. When the operator restores the talking key K—1 the ground potential will be removed from the sender control conductor 1304 and the entire switch train, together with the sender link SL—1 will release. In case an incompleted call is encountered after the operator has restored the talking key K—1 to normal, the sender link SL—1 and the associated switch train will release immediately after the operation of relay 1540.

It will be assumed for the purpose of the connection being described, that the wanted subscriber at the automatic exchange is not busy when the connection is extended to his line. Therefore, relay 1540 in the sender link SL—1 will not operate (since the connection is a completed one) and the cut-in conductor 1556 is grounded by way of the contacts of armature 1533 to operate the cut-through relay 680 of the finder, Fig. 6, and battery is connected to the EC conductor by way of contacts of armature 1532 and resistance R4 for the purpose of cutting the repeating coil and condensers of the toll office selectors TOS of Fig. 10 in the loop of the associated switch train. At armature 1535, relay 1530 opens the circuit of the sender 1 pilot lamp 1500 which is accordingly extinguished and by this same action opens the circuit of relay 1570. Relay 1570 subsequently falls back switching the circuit of relay 1560 at armature 1572, but before relay 1560 falls back a momentary pulse of battery is applied to the positive talking conductor 1553 by way of resistance R2, armature 1571 of the deenergized relay 1570, armature 1561 of the energized relay 1560, the strap 1575 connected between terminals 1576 and 1577 to the positive talking conductor of the trunk for the purpose of operating the ringing relay in the toll office selector, Fig. 10. It will be understood that the strap 1515 connected between terminals 1576 and 1577 of the sender link SL—1, Fig. 15, is connected in the sender links provided at inward operator's position only, in order that the ringing on distant lines can be initiated automatically. At the universal operator's position this strap 1575 is not provided because the operators at these positions control the ringing by means of a ringing key. Relay 1560 releases with a slow action shortly after its circuit is opened at armature 1572 and at armature 1562 opens the locking circuit of relay 1530, which also falls back. When relay 1530 deenergizes, the sender link SL—1, Fig. 15, is disconnected from the finder F—1 of Fig. 6, and the connection is held by way of the armatures of the cut-through relay 680.

Referring now to the toll office selector TOS, Fig. 10, it will be noted that the momentary application of battery potential to the EC conductor responsive to the above-mentioned operations of relays in the sender link SL—1, Fig. 15, completes a circuit by way of armature 1044 of the operated switching relay 1040, off normal contacts 1095, normally closed contacts controlled by armature 1056, upper winding of switch-over relay 1050, to ground. Switch-over relay 1050 operates and locks itself to the grounded incoming C conductor at armature 1055; it cuts in a non-ring-through repeating coil 1000 at armatures 1051, 1053, and 1054; it prepares circuits for relays 1080 and 1090 at armature 1052 and 1057, respectively; and it opens its initial energizing circuit including its upper winding at armature 1056 and the normally closed contacts and by this same action at the front contacts of armature 1056 it

prepares the supervisory circuit to the call lamp 601 at the operator's switchboard.

When the combined toll and local connector such as C1 at the automatic exchange #8 cuts in on the line of substation A, Fig. 1, the toll thousands selector TMS (also referred to as a toll transmission selector) reverses the current flow over the inter-office trunk line T-5, thereby bringing about an operation of the electro-polarized switchover control relay 1060. Upon operating relay 1060 bypasses its upper or line winding at armature 1061 in order to prevent the resistance of the relay from interfering with the talking circuit; it connects the incoming grounded C conductor to armature 1071 of the supervisory relay 1070 at armature 1062, and at armature 1063 it completes a multiple locking circuit for the lower winding of switchover relay 1050. The battery potential connected to the loop circuit from the toll thousands selector TMS at the automatic exchange, causes the supervisory relay 1070 to operate, thereby actuating its armature 1071 to extend the ground potential applied to it, by way of armature 1062 and the incoming C conductor, to armature 1056 of the operated switchover relay 1050, overflow contacts 1095, armature 1044 of the operated switching relay 1040, to the incoming EC conductor, thereby completing a circuit by way of the preceding switches to light the call supervisory lamp 601 at the toll operator's position. The lighting of the call supervisory lamp 601 indicates to the toll operator that the connection has been extended to the wanted subscriber's line.

Since the connection being described has been completed by a toll operator at an inward position of the switchboard, the momentary application of battery potential to the positive talking conductor of the connection has been automatically applied to the conductor by the operation of relays in the sender link SL-1, Fig. 15, as has been previously described. In the toll office selector TOS of Fig. 10, the battery potential applied to the positive talking conductor is extended by way of armatures 1042 and 1054 of the operated relays 1040 and 1050, respectively, lower lefthand winding of the repeating coil 1000, armature 1052 of relay 1050, winding of ringing relay 1080 to ground. Ringing relay 1080 is operated momentarily and applies ringing current by way of armature 1081 and 1082 to the inter-office toll service trunk T-5 and causes the necessary operation of switches in the automatic office to secure the usual intermittent application of ringing current to the called line.

The called subscriber answers

When the subscriber at substation A answers, the current flow over the inter-office toll service trunk T-5 is discontinued, as is the usual practice, and the supervisory relay 1070 of the toll office selector TOS, Fig. 10, falls back, the connection being held during talking condition, from the called line. When supervisory relay 1070 falls back, it removes ground potential from the associated EC lead at armature 1071, thereby causing the calling supervisory lamp 601 to be extinguished to give the toll operator answered supervision.

It is to be noted that the deenergization of the supervisory relay 1080 completes a holding circuit for the selector by applying ground potential from armature 1046 of the operated switching relay 1040 to the incoming C conductor by way of armatures 1071 of the deenergized supervisory relay 1070, armature 1062 of the operated switchover

relay 1060, whereby the selector is not restored in the event that the toll operator breaks down the called end of the connection while the receiver is off at the called substation. It is also to be noted that relays 1040, 1050, and 1060 are all locked in their energized positions by way of the grounded C conductor. This provision is made primarily to prevent a release of the toll office selector under this condition, because the inter-office trunk line T-5 would be unguarded at a time when the distant terminating selector is held operated locally (by the called subscriber) and is, therefore, unable to release. It is to be noted that this locking of the toll office selector TOS does not interfere with the release of the toll first selector TFS-1 of Fig. 6, as the C conductor associated with the toll first selector TFS-1 is not extended through the C wiper, but an independent ground connection is made by way of armature 743 of the operated switching relay 740 to the C wiper of the wiper set 770 for the normal holding of the next succeeding switch.

During conversation, it is to be noted that the pad control relay 220 of the toll line circuit, Fig. 2, is maintained actuated from the current supplied through the 44,000-ohm center tapped resistors associated with the left-hand winding of repeating coil 1000 of the toll office selector TOS, Fig. 10. Accordingly, the pad cut-off relay 210 is prevented from operating, so that the pad 214 is connected in the circuit to introduce the necessary circuit loss which tends to balance the artificial line network to maintain a uniform transmission level.

Ring-down supervision from the calling toll exchange

In the event that the calling toll operator desires to signal the central office toll operator at Fig. 11 at any time after the connection has been extended, she causes ringing current to be projected over the toll line TL-1, thereby bringing about a momentary operation of the ring-up relay 270 and a momentary restoration of signal relay 260. Relay 260 closes the circuit for the upper winding of the combination start and recall relay 280 at armature 261, whereby start relay 280 is momentarily operated. With relays 280 and 290 operated, a direct ground potential is placed on the C lead extending to terminal 297 in the banks of the finder switch, Fig. 6, thereby causing the answering supervisory relay 650 to restore, the talking key K-1 being restored (unoperated position) as previously described.

It is to be noted that start relay 280 does not lock upon operating at this time, as contrasted with its operation under similar circumstances when the call is in the reverse direction. Therefore, relay 280 restores and again removes ground potential from the C lead extending to terminal 297 and the supervisory relay 650 of the finder, Fig. 6. When the ground potential is applied to the C conductor and terminal 297 in the banks of the finder in Fig. 6, it is extended further by way of the C2 wiper of the wiper set 618, armature 623 of the operated switching relay 620, to the lower winding of the answering supervisory relay 650; ground potential being applied to the opposite terminal of the lower winding of relay 650 from armature 634 of the operated change-over relay 630. Supervisory relay 650 restores to normal and places a short circuit around its lower winding at the strap 653 and armature 651 (this strap and armature is provided on answering supervisory relays of finders provided for use by inward

operators only). The answering supervisory relay will not operate in series with the cut-off relay 290 in the toll line circuit, Fig. 2, as long as the short circuit is maintained around the lower winding of the strap 653 and armature 651, however, cut-off relay 290 is maintained operated during this circuit alteration first from the grounded armature 281 of the start relay 285, and when the start relay falls back the ground is again returned from armature 634 of the operated change-over relay 630 in the finder, Fig. 6, by way of the C2 wiper of the wiper set 618 and the C conductor of terminals 297. The answering supervisory lamp 602 is now lighted steadily to attract the attention of the central office toll operator. This lamp becomes extinguished when the operator throws the talking key K—1 to bring about the operation of relays 670, 660, and 650, respectively. It is to be noted that when the answering supervisory relay 650 is reoperated by way of its upper winding responsive to the operation of the start relay 660, that the short circuit around its lower winding (by way of the strap 653 and armature 651) is now removed from the circuit and that the relay will remain energized in series with the cut-off relay 290 of the toll line circuit, Fig. 2, after the energizing charging circuit for its upper winding has been removed.

It will be recalled that the answering supervisory relay 650 follows switchhook supervision when the finder Fig. 6, is interconnected with the CLR circuit of Fig. 1. This is accomplished by removing the strap 653 and armature 651, placed in the circuit of the lower winding of the answering supervisory relay 650. Since CLR operators answer all CLR calls, the finders associated with the CLR operator's positions are not provided with the above-mentioned strap 653 and armature 651 to shunt the lower winding of the answering supervisory relay 650 after it has been restored. The omission of the above-mentioned strap and armature changes the circuit from lock supervision to flashing supervision.

Clearing out the connection

When the called subscriber at automatic office #8 replaces his receiver, the switch train in the called office causes the current flow to be resumed over the conductors of the inter-office trunk T—5, thereby reoperating the supervisory relay 1070 to again interconnect the grounded C conductor with the associated EC conductor, thereby lighting the calling supervisory lamp 601 of the finder F1, Fig. 6, as a disconnect signal.

The central office toll operator at Fig. 11 may release the calling end of the connection by operating her release answering key K—8, and she can release the called end of the connection by operating her release call key K—12. The provision of keys K—8 and K—12 permit the toll operator to release either end of the connection separately, while the release answering and call key K—11 is a combination of the release answering key K—8 and the release calling key K—12, and is provided to facilitate the disconnection of a call by releasing both ends of a connection when it is momentarily operated.

It will now be assumed that the central office toll operator clears out the connection by momentarily operating her non-locking, release-answering and call key K—11. It is to be noted that the contacts 1408 and 1409 of the release answering key K—8 and the contacts 1414 and 1416 of the key K—11 perform the same functions, that is, place ground potential on conductors 608

and 1443, respectively. In addition, contacts 1418 and 1419 of the release call key K—12 and contacts 1415 and 1417 of key K—11 also perform the same functions, that is, place ground potential on conductors 1355 and 1448, respectively. The grounding of conductors 1343 and 608, responsive to the momentary operation of key K—11 causes the restoration of the finder F—1 of Fig. 6 in the same manner as has been previously described. When the finger switch F—1 restores to normal its wipers 618 are disconnected from the terminals 297 to which the toll line circuit TLC of Fig. 2 are connected, whereupon cut-off relay 290 restores together with pad control relay 220. The toll line circuit TLC is now available for further use.

The clearing out of the called end of the connection responsive to the momentary ground potential applied to conductors 1448 and 1355 is the same as previously described in connection with the releasing of the called end of the connection by the momentary operation of the release call key K—12. Accordingly, the operator's position relays of Fig. 13, the finder of Fig. 6, and the toll first selector TFS—1 of Fig. 6 are restored to normal in the same manner as has been previously described.

In the toll office selector TOS, Fig. 10, relays 1040, 1050, and 1060 restore responsive to the removal of ground potential from the incoming C terminal 1015 by the preceding selector (toll first selector TFS—1 of Fig. 7). The restoration of relays 1040 and 1050 breaks the holding circuit of the negative and positive wipers of the 1016 wiper set to permit the switches in the called office (automatic office #8) to restore. Release magnet RLSE. is operated responsive to the restoration of relay 1040 from ground at armature 1046, armature 1011, armature 1024, off-normal contacts 1092, winding of release magnet RLSE., to battery, whereby the selector is restored to normal position in the usual manner.

Overflow at a toll office selector

In the event that all of the trunks accessible to the toll office selector TOS on the selected level are busy, the wipers 1016 are rotated to overflow position. When this position is reached, overflow contacts 1095 disconnect the upper winding of switch-over relay 1050 to prevent an undesired operation of this relay over the EC lead after all of the digits have been retransmitted by the sender, while overflow contacts 1094 connect the upper winding of series relay 1030 in the circuit with the upper or test winding of switching relay 1040 so as to operate switching relay 1040 to terminate the operation of the rotary magnet ROT. This circuit may be traced from battery at the upper winding of series relay 1030, overflow contacts 1094, upper or test winding of switching relay 1040, to the grounded incoming C conductor. Series relay 1030 is actuated to shift the C wiper of the wiper set 1016 to ground at armature 1022, whereby a momentary metering impulse determined by the restoring time of relay 1020, is delivered over the C wiper of the wiper set 1016. Relays 1030 and 1040 remain actuated after relays 1010 and 1020 are restored. A flashing supervisory indication is transmitted from the 60-impulses-per-minute conductor through overflow contacts 1095, over the EC lead to flash the calling supervisory lamp 601 at the toll board.

The toll office selector TOS is cleared out from overflow position when ground potential

is removed from the incoming C conductor to permit relays 1040 and 1030 to restore.

Calls to busy lines

5 When a line is called at a time when it is in use, the connector through which the connection is attempted finds a busy test condition on the called line. Responsive to this, the apparatus in the toll service trunking system causes the current flow over the inter-office trunk line T—5 to be reversed and to be interrupted at a rate of one-hundred-and-twenty times a minute, which rate is double that of the rate of flashing when an all-trunks-busy or overflow condition is encountered as previously described. In the event that the toll office selector TOS of Fig. 10 is the selector used in the attempted connection to the busy line, the reversal of current flow brought about when the busy condition is encountered, results in the operation of the switch-over control relay 1060 as previously described. Following this, the intermittent operating and releasing of the supervisory lamp 1070 caused by the intermittent current flow over the conductors of the inter-office trunk line T—5, causes ground potential to be intermittently applied at a rate of one-hundred-and-twenty times a minute to the associated incoming EC lead by way of ground at armature 1046 and the interrupting armature 1071 of the supervisory relay 1070. This action results in a characteristic, somewhat rapid, flashing of the call supervisory lamp 601 to notify the operator of the busy condition of the called line.

35 When the toll operator breaks down the connection under this condition, the selectors release as before described, as the toll office selector TOS releases between successive operations of the supervisory relay 1070. The switches in the called office restore responsive to the opening of the loop when selector TOS is cleared out.

Calling from central office area to an exchange reached by way of toll line TL2

45 In order to explain how calls originating in the central office area are extended to the central office area over trunk lines and directed to a toll office area reached by way of toll line TL—2 are handled, it will be assumed that a subscriber at substation A of automatic office #8 calls the central office toll board over the CLR trunk and trunk line T—1, Figs. 1 and 3, and requests that his line be connected to a desired line of the toll office reached by way of trunk line TL—2. It will also be assumed that this call has been extended and that the finder F—1, Fig. 6, has been connected to the trunk T—1 by way of the CLR circuit of Fig. 3, and that the toll operator has answered the call.

60 In order to extend the connection, the operator depresses her digit keys DK to set up the number of the wanted subscriber, prefixing the subscriber's number with the trunking digits 4 and 6, assigned to the toll line TL—2. The trunking digits 4 and 6 are for the purpose of selecting the toll line extending to the toll office in which the connection is to be completed.

Upon referring to the trunking layout in Fig. 1, it will be noted that the call being described is from the subscriber A at automatic office #8 and that the connection will be handled by the CLR operator who is associated with the finder F—2 and the toll first selector TFS—1. If the incoming call had been received from a toll office, connected to the toll line TL—1 and was received

by way of the toll line circuit TLC and the finder F—1, the inward operator would complete the call by way of the toll first selector TFS—2. As has been previously pointed out, the toll first selectors are identical in construction and operation. Therefore, the first digit set up on the digit keys by the toll operator is the digit 4 so that the toll first selector TFS—1 will raise its wipers to the fourth level to extend the connection to a toll line selector, such as the toll line selector TLS—2, of Figs. 1 and 8. Responsive to the retransmission of the digit 6 by the register sender, the toll line selector TLS—2 will extend the connection to an idle impulse repeater, such as the impulse repeater IR—2 with its associated tone unit TU—2 and voice current repeater VCR connected to the toll line TL—2. The remaining digits of the wanted subscriber's number are transmitted by the register sender to the repeater IR—2 where they are repeated in the form of voice frequency impulses to control the switches in the distant toll office.

It will now be assumed that the sender's pilot lamp 1500 has been lighted to indicate to the operator that a register sender has been selected and connected to the associated finder selector link, Figs. 6 and 7, respectively. When the operator notes the above-mentioned lighting of the sender pilot lamp, she depresses her digit keys DK to register the trunking digits 4 and 6 assigned to the group of trunks, such as TL—2, followed by the wanted subscriber's number, on the registers R1—R6, inclusive, of Figs. 18 and 19, respectively. The operator may now restore her talking key K—1, associated with the finder F—1 of Fig. 6 in order that she may answer other calls.

The toll first selector TFS—1 of Fig. 7, responds to the first series of impulses indicative of the first digit 4, by raising its wipers opposite the fourth level of its associated bank contacts and rotating the wipers in search of an idle toll line selector. Assuming that the toll line selector TLS—2 of Fig. 8 is the one found to be idle, this selector is seized by way of terminals 800 shown in Fig. 8.

When the toll line selector TLS—2 of Fig. 8 is seized by the toll first selector TFS—1, Fig. 7, ground potential is applied to the C conductor by way of the C terminal 800, preparing the line relay 810 for operation over the loop circuit including the negative and positive talking conductors, and completing an energizing circuit for the upper winding of series relay 830 by way of the off-normal contacts 881. The loop circuit, including the negative and positive talking conductors, is completed by the switching through operation of the selector TFS—1 switch, thereby causing line relay 810 to operate and complete an energizing circuit for the slow releasing release relay 820. The operation of series relay 830 connects the C wiper of the wiper set 801 to the polarizing winding of the switching relay 870 by way of armature 831, it prepares a locking circuit for its lower winding at armature 832 in multiple with the circuit of the vertical magnet VERT.; and it opens a point in the circuit of pulse delay relay 860 at the back contacts of armature 833, while at its front contacts it prepares a circuit for stepping relay 840 and the change-over relay 850. Responsive to the operation of release relay 820, ground potential at armature 822, is applied to the C wiper of the 801 wiper set by way of armature 831 and also to the polarizing winding of switching relay 870;

ground at armature 832 is connected to the upper or testing winding of the switching relay 870 to prepare the testing circuit of the C wiper by way of armature 821 and the normally closed contacts of armature 831 after series relay 830 is restored. At armature 824 release relay 820 prepares a circuit for the vertical magnet VERT. and a holding circuit for relay 830.

When the six interruptions, indicative of the next digit, are retransmitted by the register sender equipment, line relay 810 is momentarily restored six times, thereby interrupting the circuit of the vertical magnet VERT. six times. Each time the line relay 810 falls back a circuit is completed from ground at armature 876, armature 811 and its back contact, armature 824 and its front contact, winding of vertical magnet VERT. to battery. A branch of the above-traced circuit being completed for the lower winding of series relay 830 by way of armature 832 and the lower winding, to battery. Series relay 830 is maintained energized during the impulse series due to its slow action, the circuit including its lower winding being completed each time a pulse is received for the vertical magnet. The initial circuit for the upper winding of relay 830 is opened by off-normal contacts 881 as soon as the first vertical step of the switch is made responsive to the operation of the vertical magnet. The release relay 820 is also maintained energized during the impulse series due to its slow action, the circuit for the relay is being completed each time the line relay is again energized. It is also to be noted, that the closing of off-normal contacts 883 (closed on the first vertical step of the switch) completes a circuit for the stepping relay 840. This circuit may be traced from ground at armature 876, armature 825 of the operated release relay 820, off-normal contacts 883, armature 833 of the operated series relay 830, winding of stepping relay 840 to battery. The circuit for stepping relay 840 is closed throughout the directive vertical operation so as to maintain a ground potential on the upper winding of relay 850 to avoid a possibility of change-over relay 850 operating prematurely as vertical test wiper VW passes over grounded vertical test contacts.

Level hunting

At the end of the series of impulses, wiper 801 are standing opposite the sixth level of bank contacts, and vertical test wiper VW is standing on the bank contacts associated with the sixth level. Series relay 830 is adjusted to restore shortly after the last directive impulse is received by the vertical magnet, and at armature 832 prepares an automatic level hunting circuit for the vertical magnet VERT., at the same time opening the initial circuit of stepping relay 840 at armature 833. The restoration of relay 840 depends upon whether or not all of the trunks in the sixth level of bank contacts are in use. If all of these trunks are in use, level-busy relay 802 is in actuated condition and has removed ground potential from the sixth level test contacts in the banks of all the vertical test wipers, such as VW, of the switches having access to the automatic toll line. When this condition occurs, there is no holding circuit for relay 840 and operating circuit for change-over relay 850 through the vertical test wiper VW, and relay 840 is restored to deliver an additional impulse to vertical magnet VERT., whereby the switch takes an additional vertical step to the next level, whereat the same group busy test

is made, as stepping relay 840 is reoperated through the self-interrupting contacts 891 of the vertical magnet VERT. This self-interrupting circuit for the vertical magnet is completed from ground at armature 876, armature 825 of the operated release relay 820, off-normal contacts 883, armature 833 of the deenergized series relay 830, (a branch of the circuit being traced to the pulse-delay relay 860 which will be explained hereinafter), armature 852 of the deenergized relay 850, armature 841 of the deenergized stepping relay 840, armature 832 of the deenergized series relay 830, winding of the vertical magnet VERT., to battery. The vertical magnet will operate over this circuit and raise the wipers one step as pointed out above and at its armatures 891, it completes a circuit for reoperating the stepping relay 840 to terminate the vertical movement by opening the circuit for the magnet at armature 841. The vertical magnet restores and opens the circuit for the stepping relay 840 at armature 891. This removes the ground potential from the upper winding of change-over relay 850 so that the vertical wiper VW may test the seventh level of the switch for ground potential. If idle toll lines are available in the seventh level now, ground potential is returned by way of the vertical test wiper VW through the upper winding of change-over relay 850, and the winding of stepping relay 840 to battery. Relay 840 remains energized to prevent further vertical movement of the wipers, and change-over relay 850 operates. At armature 852, relay 850 prepares the circuit for the rotary magnet, and at armature 851 it completes a locking circuit for its lower winding from ground at armature 876. From the above description it will be understood that if a group of trunks requires more than one level of a bank, the testing action of the vertical wiper VW permits the vertical magnet and the stepping relay 840 to complete their cycle of operation again until a level in which an idle trunk is available is reached.

Assuming now that there are one or more idle trunks in the called level (the sixth level), level-busy relay 802 is not in operated condition when the wipers of the selectors come to rest. Under this condition, the restoration of series relay 830 at the end of the impulse series, permits change-over relay 850 to operate in series with relay 840 over a circuit including the vertical test wiper VW, the sixth level of vertical test contacts, and contacts of the deenergized level-busy relay 802, to ground. Relay 850 closes a locking circuit for its lower winding by way of armature 851, 833, off-normal contacts 883, armature 825, armature 876, to ground. Relay 850 also opens an additional point in the automatic stepping circuit of vertical magnet VERT. at back contacts of armature 855, and at the front contacts of armature 852 it completes a self-interrupting circuit for the rotary magnet ROT. The wipers 801 are thereupon rotated step by step over the sixth level of the bank contacts in search of an idle trunk.

Upon the first rotary step, vertical test wiper VW is moved out of engagement with the vertical test bank, thereby opening the previously traced circuit for the stepping and change-over relays 840 and 850, respectively. Stepping relay 840 restores, but relay 850 is maintained operated in the above-mentioned locking circuit to maintain the self-interrupting circuit of the rotary magnet closed and the circuit of the vertical magnet open. The rotary magnet ROT. rotates the

wipers 801 step by step over the selected level of bank contacts until an idle toll line is reached.

As was pointed out above, the pulse delay relay 860 was operated responsive to the restoration of series relay 830 upon the termination of the directive impulses received by the line relay 810 to select the desired trunk level. Upon operating, pulse delay relay 860 places a battery potential on the incoming EC conductor by way of resistance R-8 and armature 861. This battery potential applied to the incoming EC lead causes delay pulsing relay 1550 of the sender link SL-1, Fig. 15, to operate. The operation of the pulse delay relay 860 is for the purpose of preventing further pulses from being transmitted by the register sender equipment during the time that the toll line selector TLS-2, Fig. 8, is hunting for an idle toll line in the selected toll line group. If the register sender equipment continues to retransmit impulses at the regular sending rate, the additional impulses may be received by the toll line selector TLS-2 before the wipers 801 have selected an idle toll line in the desired toll line group. Therefore, any impulses retransmitted by the register sender before an idle toll line has been selected, will be lost and will result in a connection with a wrong number.

It may be assumed that the toll line TL-2 associated with the repeater IR-2, Fig. 1, is the one found to be idle. This repeater is the same repeater shown in Fig. 11 in the above-mentioned Wicks application. Since the repeater is idle when the wipers 801 arrive on the terminals in its bank to which the conductors of the repeater are connected, a battery potential is encountered by the C wiper, thereby completing an energizing circuit for the upper or test winding of the switching relay 870. This circuit may be traced from the battery encountered by the C wiper of the 801 wiper set, normally closed contacts controlled by armature 831, armature 821 of the operated release relay 820, upper or test winding of the switching relay 870, to the incoming grounded C conductor. Relay 870 operates over this circuit and completes a locking circuit for its holding middle winding from the grounded incoming C conductor by way of armature 875. Relay 870 also opens the self-interrupting circuit of the rotary magnet, the holding circuit for change-over relay 850 and pulse delay relay 860, at armature 876; it by-passes its own test winding by placing ground on the C wiper of the 801 wiper set, at armature 873; it extends the incoming EC conductor to the repeater IR-2 of Fig. 1, by way of armature 874; and it disconnects the incoming negative and positive talking conductors from the windings of line relay 810 and extends them to the repeater IR-2 by way of the front contacts of armatures 871 and 872 and the negative and positive wipers of the 801 wiper set, respectively. Line 810 restores and release relay 820 restores with slow action after its circuit is opened by the deenergization of line relay 810. The deenergization of the change-over relay 850 has no effect at this time, while the deenergization of pulse delay relay 860 removes the battery potential from the incoming EC conductor to permit the delay pulsing relay 1550 of the sender link SL-1, Fig. 15, to restore. When the delay pulsing relay 1550 falls back the register sender equipment again functions to transmit the remaining impulses indicative of the digits registered on the associated registers.

Referring to sender link SL-1, Fig. 15, it will be noted that when delay pulsing relay 1550

operates it disconnects pulse relay 1520 from the series circuit including delay pulse relay 2040, Fig. 20, and connects it to a locking ground potential at the front contact controlled by armature 1551. Relay 1520 remains energized over this circuit to keep the loop circuit including (at this time) line relay 810, closed. The delay pulse relay 2040, however, falls back and at armature 2041 extends ground potential from release ground conductor 1754 to the delay ground conductor 1755, thereby shunting the lower winding of restart relay 2080. As long as restart relay 2080 is prevented from operating no additional digits are transmitted. The removal of battery from the EC conductor upon the release of relay 860 permits delay pulsing relay 1550 to fall back and again connect up the pulsing conductor including relays 1520 and 2040. Relay 2040 removes shunt from the winding of relay 2080. Restart relay 2080 can now operate in the previously described manner, thereby enabling the sender equipment to transmit the next digit.

The remaining pulses transmitted responsive to the operation of pulsing relay 1520 of the sender link SL-1, Fig. 15, are received in the impulse repeater IR-2 of Fig. 1, and are retransmitted over the toll line TL-2 step the automatic switches in the distant exchange to the wanted subscriber's line. This operation is explained in detail in the above-mentioned Wicks patent and is therefore only briefly mentioned at this time. If the wanted subscriber's line is not in use when the connection is established, the switches at the distant exchange function and cause the impulse repeater IR-2 of Fig. 1 to apply ground potential to the EC wiper of the wiper set 801 in the toll line selector TLS-2 of Fig. 8. This ground potential is extended back through the toll line selector TLS-2 of Fig. 8, and through the operated toll first selector TFS-1 of Fig. 7, to light the call supervisory lamp 601 at the central office toll operator's position. By the lighted condition of the lamp, the central office toll operator at the switchboard position of Fig. 11 is informed that the connection has been extended to the called line and that this line is idle and has been seized.

If the call being described had been received from a distant toll office by way of toll line TL-1 and the toll line circuit TLC shown in Fig. 1, an operator at the inward position of the switchboard would handle the call and the sender link SL-1 of Fig. 15 would function in the manner described hereinbefore and connect ringing control battery pulse to the positive talking conductor under control of the release action of relays 1570 and 1560. As has been pointed out previously, the strap 1575 between terminals 1576 and 1577 is provided at the inward operator's position so that the battery potential may be momentarily applied to the positive talking conductor to control the automatic ringing of the wanted subscriber's line. The automatic ringing control battery pulse projected over the positive talking conductors to the impulse repeater IR-2 of Fig. 1, causes this switch to function and initiate the automatic ringing of the switches at the distant toll office to signal the wanted subscriber.

Since the call being described is from the automatic office #8, which is a local office in the central office area, the call is handled by an operator at a universal (CLR) operator's position, which positions are not provided with the strap 1575 in order to start the automatic ring-

ing at the distant toll office switch train. Therefore, the operator upon noting the lighted condition of the call supervisory lamp 601 will now momentarily operate her non-locking ring-call key K—13 so that the battery potential will be applied to the positive talking conductor to indicate the above-mentioned operation and thereby start the automatic ringing of the wanted subscriber from the ringing equipment at the distant toll office. The detailed operation of the equipment at the central office toll board responsive to the momentary operation of the ringing call key K—13 is the same as has been described hereinbefore.

Answering supervision

When the called subscriber answers, the well-known supervisory action takes place in the train of switches in the called exchange to cause an answering supervisory signal to be transmitted back over the toll line TL—2 to the impulse repeater IR—2, Fig. 1.

In the calling central office exchange, when this answering supervisory signal is received by the impulse repeater IR—2, ground potential is disconnected from the EC wiper of the 801 wiper set, thereby extinguishing the call supervisory lamp 601 at the central office toll board (finder F—1 of Fig. 6), to inform the toll operator that the call has been answered.

Conversation now takes place over the established connection. The central office toll operator stamps the toll ticket to indicate thereon the starting time of the toll call, and she also restores her talking key K—1 to disconnect her position talking conductors from the connection so she may complete other calls.

Disconnect supervision

When the conversation has been terminated and the called subscriber at the distant toll office replaces his receiver, the impulse repeater IR—2 is again controlled by the distant exchange switches to place a ground potential on the EC wiper of the wiper set 801, Fig. 8. When this occurs, the call supervisory lamp 601 of the finder F—1, Fig. 6, is again lighted to give disconnect supervision to the toll operator at the central office toll board.

It will be understood, that in the event that the called subscriber at the distant toll office desires to signal the operator at the central office toll board he may do so by operating his switch-hook up and down a few times so that the call supervisory lamp 601 gives a flashing signal (which is more or less irregular) to indicate to the toll operator that the called subscriber desires to talk to her.

When the calling subscriber at the automatic office #8 replaces his receiver, the answering supervisory relay 650 of the finder F—1, Fig. 6, will restore and cause the answering supervisory lamp 602 to light, thereby giving the toll operator the disconnect signal for the calling subscriber.

Clearing out

The operator may now clear out the connection by depressing the non-locking release answer and call key K—11 thereby releasing the calling and called ends of the connection. The release of the toll first selector TFS—1 of Fig. 7 and the finder F—1 of Fig. 6 has been previously described.

In the toll line selector TLS—2, Fig. 8, when ground is removed from the C terminal 800, upon

the release of the toll first selector TFS—1, switching relay 870 restores and disconnects the wipers 801, at the same time it closes a circuit at armature 876, through contacts of restored relays 810 and 820, and by way of off-normal contacts 882, for release magnet RLSE. By the operation of release magnet RLSE, the wipers 801 are restored to normal position in the usual manner. The releasing of the repeater IR—2 of Fig. 1 is the same as described in the above-mentioned Wicks application.

Overflow at the toll line selector TLS—2

The operation involved when an overflow condition is encountered at a toll line selector, such as the selector TLS—2, Fig. 8, will be explained.

In the previous description of the operation of this toll line selector in a call through the central office toll board apparatus and the toll line TL—2 to a distant toll office, it was brought out that the toll line selector TSL—2 is a level-hunting selector, so arranged that it may automatically elevate its wipers one or more additional steps to enable trunk groups having trunk lines leading from successive levels to be reached in the event that all the trunk lines in the first level of a multi-level group are in use. As explained, this automatic operation is under control of the change-over relay 850 and the vertical test wiper VW. In the event that all of the trunks leading from the sixth level, for example, are in use, level busy relay 802 is energized over conductor 803 in a chain circuit including contacts of chain relays connected to the trunk lines of the sixth level. Under this condition, the vertical test wiper VW is unable to find a ground potential to actuate the change-over relay 850. Therefore, the vertical magnet VERT. is again operated to raise the wipers 801 and vertical test wiper VW of the selector to the next level. The seventh level also is provided with a level busy relay, as is indicated by the broken line connection to ground, extending from the seventh contact in the banks of the vertical test wiper VW. It will be noted that no level busy relay is provided, however, for the eighth level, as this level is the final level of the #6 trunk group. The eighth contact in the bank of the vertical test wiper VW is directly grounded, whereby an actuating circuit for the change-over relay 850 is always closed when the wipers of the selector are brought to the eighth level in its level hunting operation. The wipers are rotated over the terminals of the eighth level to search for an idle trunk in the same manner as has been previously described.

In the event that no idle trunk is found in this final level of the group, the wipers of the selector continue to be rotated until they pass onto the eleventh rotary position (one step beyond the set of bank contacts of the tenth trunk of the level) or overflow position. When this position is reached, overflow contacts 884 are closed to provide a reoperating circuit from battery, upper winding of series relay 830, overflow contacts 884, test or upper winding of switching relay 870, to the grounded incoming C conductor. Series relay 830 and switching relay 870 will both energize over this circuit, switching relay 870 opening the stepping circuit of the rotary magnet ROT. at armature 876. The line relay 810 and release relay 820 are restored to normal responsive to the opening of the circuit of the line relay at armatures 871 and 872. The switching relay 870 is now maintained operated by a locking circuit including its middle winding, armature 875 and the

grounded incoming C conductor. Series relay 830 remains operated from the grounded incoming C lead in series with the upper winding of the switching relay 870 through the actuated overflow contacts 884.

During the time required for slow-acting release relay 820 to restore, a meter operating pulse is transmitted from ground at armature 822, armature 831 of the actuated series relay 830, to the C wiper of the 801 wiper set.

Supervisory pulses of about sixty impulses per minute are transmitted back over the incoming EC lead through the overflow contacts 885, to flash the call supervisory lamp 801 and thereby inform the calling toll operator of the group busy condition.

When the preceding switch restores, responsive to the operation of the release call key K—12 by the central office toll operator, ground potential is removed from the incoming C lead of toll line selector TLS—2, thereby removing the holding circuit for series relay 830 and switching relay 870, which relays thereupon restore to normal. At armature 876, relay 870 completes a circuit by way of the armatures 811 and 824, and off-normal contacts 882 to the release magnet RLSE, which, upon operating, clears out the selector in the usual manner.

The called line busy

When the called line in the distant toll office, reached by way of the toll line TL—2, is busy, the call supervisory lamp 601 at the toll operator's position is caused to flash at the rate of 120 times a minute instead of 60 times a minute, whereby the operator may distinguish between a busy line supervisory signal and a busy trunk group supervisory signal. When the toll operator receives a busy line flashing signal she operates her release call key K—12 to release the called end of the connection, but she does not operate her release answer key K—8, thereby holding the calling end of the connection. The operator may now set up the connection again to call the wanted subscriber.

Calling a toll operator over toll line TL—2

In order to secure extension of the above described connection to the toll board at the distant end of the toll line TL—2, instead of to a called subscriber, the central office toll operator sets up the digits 4 and 6 on her digit key set DK (see Fig. 1), to extend the connection to a toll line group, of which the toll line TL—2 is one. As is explained in the above-mentioned Wicks application, the transmission of ringing current following the seizure of the toll line TL—2 without the inter-position of further digits, results in the signalling of the operator at the distant toll line TL—2.

As has been pointed out hereinbefore, if the call being extended by the toll operator at the central office has been received at an inward position of the switchboard, the ringing pulse is automatically connected to the positive talking conductor immediately after the completion of the retransmission of the digits registered on the register sender equipment. However, if the call is received by an operator at the universal position of the switchboard, she will operate her ring call key K—13 to connect the ring control pulse to the positive conductor. The operators at the universal positions of the switchboard are instructed to operate the ring call key immediately after the sender pilot lamp is extinguished

responsive to the completion of the retransmission of registered digits.

It will be remembered that the connection over the toll line TL—2 previously described, that the digits 4 and 6 to select the trunk group were followed by the registration of the digits of the wanted subscriber at the distant end of the toll line TL—2. The retransmission of these digits resulted in establishment of a connection with the wanted subscriber by way of the automatic switches at the distant end of the toll line TL—2. However, in the connection being described the transmission of the digits 4 and 6 to select the trunk group in which toll line TL—2 is located, is immediately followed by the ringing control pulse which results in the signalling of the toll operator at the distant toll office.

It may be assumed that a connection is extended through the finder selector link of Figs. 6 and 7 and the toll line selector TLS—2, to the toll line TL—2 by way of the repeater IR—2 of Fig. 1. This repeater operates in the manner described in detail in the above-mentioned Wicks application responsive to the completion of the transmission of the digits registered and the resulting connection of the ground connected loop test relay 1540 of the sender link SL—1 of Fig. 15 to the negative talking conductor, coupled with the opening of the positive talking conductor, to render the trunk "dry". When the loop test relay 1540 is permitted to restore upon the drying of the loop, relays 1560 and 1570 momentarily connect the ringing control battery pulse to the positive talking conductor of the trunk to control the ringing relay in the repeater IR—2. The toll operator at the central office receives a signal in the form of the lighting of the call supervisory lamp 601 and repeater IR—2 controls the signalling of the toll operator at the distant end of the toll line TL—2.

The call supervisory lamp 601 at the central office operator's position remains lighted during the interval that the distant office toll operator is being signalled and when the distant office operator responds, the answering supervisory pulse transmitted back over the toll line TL—2 causes the supervisory lamp 601 to be extinguished to give the central office toll operator a dark lamp answering supervision.

The central office toll operator gives the distant toll operator the necessary information for extending the call to the wanted subscriber in the distant toll office area. After the established connection has been completed and the central office toll operator receives the disconnect supervision by the lighting of her calling and answering supervisory lamps 601 and 602, respectively, she may operate her release answering and call key K—11 to clear out the entire connection.

Calling from toll to local manual office #4

The operations involved in completing a call originating in a distant office (toll) to a desired line of a manual exchange in the central office area will now be explained. For this purpose it will be assumed that a subscriber in a toll office (interconnected by means of toll lines such as toll line TL—1) is calling the subscriber at substation B, Fig. 2, in the manual office #4 of the central office area. It will be assumed further that the call is received over the toll line TL—1 which terminates in the toll line circuit TLC of Fig. 2.

When the toll line TL—1 is seized at the dis-

tant exchange and ringing current is projected thereover, the shaded-pole, alternating current, ring-up relay 270 is actuated and thereby opens the energizing circuit for the slow releasing signal relay 260. The start relay 280 is accordingly operated, causing the grounding of the start conductor 286 to start the distributor of Fig. 12, and to mark the C conductor in the banks of the finder switches.

It will be assumed that an inward operator at the central office switchboard, Fig. 11, has operated her talking key K—1 to select an idle finder, such as the finder F—1 of Fig. 5, and thereby has marked her position idle in the testing circuit of the distributor, Fig. 12. Furthermore, it will be assumed that the finder has been selected by the operation of the distributor (as previously described) to respond to the present call. The finder F—1 of Fig. 6 operates in the manner previously described to search for the calling toll line circuit. When the finder F—1 has found the calling toll line circuit TLC of Fig. 2, the central office toll operator receives the seizure tone (commonly referred to as zip-zip tone). The toll operator converses with the distant operator over the toll line TL—1 and receives the information as to the destination of the call being extended.

The group identity lamp 215 of the toll line circuit TLC is lighted to indicate the toll group over which the call is received, the link busy lamp 603 is lighted to indicate the link used in connecting with the calling line, and the sender 1 pilot lamp 1500 is lighted to indicate that the sender link SL—1 has found an idle register sender equipment and is in a position to receive the digits of the called number.

Having acknowledged the call and having received the number of the wanted subscriber, which in this case is the subscriber B at the local manual exchange in the central office area, the operator is now ready to set the call up by operating her digit keys DK.

Referring now to Fig. 1, it will be noted that the toll line TL—1, which terminates in the toll line circuit TLC, is accessible to the finder F—1 and its associated toll first selector TFS—2. The inward operator's equipment PE—1 together with the link finder LF—1 or LF—2, sender links SL—1 and SL—2, and sender selectors SS—1 and SS—2 together with the register sender RS are associated with the finder selector link, F—1 and TFS—2, to control the setting up of the above-mentioned connection. The operator at the inward position of the switchboard, when setting up the digits of the wanted subscriber, must prefix the subscriber's number with the trunk selecting digits 2 and 4.

The toll first selector TFS—2 will respond to the two impulses indicative of the digit 2 as transmitted from the register sender equipment to set the wipers of the switch to the second level of its associated bank contacts. The wipers are automatically rotated over the contacts in the second level of the bank to select an idle trunk extending to the toll office selector, such as TOS. The second digit registered, the digit 4, controls the toll office selector TOS to raise its wipers to the fourth level of the switch and then automatically rotates them to find an idle trunk circuit and associated trunk line, such as the trunk circuit TC—1 and the associated trunk line T—3, terminating in a repeater at the B-operator's position in the manual office #4. The call indicator equipment CI—1, associated with the repeater R—1, responds to the remaining digits

retransmitted by the register sender equipment at the central office, to light the call indicating lamps at the B operator's position to indicate the number of the wanted subscriber's line. From the above description, a general idea may be had of the switching operations required to extend a call from the toll line TL—1 to the subscriber at substation B in the local manual exchange #4 of the central office area.

Setting of the toll first selector

When the toll operator notes the above-mentioned lighting of the sender No. 1 pilot lamp 1500, she depresses her digit keys DK to register the numbers 2 and 4 (the manual office #4 trunk group number) plus the number of the subscriber at substation B. The registers R1 to R6, inclusive, of Figs. 18 and 19, together with the interrupter and control relay, Fig. 20, impulse counting relays of Fig. 21, and the sender control relays, Fig. 17, cooperate in the manner previously described to control the pulsing relay 1520 of the sender link SL—1, Fig. 15, to operate the pulsing contacts 1521 and thereby retransmit impulses corresponding in number to the digits as registered. When all of the digit keys have been depressed to register the number, the operator then depresses the disconnect key in order to release the register sender equipment from the sender link when all of the digits registered have been transmitted. The operator may also restore her talking key K—1 associated with the finder F—1 of Fig. 6 in order that she may answer other calls.

The toll first selector TFS—1 of Fig. 7 (which selector is the same as TFS—2, Fig. 1) responds to the first set of impulses, indicative of the first digit 2, by raising its wipers opposite the second level of its associated bank contacts and automatically rotating the wipers in search of an idle toll office selector. The toll office selector TOS of Fig. 10 is the first one found to be idle, and is accordingly seized by way of the terminals 1015, shown in Fig. 10.

Setting of the toll office selector TOS

When the toll office selector TOS of Fig. 10 is seized by the toll first selector TFS—1 of Fig. 7, ground potential is applied to the C conductor preparing the line relay 1010 for operation over the loop circuit including the negative and positive talking conductors. The toll office selector responds to the second set of impulses, indicative of the second digit 4, by raising its wipers opposite the fourth level of its associated bank contacts.

The wipers 1016 are then rotated across the bank contacts in search of an idle trunk circuit, similar to the trunk circuit TC—1 shown in Fig. 22A, connected to an idle interoffice trunk line, such as the trunk line T—3 extending to the repeater R—1, Figs. 23 and 24, in the called manual office #4.

It will be assumed that the first idle trunk circuit reached by the wipers 1016 is the trunk circuit TC—1 of Fig. 22A. When this occurs, the battery potential applied to the C terminal 2250 in the bank of the selector TOS, by way of the winding of cut-off relay 2270 and the armature 2261, is encountered by the C wiper of the wiper set 1016. The switching relay 1040 and the cut-off relay 2270 energize in series in a circuit from battery, winding of the cut-off relay 2270, armature 2261, C terminal 2250, C wiper of the 1016 wiper set, the normally closed contacts con-

trolled by armature 1031, armature 1021 of the operated release relay 1020, test winding (upper winding) of the electro-polarized switching relay 1040, to the grounded incoming C conductor.

- 5 The operation of the cut-off relay 2270 of the trunk circuit TC-1 removes battery potential, by way of the winding of busy relay 2260, from the negative talking conductor, at armature 2271. The switching relay 1040 of the selector TOS, operates to extend the dialling loop circuit to the trunk circuit TC-1 and the trunk line T-3 to the repeater R-1 in the manual office #4. Relay 1040 also places a direct ground potential on the C wiper to maintain the cut-off relay 2270 energized and to prevent other selectors, such as the selector TOS, from seizing this trunk circuit; and it terminates the rotary movement of the switch and prepares the supervisory circuit over the EC conductor as has been pointed out previously.

Seizing the repeater R-1

- When the above-mentioned loop circuit is extended over the negative and positive talking conductors to the trunk T-3 a circuit is completed for the line relay 2410 of the repeater R-1, shown in Figs. 23 and 24. The operating circuit of the line relay 2410 may be traced over the following path: ground, upper winding of line relay 2410, normally closed contacts controlled by armature 2354, armature 2342, upper winding of differential relay 2330, armature 2352, armature 2311, positive talking conductor of the loop circuit including the impulsing contacts 1521 on the pulsing relay 1520 of the sender link SL-1, Fig. 15, back over the negative talking conductor, armature 2312, armature 2351, armature 2341, lower winding of the differential relay 2330, normally closed contacts controlled by armature 2355, lower winding of line relay 2410, to battery. The line relay 2410 operates over this circuit and completes an operating circuit for the release relay 2420 from ground at armature 2411.

- Attention is called to the fact that the repeater R-1 of Figs. 23 and 24 is similar to the operator's plug-ended cord circuit O of Fig. 2 in Patent 1,775,834, issued to Rudolph F. Stehlik, September 16, 1930. The conductors 2371-2379, inclusive, extending from the repeater R-1, connect with call indicator apparatus similar to that disclosed in the above-mentioned Stehlik patent. The call indicating equipment is not a part of this disclosure and is therefore, not shown. However, the controlling operations required to operate the register selector, register control switches, and registers in the above-mentioned Stehlik patent, in order to have the called subscriber's number displayed on the B operator's lamp panel, will be pointed out in connection with the description of operation of the repeater R-1.

- It will be assumed that the register selector (not shown) associated with the repeater R-1 has its wipers connected to a busy register (not shown). Therefore, when the repeater R-1 is seized, and line relay 2410 and release relay 2420 are operated, the release trunk conductor 2373 is grounded and completes a circuit for operating the motor magnet of the associated register selector over the following circuit: the grounded release trunk conductor 2373, armature 2359, armature 2444, armature 2424 of the operated release relay 2420, over the motor magnet conductor 2375, to operate the motor magnet of the register selector, causing it to advance its wipers in search of an idle register. The pulse cut-

through relay 2440 of the repeater R-1 is short-circuited from ground at armature 2421 of the operated release relay 2420, so that it cannot operate until a free register is found. At armature 2422, release relay 2420 prepares a circuit for the transmission of impulses over the impulse conductor 2374 and at armature 2423 opens the circuit of the trunk busy relay 2310 in order to prevent the trunk busy relay from operating and disconnecting the talking conductors of the trunk T-3 from the repeater R-1. When an idle register (not shown) is found by the register selector (not shown), ground potential is removed from the release conductor 2373, thereby removing the short circuit from around the winding of the pulse cut-through relay 2440. When this occurs, the pulse cut-through relay operates over a circuit from ground at armature 2412 of the operated release relay 2420, armature 2357, winding of the pulse cut-through relay 2440, motor magnet conductor 2375, to battery by way of the register selector motor magnet. The motor magnet of the register selector (not shown) does not operate in series with the resistance of the pulse cut-through relay 2440, however, the pulse cut-through relay operates and replaces the indirect ground from armature 2421 maintained on the release trunk conductor 2373, by direct ground from armature 2444. The direct ground placed on the release trunk conductor 2373 locks up the seized register (not shown), while the closing of the contacts at armature 2441 prepares the impulsing circuit to the seized register by way of impulsing conductor 2374.

The repeater R-1 is now prepared to receive the impulses indicative of the remaining digits of the wanted subscriber's number. The pulsing relay 1520 of the sender link SL-1, Fig. 15, interrupts the circuit of the line relay 2410, in the repeater R-1, at the impulsing contacts 1521. Line relay 2410 follows the impulses of each series received, causing the operation of the various registers of the call indicator equipment in order to display the wanted subscriber's number on the lamp panel at the B operator's switchboard position. The pulses for setting the various registers (not shown) are transmitted from ground at armature 2411 of the line relay 2410. Each time the line relay falls back this ground potential is applied, by way of armature 2422 of the operated release relay 2420, armature 2441 of the operated pulse-cut-through relay 2440, armature 2423, over the impulsing conductor 2474 to set the above-mentioned registers. The release relay 2420 is of the slow-to-release type and remains energized during the momentary interruption of its circuit by the falling back of the line relay 2410.

The register equipment of the call indicator board as described in the above mentioned Stehlik patent, and when the display lamps at the switchboard are lighted, a ground potential is applied to the lamp conductor 2376 causing the operation of relay 2470 and the lighting of the call lamp 2415 over the following circuit: grounded lamp conductor (grounded by the operation of the register equipment), armature 2442 of the operated pulse cut-through relay 2440, winding of relay 2470, armature 2356, armature 2492, call lamp 2415, to battery. It will be noted that a branch of the circuit includes armatures 2472 of relay 2470, armature 2406, supervisory lamp 2416 and battery. Both the call lamp and the supervisory lamp 2415 and 2416, respectively, will light, the latter lamp lighting only momen-

tarily because of the immediate operation of the relay 2470 in series with the call lamp 2415.

The manner in which the B operator handles the call displayed before her on the lamp panel will now be considered. The call lamp 2415, which is individual to the plug-ended repeater R-1, is lighted simultaneously with the lamps in the lamp panel, thus enabling the operator to know which one of the repeater circuits is being used by the incoming call. When the operator observes the number of the wanted subscriber's line and knowing by the lighting of the call lamp 2415 that the repeater R-1 is the one in use, the operator will test the multiple jack of the called subscriber's line with the tip of her plug P in the usual manner in order to find out whether or not the called line is busy.

It will be recalled that when the digits as registered by the register sender equipment at the central office have been transmitted that the automatic ring control pulse of battery is momentarily applied to the positive talking conductor of the trunk. Since this call is being handled by an operator at the inward position of the switchboard, this ringing control pulse of battery is automatically connected to the positive talking conductor, whereas, if the call is handled by an operator at a universal position of the switchboard, the ringing control battery pulse is applied to the positive talking conductor by way of the momentary operating of the ringing call key K-13.

Responsive to the momentary application of battery to the positive talking conductor, the ringing relay 1080 of the toll office selector TOS, Fig. 10, is momentarily operated and connects the ringing generator GEN. to the negative talking conductor and ground to the positive talking conductor of the trunk T-3 by way of the negative and positive wipers of the wiper set 1016. When this occurs, the ringing control relay 2320 of the repeater R-1, Fig. 23, is momentarily operated and closes a circuit for the ringing relay 2450 at armature 2321. Ringing relay 2450 operates and at armature 2453 completes a locking circuit for itself by way of armature 2461, armature 2482, and ground at armature 2421 of the operated release relay 2420. When the battery pulse on the positive talking conductor is removed, responsive to the deenergization of slow-to-release relay 1560 of the sender link SL-1, Fig. 15, ringing relay 1080 in the toll office selector TOS falls back and again connects the talking conductors of the trunk through to the repeater R-1. Ringing control relay 2320 restores and opens the initial energizing circuit of ringing relay 2450, which is now locked up by way of a circuit including armature 2453. Responsive to the operation of relay 2450, a circuit is prepared for the ring-cut-off relay 2450 by way of armature 2451, and the ringing circuit is prepared by the closing of the front contacts of armature 2452.

The repeater R-1 is now prepared to ring the called subscriber when the operator inserts the plug P in the wanted subscriber's line jack.

Called line busy

It will be assumed that when the operator at the manual exchange made the busy test by touching the tip of the plug to the line jack, that the selected line was in use and that the operator heard the well known busy "click" in her receiver. The B operator will then operate her busy key, thereby applying ground potential to

the busy key conductor 2379. When the busy key conductor 2479 is grounded, busy relay 2480 is operated by way of armature 2471 of the operated relay 2470, and armature 2402. Busy relay 2480 completes a locking circuit for itself by way of armature 2482 and ground at armature 2421 of the operated release relay 2420. At the back contacts of armature 2482, relay 2480 opens the locking circuit of the ringing relay 2450 which restores; it completes a circuit for reversing relay 2350 from the grounded lamp conductors 2376, armature 2442 of the operated pulse-cut-through relay 2440, armature 2484 of the operated busy relay 2480, normally closed contacts controlled by armature 2357, winding of reversing relay 2350 to battery; and at armature 2481 it connects the interrupted ground conductor 2377 to the upper winding of the back bridge relay 2340 over the following circuit: interrupted ground conductor 2377, armature 2481, resistance R9, lower right-hand winding of the repeating coil 2360, upper winding of back-bridge relay 2340, to battery.

Responsive to the operation of reversing relay 2350, the current flow over the talking conductors of the trunk is reversed at armatures 2354 and 2355, respectively, thereby reversing the current flow through the upper winding of switch-over control relay 1060 in the toll office selector TOS of Fig. 10, to prepare the supervisory circuit of the call lamp 601 at the toll operator's switchboard. Supervisory relay 1070 is also operated over the loop circuit and completes a circuit at armature 1071 for lighting the call supervisory lamp 601 at the operator's switchboard. The back bridge relay 2340 of the repeater R-1 is rapidly operated and restored and consequently removes battery from the talking conductor of the trunk T-3 at the back contacts of armatures 2341 and 2342, respectively. At the front contacts of armature 2342, relay 2340 completes a holding circuit for the lower winding of line relay 2410 from ground at armature 2431, to prevent the line relay from restoring at the time the back bridge relay 2340 is operated. This rapid removal of the battery potential from the talking conductors of the trunk T-3 results in an interrupter circuit for the supervisory relay 1070 of the toll office selector, Fig. 10. The interrupted ground conductor 2377 connects the ground potential to the conductor intermittently at a rate of about 120 times a minute, consequently back bridge relay 2340 also operates and falls back at the same rate, together with the supervisory relay 1070. When this occurs, the circuit for the call supervisory lamp 601 at the toll operator's switchboard is interrupted at the same rate and results in the characteristic flashing of the call supervisory lamp 601 to notify the toll operator of the busy condition of the called line.

As a further result of the operation of reversing relay 2350, the direct ground potential applied to the release trunk conductor 2373 is removed at armature 2359 and results in the restoration of the associated call indicating equipment (not shown); it completes a locking circuit for itself from the ground at armature 2421 of the operated release relay 2420; and it opens the circuit for the call supervisory lamp 2415 at armature 2356.

The toll operator at the central office clears out the called end of the connection by operating her release call key K-12 (when she receives the flashing lamp signal) which results in the release of the selectors used in the present connection,

as before described, the toll office selector TOS, Fig. 10, releases between successive operations of the supervisory relay 1070. When the toll selector TOS restores it opens the loop circuit of line relay 2410, when the back bridge relay 2340 is in a restored position, which falls back and opens the circuit of release relay 2420. At armature 2421, release relay 2420 removes the holding ground from reversing relay 2350, and busy relay 2480 and accordingly, the repeater R—1 is restored to normal.

Called line idle

It will now be assumed that when the call is received by the B operator at the manual exchange #4 and the usual busy test is made, that the wanted subscriber's line is idle. The operator will insert the plug P into the line jack of the wanted line (not shown), causing the immediate operation of the sleeve relay 2400 by way of the grounded sleeve conductor of the wanted subscriber's line. The cut-off relay of the called line is energized in series with the sleeve relay 2400 to clear the line of its normal battery and ground connections in the usual manner.

It may be well to mention at this time that when the call lamp 2415 was lighted, that relays 2410, 2420, 2440, 2450, 2470, are all in operated condition when the operator inserts the plug P in on the wanted subscriber's line jack. Therefore, when sleeve relay 2400 is operated, it performs a number of circuit operations as follows: at armature 2401 sleeve relay 2400 removes the busy test conductor 2378 from the tip of the plug P and at its front contact prepares a point in the talking circuit; at armature 2402 it opens a point in the circuit of busy test relay 2480 to prevent its operation as long as the connection is made to an idle line; it opens a point in the locking circuit of the without busy-test relay 2490 at armature 2403 in order to prevent the relay from being locked in its energized position when it is used for supervisory purposes; at armature 2404 it applies ground potential to the trunk busy conductor 2272 which is of no consequence at this time; at armature 2405 it opens a point in the circuit of the interrupted ground conductor 2377; at armature 2405 it opens a point in the circuit of the supervisory relay 2416; at armature 2407 it completes an energizing circuit for the reversing relay 2350 from the grounded lamp conductor 2376, armature 2443, armature 2407, normally closed contacts controlled by armature 2357, winding of reversing relay 2350 to battery; and at armature 2408 it prepares a circuit for the supervisory lamp 2416 which is now opened by the reversing relay 2350.

Responsive to the operation of reversing relay 2450, a locking circuit is completed for itself by way of armature 2357 and its front contact and ground at armature 2421 of the operated release relay 2420, while at the back contacts of this same armature the initial energizing circuit for the pulse cut-through relay 2440 is opened, permitting the relay to restore, while at the normally closed contacts controlled by the front contacts of armature 2357, it opens its initial energizing circuit in order that the releasing of the pulse cut-through relay and its subsequent disconnecting of the ground lamp conductor does not have any effect on relay 2350 at this time. As a further result of the operation of relay 2350, ringing current is now extended to the called subscriber's line over the following path: Interrupted generator conductor 2371, armature 2353,

armature 2452 of the operated ring relay 2450, ring conductor of the plug P, over the ring conductor of the called subscriber's line and through his associated ringer, back over the tip conductor of the line and plug P, armature 2401 of the operated sleeve relay 2400, armature 2451 of the operated ring relay 2450, winding of the ring cut-off relay 2460, to battery. At the same time that the above-traced circuit is completed a ring-back circuit for transmitting ringing tone to the calling subscriber (or to the toll operator if she has not restored her talking key K—1) by way of the tone condenser 2409, armature 2481, resistance R—9, lower right-hand winding of repeating coil 2360, upper winding of the back bridge relay 2340, to battery. The tone current flowing through the right-hand winding of the repeating coil 2360 induces a tone in the left-hand winding which is audible to the calling subscriber or toll operator, as the case may be. The operation of reversing relay 2350 removes the shunt around the left-hand windings of the repeating coil 2360 by the opening of contacts of armatures 2350 and 2352, so the above-mentioned tone will be audible to the listening party. As a further result of its operation, relay 2350 opens a point in the circuit of the supervisory lamp 2416 at armature 2358; it removes ground potential from the release trunk conductor 2373 at armature 2359, thus permitting the associated call indicator equipment to be restored to normal; it opens the circuit of relay 2470 at back contacts of armature 2356, while at its front contacts it prepares a circuit for connecting the call lamp 415 to the interrupter ground conductor 2377 in order to give the B operator a flashing lamp in case she removes the plug P from the jack of the called subscriber's line prematurely. Furthermore, at armatures 2354 and 2355, relay 2350 reverses the direction of current flow over the talking conductors of the trunk T—3 thereby causing the operation of the switch-over control relay 1060 of the toll office selector TOS, Fig. 10. Differential relay 2330 of the repeater R—1 does not operate because its windings are in opposition.

Supervision for the central office toll operator

Referring now to the toll office selector TOS, Fig. 10, it will be noted that when the direction of current flow over the trunk T—3 is reversed, the current flow through the upper winding of the switch-over control relay 1060 is in the proper direction thereby causing the relay to operate and short-circuit its upper winding at armature 1061. However, the relay does not fall back when the short circuit is placed around its operating winding because of the holding circuit maintained through the lower winding of the relay. At armature 1062, switch-over control relay 1060 connects the incoming grounded C conductor through to the armature 1071 of the supervisory relay 1070, and at armature 1063 connects the incoming grounded C conductor through the lower winding of switch-over relay 1050.

It will be recalled that when all the digits have been retransmitted by the register sender equipment at the toll operator's switchboard that a momentary pulse of battery is applied to the EC conductor, resulting in the operation of the switch-over relay 1050 by way of its upper winding. If the relay is not operated for some reason or other, the circuit completed for its lower winding by way of armature 1063 of the switch-over control relay 1060 will cause the operation of the

relay at this time. It will be assumed, however, that the relay has been previously operated, and that the supervisory relay 1070 is operated over the loop circuit in series with the line relay 2410 of the repeater R—1. Therefore, when the ground is connected to the armature 1070, it is extended by way of its front contacts, armature 1056, overflow contacts 1095, armature 1044, to the EC conductor, thereby causing the lighting of the call supervisory lamp 601 at the toll operator's switchboard position. If the toll operator has restored her talking key K—1 she will not hear the ring-back tone signal but will know that the called subscriber is being signalled by the lighting of the supervisory lamp 601 as just explained. On the other hand, if she has not restored her talking key K—1 she will hear the ring-back tone signal and will also receive the visual signal and will restore her talking key K—1 if she has not previously done so.

Called subscriber answers

Referring again to the repeater R—1, it will be remembered that the called subscriber is being signalled by the transmission of ringing current over his line. When the called subscriber answers, the ring-cut-off relay 2460 energizes in the well known manner and opens the locking circuit of the ringing relay 2450 at armature 2461. Ringing relay 2450 falls back, opening the energizing circuit of the ring-cut-off relay 2460 at the front contacts of armature 2451 and removing the interrupter generator conductor 2371 from the called subscriber's line at the front contacts of armature 2452, while at the back contacts of these armatures it connects the called subscriber's line to the right-hand windings of the repeating coil 2360, thereby completing a talking circuit for the called subscriber which includes the upper and lower windings of back bridge relay 2340 and the right-hand windings of the repeating coil 2360. The back-bridge relay 2340 (sometimes referred to as the battery feed relay) is operated over the called subscriber's loop and "dries" the trunk T—3 at armatures 2341 and 2342. At the back contact of armature 2341, relay 2340 opens a point in the circuit for the upper winding of line relay 2410, which relay is prevented from restoring by the circuit closed through its lower winding by way of the front contact of armature 2342; at the front contact of armature 2341 the left-hand windings of the repeating coil 2360 are connected in series with the conductors of the trunk T—3, while at back contact of armature 2342, the battery from the lower winding of line relay 2410 is disconnected from the upper winding of differential relay 2330 and the lower left-hand winding of the repeating coil 2350.

Referring now to the toll office selector TOS of Fig. 10, it will be noted that when the trunk T—3 is "dried" supervisory relay 1070 restores to normal, thereby removing the ground potential from the incoming EC conductor from the toll operator's switchboard. When the ground potential is removed from the EC conductor, the call supervisory lamp 601 at the toll operator's position is extinguished, giving the toll operator a dark lamp answering supervisory signal. The required connection having been established, the subscriber may now converse as desired.

Switchboard supervision from the called manual subscriber

If the local manual subscriber at substation B, Fig. 1, should desire to recall the toll operator

at the central office, he will momentarily operate his switchhook a few times, thereby momentarily opening and closing the circuit of the back bridge relay 2340. Battery and ground from the windings of line relay 2310 are momentarily connected to the talking conductors of trunk T—3 by way of the resting contacts of armatures 2341 and 2342 and the winding of differential relay 2330, causing the momentary operation of the supervisory relay 1070 in the toll office selector TOS, Fig. 10. Each time supervisory relay 1070 is energized, it applies the ground potential from the incoming C conductor to the incoming EC conductor by way of armatures 1062 and 1071. The momentary application of ground potential to the EC conductor causes the call supervisory lamp 601 at the toll operator's switchboard to give a flashing signal indicative of the fact that the called subscriber desires to converse with her. The operator then throws her key K—1 to connect her position talking conductors with the talking conductors of the completed connection.

The supervision of the calling end of a connection received over toll line TL—1 has been described hereinbefore.

Controlling the toll line pad

When the above described connection from a toll operator at a distant toll office is completed by the central office toll operator to an exchange in the central office area, the toll line pad 214 is connected in the toll line circuit for the purpose previously described. Therefore, when this connection is established by way of the toll office selector TOS, Fig. 10, to the wanted subscriber at substation B in the local manual office #4, the 44,000-ohm pad control resistors and battery is bridging the conductors of the trunk by way of the left-hand windings of the repeating coil 1000, thereby causing the operation of the pad control relay 220 in the toll line circuit TLC of Fig. 2, over a simplex circuit including the negative and positive talking conductors of the connection and the winding of the pad control relay 220. The pad control relay is operated over this circuit, thereby preventing the operation of the pad cut-out relay 210. Therefore, the toll line pad 214 is bridged across the talking conductors of the above-mentioned connection to increase the transmission qualities of the circuit.

Disconnect supervision

When the conversation has been terminated and the toll operator at the distant toll office rings over the toll line TL—1, the AC relay 270 responds and causes the deenergization of signal relay 260. The answering supervisory relay 650 of the finder F—1, Fig. 6, will restore and cause the answering (calling) supervisory lamp 602 to light and give the toll operator at the central office the disconnect signal for the calling end of the connection.

When the called subscriber at the manual office #4 hangs up his receiver, the back bridge relay 2340 of the repeater R—1 restores to normal, thereby connecting the windings of the line relay 2410 to the conductors of the trunk T—3. The supervisory relay 1070 and the toll office selector TOS, Fig. 10, operate and connect the ground potential by way of armature 1071 to the EC conductor and thereby light the calling supervisory lamp 601.

The toll operator having received the disconnect signal by the lighting of the answering and call supervisory lamp 602 and 601, respectively,

may now operate her non-locking release answer and call key K—11 to clear out both ends of the connection. The disconnecting of the calling end of the connection has been previously described, together with a portion of the clearing out of the calling end of the equipment. The clearing out of the repeater R—1 together with a portion of the toll office selector TOS will now be described.

Responsive to the restoration of the switch preceding the toll office selector TOS of Fig. 10, ground potential is removed from the incoming C conductor, thereby opening the holding circuit for relays 1040, 1050, and 1060, and causing these relays to restore to normal. When relay 1040 falls back a circuit is completed for the release magnet RLSE, and the switch is accordingly restored to normal. When ground potential is removed from the incoming C conductor cut-off relay 2270 falls back. The circuit maintained by way of the right-hand windings of the repeating coil 1000 over the trunk line T—3 for line relay 2410 of the repeater R—1 is opened at armatures 1053 of relay 1050, thereby causing the line relay 2410 to restore.

It should be noted, however, that if the called subscriber has not released and the back-bridge relay 2340 is maintained in its operated position, the supervisory relay 1070 in the toll office selector will be deenergized. Therefore, when ground is removed from the incoming C conductor by the restoration of the preceding switch, the above-mentioned relays 1040, 1050, and 1060 are now maintained operated from ground at armature 1046 of the operated relay 1040, by way of armature 1071 and armature 1062. Accordingly, the toll office selector TOS cannot be released by the toll operator until the called subscriber has replaced his receiver. This precaution has been provided to prevent another toll office selector, such as TOS, from seizing the trunk line T—3, while the called subscriber is still connected to the circuit.

In the present connection, it will be assumed that the supervisory relay has been operated responsive to the deenergization of the back bridge relay 2340 when the called subscriber replaced his receiver. Therefore, armature 1053 opens the above-mentioned circuit of line relay 2410 causing the line relay to restore and open the circuit of release relay 2420, which relay restores with slow action. At armature 2421, release relay 2420 opens the holding circuit of reversing relay 2350. Relay 2350 falls back at armature 2358 and closes a circuit for the supervisory lamp 2416, thereby lighting the lamp to give the B operator the disconnect signal. It will also be noted that when the release relay 2420 falls back, a circuit is completed from ground at armature 2404 of the operated sleeve relay 2400, armature 2423 of the deenergized release relay 2420, to the winding of the trunk busy relay 2310. Relay 2310 operates and connects ground, at armature 2312, to the negative conductor of the trunk T—3 causing the operation of the busy relay 2260 of the associated trunk circuit TC—1, Fig. 22A. At armature 2261, ground potential is applied to the C conductor connected to the bank terminals 2250 and multiples thereof to busy the trunk circuit to all toll office selectors having access to it, during the time the B operator is disconnecting the repeater R—1 from the called subscriber's line. This precaution prevents any possibility of the toll line T—3 from again being seized before the B operator has cleared out the repeater R—1.

When the B operator receives the disconnect signal (the lighting of the supervisory lamp 2416) she removes the plug P from the called subscriber's line jack, thereby causing the sleeve relay 2400 to be restored to normal. Ground is removed from the winding of the trunk busy relay 2310 at armature 2404, thereby removing the busy condition from the banks of the toll office selectors and opening the circuit of the supervisory lamp 2416 at armature 2408, to extinguish the supervisory lamp 2416. The repeater R—1 is now restored to normal and is available for new calls.

Receiving a called subscriber's number before the repeater R—1 is connected to an idle call indicating equipment

The purpose of the pulse disconnect relay 2340 will now be explained. It will be assumed that the repeater R—1 has been seized and that the line relay 2410 has been operated over the calling loop and has accordingly operated release relay 2420. If the repeater R—1 is not associated with an idle call indicating equipment, the pulse cut-through relay 2440 cannot operate. The operation of the release relay 2420 closes a circuit at armature 2424 for operating the rotary magnet of a call indicating selector switch by way of conductor 2375 from the grounded release conductor 2373. However, it may be possible that an idle call indicator is not associated with the repeater R—1 before a portion of the first digit of the wanted subscriber's number has been received by the line relay 2410. Therefore, when line relay 2410 falls back the first time (responsive to the first impulse received) a circuit is completed from ground at armature 2411, armature 2422 of the operated release relay 2420, armature 2441 of the deenergized pulse cut-through relay 2440, winding of pulse disconnect relay 2430, to battery. Relay 2430 energizes and at armature 2432 completes a circuit for itself independent of the back contacts of armature 2411 and at armature 2433 it opens a point in the circuit for the impulse conductor 2374. Therefore, each time the line relay falls back, responsive to the remaining impulses of the first digit, the circuit of the pulse disconnect relay is completed, thereby preventing any of the impulses of the first digit from being retransmitted over the impulse conductor 2374 to control the call indicating equipment registers. If the pulse cut-through relay is operated in the meantime, due to the fact that an idle call indicating equipment has been found, it prepares the impulsing circuit at the front contact of armature 2441. After the impulses of the first series have been received, line relay 2410 remains energized for a longer period of time and the slow-release pulse disconnect relay 2430 falls back and again prepares the pulsing circuit for conductor 2374 at the back contacts of armature 2433. Therefore, when the remaining impulses, indicative of the remaining digits of the called number, are received by the line relay 2410, the registers of the call indicating equipment associated with the repeater R—1 are operated in accordance with the received digits.

When the call supervisory lamp 2415 and the lamps of the display panel are lighted in front of the B operator, she will immediately know that one of the digits of the called subscriber's number has not been registered (since all the subscribers in the area have the same number of digits in their telephone numbers) and will therefore operate her busy key. Busy relay 2480 op-

erates when the busy key (not shown) is operated and signals the operator at the central office toll switchboard, as previously described. The central office toll operator will then set up the connection again in the usual manner.

From the foregoing description it will be readily understood that if the pulse disconnect relay 2430 is not provided, a portion of the impulses received by the line relay 2410 may not be transmitted over the impulse conductor to set the registers in the call indicating equipment and will, therefore, result in the extension of connections to wrong numbers.

Local manual subscriber in central office area calling toll

A description will now be given of a call from a local manual exchange subscriber, for example, the subscriber at substation B in the local manual exchange #4, to a subscriber, reached by way of the toll line TL-1, in a distant toll office.

Referring to Fig. 1, it will be assumed that the local manual exchange subscriber at substation B (local manual office #4) initiates a call and that the A operator extends the call, by way of trunk line T-2 and the manual recording trunk MR, to the central office. A finder at the central office will find the calling line and extend the connection to the toll operator's switchboard, which in this case is an operator at CLR (universal) position. The toll operator acknowledges the call, receives the order, and makes out a toll ticket. The toll operator now operates a delay call key at her position to convert the switching mechanism at her position from a CLR service to point-to-point service. The toll operator now holds the original connection while she sets up a call back to the calling subscriber through the B operator's equipment at the local manual exchange #4. In order to do this, she operates her dial answer key to connect an idle register to her position equipment and then operates the talking key of an idle finder. The selected finder, such as finder F-2, raises its wipers to the first level (marked by the operation of the dial answer key) and then rotates the wipers over the first level to find an idle toll first selector, such as TFS-3, Fig. 1. With the dial answer key thrown, the register sender equipment is connected to the answering end of the finder (the wiper end) so that the operator may set up the calling subscriber's number prefixed by the trunk group selecting digits 2 and 4. The toll first selector TFS-3 of Fig. 1 responds to the first digit and raises its wipers to the second level to select an idle toll office selector TOS, which selector responds to the second digit (4) to extend the connection by way of trunk circuit TC-1 and trunk line T-3 to the manual B operator's position. When the B operator receives this call, she will note a flashing condition of her calling lamp, which is an indication to her that she is to plug into the called line without making the usual busy test. The flashing of the call lamp at the B operator's position is controlled by the operation of a "without" key K-16 (without busy test). The B operator accordingly plugs in on the calling subscriber's line. The toll operator now restores her dial answer key and the sender link operates to find an idle register sender equipment. When the sender equipment is found, it is associated with the called end of the finder link. The operator now sets up the number of the toll line group over which the connection is to be extended. The toll first selector TFS-1 (the selector portion of the connected

finder selector link) and the toll line selector TLS-1, are controlled by the impulses transmitted by the register sender equipment to find an idle toll line circuit in the desired toll group. When the distant toll operator responds the wanted subscriber's number is given by the central office toll operator and the connection is extended accordingly. When the called subscriber responds, the central office toll operator disconnects from the connection and stamps the starting time of the conversation on the toll ticket.

The central office toll operator now associates her equipment with the finder of the original connection set up by the manual A operator and operates her release answer key to release the connection set up by the A operator. The reason that the connection set up through the A operator's position cannot be used for a toll connection is that her cord circuits are not arranged to give the central office toll operator the necessary subscriber's disconnect supervision. Therefore, the toll operator sets up a new connection to the calling subscriber, through the manual B operator's position, which position is with the necessary equipment to give toll supervision to the central office toll operator.

In order to explain the detailed operation of the above-described connection, it will be assumed that the subscriber at substation B (Fig. 1) has removed his receiver and that the A operator at the local manual office #4 has responded and has extended the connection by way of the toll line T-2 to the manual recording trunk circuit MR of Fig. 4. When the A operator inserts her plug into the trunk jack, line relay 410 of the manual recording trunk MR is operated over the loop circuit including the A operator's cord circuit. At armature 412, line relay 410 completes a circuit for the lower winding of the start relay 420, and at armature 411 battery potential from the upper winding of cut-off relay 430 is connected to the C conductor 460 and multiples thereof in the banks of the finder switches, such as the finder F-1, Fig. 6, to mark the line as calling. In response to the operation of start relay 420, ground potential is applied to the start conductor 445, at armature 442, to start the distributor of Fig. 12 in the same manner as has been previously described.

It will be assumed that a CLR (universal) operator at the central office switchboard has operated a talking key of an idle finder link (such as the finder F-1 of Fig. 6) and thereby has marked her position idle in the testing circuit of the distributor, Fig. 12. Furthermore, it will be assumed that the finder has been selected and has found the calling line, which in this case is the manual recording trunk circuit of Fig. 4, and that the operator has been signalled by the lighting of the link busy lamp, and, in addition, has received the call tone (zip-zip tone) signal.

When the finder finds the calling manual recording trunk, cut-off relay 430 is operated when ground potential is returned on the C conductor from the finder switch. At armature 431, cut-off relay 430 prepares a locking circuit for both of its windings in series with the grounded C conductor; at armature 433 it prepares a shunting circuit for the lower winding of line relay 410; and at armature 432 it completes an energizing circuit for supervisory relay 440. Supervisory relay 440 operates and at the back contact of armature 442 it opens the energizing circuit for the start relay 420; it opens the start conductor at armature 444; it prepares a holding

circuit for the cut-off relay 430 at armature 441, which circuit is at present shorted by the circuit including the upper winding; and at armature 442 and its front contact, it completes a locking circuit for itself. Responsive to the deenergization of start relay 420, the high resistance lower winding of line relay 410 is shunted out of the loop circuit, causing the supervisory lamp at the manual A operator's position to be extinguished.

The trunk group-identity lamp 450 of the manual recording trunk is lighted, to indicate to the toll operator the trunk group over which the call has been received.

The toll operator acknowledges the call and converses with the originating manual operator and receives any necessary information, including the calling subscriber's number and the wanted subscriber's number.

As has been explained hereinbefore, the cord circuit at the A operator's position is not provided with the necessary equipment for toll supervision. Therefore, the toll operator at the central office sets up a new connection for the calling subscriber at substation B, by way of the B operator at the call indicator position of the local manual exchange switchboard.

The central office toll operator may dismiss the calling subscriber and the A operator, and then extend a new connection by way of the call indicator B operator's position, to the originating subscriber.

It will be assumed in the present case, however, that the central office toll operator holds the original connection while she sets up a new connection through the manual office call indicator position to the calling subscriber.

Supervision on original connections

Before describing the extension of connection back to a calling subscriber via the B operator's position, the supervision of a connection through the A operator's position will be described.

If the manual A operator desires to recall the central office toll operator, she momentarily removes her plug from the trunk jack a few times, thereby causing a flashing of an answering lamp in the connected finder. When the plug is removed, momentarily, line relay 410 falls back, opening the initial energizing circuit for the upper winding of cut-off relay 430 at armature 441. Relay 430 remains in its operated condition by way of the locking circuit including both of its windings and the resistance R—10. The added resistance of the lower winding of the relay and the resistance R—10 now connected to the C conductor causes the supervisory relay of the finder to fall back and light the answering supervisory lamp. When the manual A operator reinserts the plug into the trunk jack, line relay 410 will again operate over the loop and close the circuit at armature 441 for the upper winding of cut-off relay 430, thereby removing the high resistance circuit including the lower winding of the relay 430 and resistance R—10 from the C conductor. When this resistance is removed from the circuit including the lower winding of supervisory relay (650), the relay will again energize and open the circuit for the answering supervisory lamp (603), thereby causing the lamp to become extinguished. The central office operator will then operate the talking key (K—1) to establish a talking connection with the A operator.

When the central office toll operator desires to flash the manual switchboard operator, she operates the talking key K—1 to connect ring-

answering key W—7 momentarily, thereby connecting battery and ground by way of contacts 1405 and 1404 and conductors 1445 and 1444, respectively, to the tip and ring answering conductors 653 and 654, respectively, to the positive and negative talking conductors of the incoming connection, causing the operation of the start relay 420 in the manual recording trunk circuit MR, Fig. 4. When this occurs, the shunt around the high resistance lower winding of line relay 410 is removed by the opening of armature 421, thereby inserting the high resistance lower winding of line relay 410 in the loop circuit extending to the manual A operator's position, causing operations to take place in the cord circuit to light the supervisory lamp. When the manual A operator responds to the flashing supervisory lamp (lighted each time the ring answering key K—7 is momentarily operated by the central office operator) the central office toll operator may pass information as desired.

Extending a call over the answering end of a finder

As has been previously pointed out, the first level of the finder switch banks is wired to preceding selectors such as the toll first selector TFS—3, Fig. 1, which is the same as the selector TFS—1, Fig. 7.

To enable the toll operator to set up the call by way of the B operator at the manual exchange, a dial answering key K—9 has been provided, which places ground potential on the first level of the test contacts associated with the test wiper of the finder switches, when it is operated. In addition it prepares a start circuit for the selected finder switch and also takes care of the necessary operations for connecting an idle register sender equipment to the answering end of a selected finder switch.

When the CLR operator throws her dial answering key K—9, ground is extended from contacts 1412 by way of conductor 1440 to the first level in the vertical banks and multiples thereof associated with the vertical test wipers of finder switches similar to the finder switch F—1 of Fig. 6 accessible to the answering operator. In addition, responsive to the operation of key K—9, ground potential at contacts 1410, is supplied by way of conductor 1449, armature 1344, to the start conductor 1302 to prepare a selected finder for operation; while at contacts 1428, ground potential is applied to conductor 1451 causing the operation of the delay call relay 1380 and call pilot relay 1350.

In order to prepare the operator's equipment to extend a connection back to a calling manual subscriber by way of the B operator's position, (sometimes referred to as a delayed call), the CLR operator first operates her delayed call key K—3, Fig. 11, to prevent other incoming calls from being received at her position. When this key is operated, battery potential is removed from the distributor start relay 1170, thereby preventing the relay from operating to remove the guarding ground potential from the guard conductor 1188 extending to the distributor in Fig. 12. Therefore, other calls are prevented from being received by the operator making a delayed call.

It will be assumed that the original connection from the A operator at the local manual exchange has been completed through a finder similar to the finder F—1 of Fig. 6, and that the connection set up for recalling the originating manual subscriber, by way of the B operator's

position, is made by way of the finder F—1 shown in Fig. 6.

With the delay call key K—3 of Fig. 11 and the dial answering key K—9 of Fig. 14 actuated, the following operations will take place. As has been pointed out, when the delay call key K—3 is operated, battery is removed from distributor start relay 1170, thereby preventing the distributor circuit of Fig. 12 from finding the position equipment of Fig. 11 due to the fact that the guarding conductor 1188 is maintained grounded.

Responsive to the operation of the dial answering key K—9, ground potential at contacts 1410 is extended by way of conductor 1449, armature 1363, armature 1344 of the deenergized answering pilot relay 1340, to the start conductor 1302, to start the operation of a selected finder. Ground potential is applied by way of contact 1428 to conductor 1451 to cause the operation of the delay call relay 1380 and the call pilot relay 1350 by way of a circuit including the normally closed contacts controlled by armature 1392 of the cut-through relay 1390. Call pilot relay 1350 operates, and at armature 1351 opens another point in the circuit of the distributor start relay 1170.

Responsive to the operation of delay call relay 1380, ground potential is applied to the KC conductor 1356 at armature 1381, to prepare a locking circuit for the connecting relay, similar to connecting relay 670 of the finder F—1, after an idle finder has been selected by the operation of its associated talking key, similar to the talking key K—1; at the resting contacts of armature 1382, it disconnects the conductor 606 from the winding of supervisory relay 1370 and connects it by way of EC conductor 1318 and cable 3, to EC bank contacts in the delay call bank contact group of the line finders LF—1 and LF—2 associated with the sender link SL—1 and SL—2 of the toll operator's position equipment; at armature 1583 it prepares the locking circuit for its upper winding which is controlled by the operation of the answering pilot relay 1340; at armature 1384 it prepares a circuit for shunting out the answering pilot relay 1340; at armature 1385 it places ground potential on the sender control lead 1304 in order to operate one of the sequence control relays 1610 or 1630, dependent upon which of the sender links is to be selected; at armature 1386 it completes an energizing circuit for the split answer relay 1310 which relay extends the tip and ring answering conductors 653 and 654 by way of the front contacts of armatures 1311 and 1312, respectively, conductors 1315 and 1316, respectively, cable 3, to the negative and positive bank contacts of the delay call contact group in the banks of the link finders LF—1 and LF—2; and at armature 1387 it removes the guarding ground potential from the F conductor 1317 to mark the delay call bank contacts idle.

It will be understood from the above description, that by the operation of the delay call key K—3 and the dial answering key K—9, the operator has prepared her position equipment to set up the call via the answering end of a finder switch.

It will now be assumed that the grounding of the sender control conductor 1304 causes the operation of the sequence relay 1610, thereby initiating the operation of the sender link SL—1 to connect an idle register sender to the sender link by way of the sender selecting switch SS—1 and to connect the sender link SL—1 and a selected idle register sender to the operator's positional

equipment by way of the delay call bank contacts associated with the link finder switch FL—1. The operation of the sender link SL—1 of Fig. 15 has been described hereinbefore and it will be understood that when the wipers 1522—1527, inclusive, are advanced to the bank contacts connected to conductor 1315 to 1319, inclusive, no ground potential will be encountered on the F conductor 1317, thereby removing the short circuit from the switching relay 1510 which will operate in series with the stepping magnet LFM to terminate the stepping action of the wipers. It may be well to mention at this time, however, that all of the F conductors, similar to conductor 1557 connected by way of cable 2 to the finder links, similar to finders F—1 and toll first selector TFS—1 of Figs. 6 and 7, respectively, are grounded to prevent the link finder switch LF—1 from seizing a finder link while it is searching for a marked delay call bank contact set. These contacts will either be grounded from the back contacts of armature 675 of the disconnect relay, similar to disconnect relay 670 of the finders, or if a finder has been previously seized and is being used in a connection, the F conductor will be grounded by way of the connected C conductor and the front contacts of armature 675 of an operated connect relay, similar to relay 670 of finder F—1.

When the sender link SL—1 has completed its operation and has connected an idle register sender equipment to the operator's positional equipment by way of conductors 1522—1527, inclusive, sender 1 pilot lamp 1500 will light as an indication to the toll operator that the equipment is prepared for key sending. It will be recalled, that ground potential was applied to the vertical bank contacts of the finders, when the dial answering key K—9 was operated, to mark the first level.

The toll operator now selects an idle finder by operating the talking key associated with the finder. It will be assumed that the toll operator actuates the talking key K—1, thereby selecting the finder F—1 of Fig. 6. The connecting relay 670 is operated in the same manner as has been previously described and locks itself up by way of its upper winding and armatures 678 and 679 to the grounded KC conductor 1356. Start relay 660 is operated by way of armature 677 and the grounded start conductor 1302 (grounded by the operation of the dial answering key K—9) to initiate the operation of the finder F—1. The finder is, therefore, operated as in search of a calling line, but the vertical movement is terminated as soon as one vertical step has been taken, due to the fact that the vertical test wiper 617 encounters the first level marking contact grounded as previously described, over conductor 1440. As a further result of the wipers raising to the first level, normal post springs 627 are closed, to transfer the EC wiper from ground at armature 663 to the answering supervisory lamp circuit. The wipers 618 of the finder F—1 are, therefore, rotated over the first level of bank contacts in search of an idle one of the delay call selectors (which selectors are the same as the toll first selector TFS—1 of Fig. 7), referred to in Fig. 1 as the selector TFS—3.

Assuming that the toll first selector TFS—1 of Fig. 7 (which will be referred to during this connection as the delay call selector) is the first one to be found idle, and is seized over its incoming leads. The selector is normally marked idle by the battery potential applied to the incoming C

lead by way of the upper winding of series relay 730, and off-normal contacts 750. Therefore, when the C1 wiper, of the wiper set 618, encounters the battery potential on the C conductor 773 the electro-polarized switching 1 relay 610 is operated over a circuit including its upper windings, armature 623, lower winding of supervisory relay 650, to ground at armature 634 of the operated change-over relay 630. Switching relay 610 operates in the same manner as previously described to connect the negative 1, positive 1, C1 and EC1 wipers of wiper set 618 to the incoming conductors 771, 772, 773, and 774, of the delay call selector of Fig. 7.

At the time change-over relay 630 operated and locked itself by way of its upper winding battery potential was applied to the release answering conductor 608, causing the operation of the answering pilot relay 1340. At armature 1342, answering pilot relay 1340 completes a locking circuit for the upper winding of delay call relay 1380 and ground potential applied to the start conductor 1302 is transferred from the dial answering key K—9 to the front contact of armature 1342. As a further result of the operation of the change-over relay 630, a circuit is completed at armature 636, to light the link busy lamp 603.

When the toll operator notes the above-mentioned lighting of the link busy lamp 603 (the sender 1 pilot lamp 1500 having been previously lighted) she depresses her digit keys DK to register the digits 2 and 4 (the manual office #4 trunk group number) plus the number of the calling substation B. The sender disconnect key is operated after all the digits of the wanted subscriber's number have been registered, in order to release the register sender equipment after all of the registered digits have been retransmitted. The registers R1-R6, inclusive, of Figs. 18 and 19, together with the interrupter and control relays of Fig. 20, impulse counting relays of Fig. 21, and the sender control relay of Fig. 17, cooperate in the manner previously described to control the pulse relay 1520 of the sender link, Fig. 15, to operate the pulsing contacts 1521 and to retransmit impulses corresponding in number to the digits registered on the registers.

The toll first selector TFS—1 of Fig. 7, which is used in this connection as a delay call selector, responds to the first set of impulses, indicative of the first digit 2, by raising its wipers opposite the second level of its associated bank contacts and automatically rotating the wipers in search of an idle toll office selector. Since the loop circuit over which the impulses are transmitted for operating line relay 710 pass through several circuits, it may be well to describe the circuit in detail starting from battery at the upper winding of line relay 710, armature 741, conductor 171 connected to the finder F—1 by way of negative 1 wiper of the wiper set 618, armature 611, armature 672 of the operated connect relay 660, ring answering conductor 654 and cable 1, armature 1312 of the operated split answering relay 1310, conductor 1315 and cable 3, conductor 1315 connected to the delayed call bank contact and the associated negative wiper 1522 of the link finder LF—1, normally closed contacts controlled by armature 1531, impulsing contact 1521 of the pulse relay 1520, armature 1511 of the operated switching relay 1510, positive wiper 1522 connected to the bank contact associated with conductor 1316 and cable 3, conductor 1316 of Fig. 13, armature 1311 of operated split answering relay 1310, tip answering conductor 653, and cable 1,

armature 674 of the operated connect relay 670, armature 612 of the operated switching relay 610, positive 1 wiper of the wiper set 618, connected to positive conductor 772 by way of its bank contact, armature 742, lower winding of line relay 710, to the ground incoming C conductor 773. When the above loop circuit is closed, the C conductor 773 is grounded by way of armature 634 of the operated change-over relay 630 in the finder F—1, lower winding of supervisory relay 650, armature 613 of the operated switch through relay 610, C1 wiper of the wiper set 618, connected to the C conductor 773. When the selector is initially seized the series relay 730 is operated from this ground potential applied to the C conductor 773.

It will be assumed that the delay call selector (selector TFS—1 of Fig. 7) seizes the toll office selector TOS by way of terminals 1015 shown in Fig. 10. The selector TOS operates in the manner previously described and responds to the second set of impulses, indicative of the second digit 4, by raising its wipers opposite the fourth level of its associated bank contacts.

The wipers 1016 of the toll office selector TOS, are rotated across the bank contacts if the fourth level in search of an idle trunk circuit, similar to the trunk circuit TC—1 shown in Fig. 22A, connected to an idle inter-office trunk line, such as the trunk line T—3 extending to the repeater R—1, Figs. 23 and 24, in the manual office #4.

It will be assumed that the first idle trunk circuit reached by the wipers of the toll office selector TOS, is the trunk circuit TC—1 of Fig. 22A.

When this occurs, the trunk circuit is operated in the manner previously described, extending the dialling loop circuit to the repeater R—1 in the manual office.

When the above-mentioned loop circuit is extended to the repeater R—1, Figs. 23 and 24, a circuit is completed for line relay 2210. The line relay follows the impulses received and causes the call indicator equipment to operate as previously described. The detail operation of the repeater R—1 has been described hereinbefore and at this time it will only be necessary to describe that part of the operation which has to do with the handling of delayed calls.

Before describing the further operation of the repeater R—1, additional circuit operations of the operator's position relay equipment, responsive to the completion of the retransmission of registered digits by the register sender equipment, will now be discussed.

When the sender link SL—1, Fig. 15, has completed the retransmission of registered digits, relay 1530 operates and connects battery potential by way of resistance R—1 and armature 1532 to the EC wiper 1525 to operate the switch-over relay 1050 in the toll office selector TOS, Fig. 10. This circuit may be traced from battery potential connected to the EC wiper 1525, conductor 1318 and cable 3 connected to the delay call bank, armature 1382, conductor 606 and cable 1, armature 664 of the operated start relay 660, normal post contacts 627, EC1 wiper of the wiper set 618, EC conductor 774 extending through the delay call selector (toll first selector TFS—1) Fig. 7 to the incoming EC conductor of the toll office selector TOS, Fig. 10, armature 1044 of the energized switching relay 1040, overflow contacts 1095, normally closed contacts controlled by armature 1056, upper winding of switch-over relay 1050, to battery. Relay 1050 operates and cuts in the

repeating coil 1000 in the same manner as has been previously described.

In addition to the above, relay 1530 of the sender link SL—1 also makes the usual loop test of operation at armature 1531; at armature 1533 ground potential is connected to the cut-in wiper 1526, thereby causing the operation of the cut-through relay 1390 of the operator's position relays, Fig. 13; and at armature 1535 the circuit of the sender 1 pilot lamp 1500 is opened to extinguish the lamp.

After the toll operator has manipulated the digit keys DK in accordance with the trunk group number and the calling subscriber's number, followed by the momentary operation of the sender disconnect key, the operator then operates the without key K—16. The operation of key K—16 connects battery potential by way of resistance R7, contacts 1411 of the operated dial answering key K—9, contacts 1427 of the without key K—16, conductor 1452, to the armature 1394 of the cut-through relay 1390. The without key K—16 is provided for the purpose of giving the B operator at the manual exchange a flashing signal, as an indication that she may plug in on a calling subscriber's line without making the usual busy test.

Responsive to the operation of the cut-through relay 1390, the circuit including the lower windings of relay 1350 and 1380 is opened at the normally closed contacts controlled by armature 1392 and at armature 1391 relay 1390 opens the locking circuit for the upper winding of armature 1380. Relays 1350 and 1380 both fall back, and at armature 1386, relay 1380 opens the circuit for the slow-to-release split answering relay 1310. Before relay 1310 has had sufficient time to fall back, the battery potential applied to conductor 1452 extended by way of the armature 1304 of relay 1390, armature 1312 of the slow-releasing split answering relay 1310, ring answering conductor 654 and cable 1, to the negative talking conductors of finder F—1, delay call selector (selector TFS—1) of Fig. 7, to the upper left-hand winding of repeating coil 1000 (selector TOS of Fig. 10), by way of armatures 1041 and 1051 of operated relays 1040 and 1050, respectively, armature 1057, through the winding of relay 1090, to ground. This battery potential is only applied momentarily since relay 1310 subsequently falls back and transfers the tip and ring answering conductors 653 and 654, respectively, to the operator's talking conductors 1180 and 1181, respectively.

Responsive to the deenergization of the delay call relay 1380, the battery potential applied to the EC conductor of the toll office selector TOS by way of armature 1382 and conductor 606, is transferred to the back contacts of armature 1382 and now includes the winding of supervisory relay 1370. At armature 1381, ground potential is removed from the KC conductor 1356 to unlock the finder F—1 from the positional equipment should the talking key K—1 be restored to normal, and if it has not been restored to normal, the finder F—1 is held under control of the operator by the talking key K—1.

Referring now to the toll office selector TOS of Fig. 10, it will be noted that when the battery potential is applied momentarily to the incoming negative conductor and caused the operation of relay 1090, ground potential was applied to the negative wiper of the wiper set 1016 from ground at armature 1091. This ground potential is extended by way of the negative terminal 2250 of the trunk circuit TC—2, Fig. 22A, negative talk-

ing conductor of the trunk T—3, armature 2312, armature 2351, armature 2341, lower winding of differential relay 2330, normally closed contacts controlled by armature 2355, lower winding of line relay 2410, to battery. This circuit maintains an operating condition on the lower winding of line relay 2410, thereby preventing the line relay from falling back, and because of the shunting out of the upper winding of differential relay 2330 and upper winding of line relay 2410, by the same ground potential applied by way of armature 1091 of the operated relay 1090 of the selector TOS no current flows in the upper winding of differential relay 2330 or in the upper winding of line relay 2410. This shunting circuit may be traced from ground at armature 1091, upper right-hand winding of the repeating coil 1000, supervisory relay 1070, lower right-hand winding of the repeating coil 1000, armature 1053, upper winding of switch-over control relay 1060, armature 1082, positive wiper of the wiper set 1016, positive terminal 2250, positive conductor of the trunk T—3, armature 2311, armature 2352, upper winding of differential relay 2330, armature 2342, normally closed contacts controlled by armature 2354, upper winding of line relay 2410, to ground. The line relay 2410 is maintained in its energized position by way of the circuit including its lower winding, and the differential relay 2330 is now operated because no current flows in its upper winding while an energizing circuit is completed for its lower winding. Responsive to the operation of differential relay 2330, a circuit is now completed for the without busy test relay 2490 from ground at armature 2321, armature 2331 of the operated differential relay 2330, winding of without busy test relay 2490, to battery. Relay 2490 operates over this circuit and at armature 2491 completes a locking circuit for itself by way of armature 2403 and ground at armature 2421 of the operated release relay 2420. As a further result of its operation, relay 2490 connects the interrupted ground conductor 2377 by way of armature 2492, to the call supervisory lamp 2415 and battery. When this circuit is closed, the call supervisory lamp gives a flashing signal to the B operator.

It will be recalled that the subscriber at substation B initiated a call which was completed to the toll operator by the A operator at the manual office #4, and that the central office toll operator has made what is termed a delayed call, by calling back the subscriber at substation B, by way of the toll train and the call indicating B operator's position. Therefore, a flashing calling lamp at the B operator's position is an indication to her that the line being called by the central office operator is busy and that the subscriber is waiting for his call to be completed. When the B operator inserts the plug P into the jack of the calling subscriber's line, the talking connection will now be extended to the toll operator by way of the B operator's switchboard, trunk T—3, and the described switching apparatus.

B-operator connects with the calling subscriber's line

Since the connection, extended back to a calling subscriber's line by way of the B operator's position, is handled by the CLR (universal) operator, the ring relay 2450 of the repeater R—1 of Figs. 23 and 24, is not automatically operated as a result of the completion of digit transmission through the sender link SL—1 of Fig. 15. As has been pointed out hereinbefore, the sender

links at the CLR (universal) operator's position are not equipped to provide automatic ringing. The ringing, from a CLR operator's position, is controlled by the operation of the ring call key K—13. However, in this particular type of a call (delay call) the subscriber does not hang up his receiver while the central office toll operator is recalling him and consequently it is not necessary to ring the subscriber's line.

When the B operator inserts the plug P into the wanted subscriber's jack (not shown) the sleeve relay 2400 is operated. At armature 2407, sleeve relay 2400 completes a circuit for reversing relay 2350, thereby reversing the flow of current over the trunk line T—3 and causing the operation of the switch-over control relay 1060 in the toll office selector TOS, Fig. 10. Relay 1060 locks itself to the grounded incoming conductor by way of its lower winding and at armature 1061 it places a shunt around its upper winding to remove the upper winding from the talking conductors of the trunk. Supervisory relay 1070 operates over the loop circuit including the battery and ground at line relay 2410 and connects ground potential, by way of armature 1062 of the operated switch-over control relay 1060, armature 1071, armature 1056 of the operated switch-over relay 1050, overflow contacts 1095, and armature 1044 to the EC conductor. The ground potential applied to the EC conductor is extended by way of the EC wiper of the 770 wiper set of the delay call selector (toll first selector TFS—1 of Fig. 7), to the EC wiper of the wiper set 618 of the finder F—1, Fig. 6, normal post springs 627, armature 664, conductor 606, and cable 1, armature 1382 of the deenergized relay 1380, to winding of supervisory relay 1370, and battery. The supervisory relay operates and at armature 1371 connects ground potential to the RL conductor 607 causing the lighting of the answering lamp 602. The answering supervisory lamp 602 is lighted momentarily as a signal to the toll operator that the B operator has extended the connection to the calling subscriber's line.

The above-described operation resulting in the lighting of the toll operator's supervisory lamp is controlled by the operation of the reversing relay 2250 of the repeater R—1, which relay in turn is controlled from armature 2407 of the sleeve relay 2400. It will be noted that at armature 2401 of sleeve relay 2400 a circuit is also closed for the back bridge relay 2340. However, the adjustment of armatures 2401 and 2407 is such that armature 2407 closes its contact before armature 2401 closes its front contact. When armature 2401 closes the circuit by way of its front contact, the back bridge relay 2340 (battery feed relay), is operated over the loop circuit including the line at substation B. Back-bridge relay 2340 operates and dries the trunk T—3 as has been described hereinbefore.

The supervisory relay 1070 in the toll office selector TOS of Fig. 10 restores to normal when the trunk line T—3 is dried and removes the ground potential from the incoming EC conductor of selector TOS, thereby causing the supervisory relay 1370 in the operator's positional relay equipment to restore to normal and open the circuit for the answering supervisory lamp 602. It is to be noted from the above description of the operation of relays 2350 and 2430, that the slight delay between the operation of relay 2350 and the subsequent operation of relay 2340, is sufficient to permit the current flow over the trunk T—3 to

be reversed and thereby remove the resistance of the upper winding of switch-over control relay 1060 from the talking circuit, and also provide a signal for the toll operator, to indicate that the B operator has extended the connection to the calling subscriber's line before the trunk line T—3 is "dried".

Ringing the calling subscriber

If the calling subscriber has replaced his receiver, the toll operator may recall the subscriber by momentarily operating the ring answering key K—7 of Fig. 14. When the key K—7 is momentarily operated, ground potential is applied to conductor 1443 to cause the operation of the split answering relay 1310, thereby extending the tip and ring answering conductors 653 and 654 by way of armatures 1311 and 1312, respectively, and conductor 1445 and 1444 to battery and ground by way of contacts 1405 and 1404, respectively, of the ring answering key K—7. The battery and ground potential is extended by way of the positive and negative wipers of the finder F—1, Fig. 6, and the toll first selector TFS—1 of Fig. 7 to the positive and negative conductors, respectively, of the toll office selector TOS of Fig. 10. The battery potential applied to the positive conductor is extended by way of armature 1042, armature 1054, lower lefthand winding of the repeating coil 1000, armature 1052, winding of ring relay 1080, to ground. The ground potential connected to the negative conductor has no effect at this time. Ringing relay 1080 is momentarily operated and at armature 1081 and 1082 connects the ringing generator by way of the negative and positive wipers of the wiper set 1016, to the trunk line T—3, thereby causing the operation of the ring control relay 2320 of the repeater R—1. Ringing control relay 2320 operates and at armature 2321 completes a circuit for the ring relay 2450, which locks itself by way of armature 2453 to ground at armature 2421 of the operated release relay 2420. At armatures 2451 and 2452, relay 2450 completes the ringing circuit to the subscriber's line.

When the subscriber responds by removing his receiver, the ring cut-off relay 2460 operates and disconnects the ringing current, and the back bridge relay 2340 is operated over the subscriber's loop circuit. The operation of the back-bridge relay 2340 dries the trunk T—3, thereby causing the release of the supervisory 1070 of the selector TOS and accordingly extinguishing the answering supervisory lamp 602 at the toll operator's switch-board.

Restoring the dial answer key

When the toll operator receives the answering signal, she restores her dial answering key K—9 to normal. When the ground potential is removed from conductor 1451, by the opening of contacts 1428 of key K—9, cut-through relay 1390 restores to normal, causing ground potential to be reapplied to the sender control conductor 1304. The sequence control relay 1630 operates and starts the sender link SL—2 searching for an idle register sender and the selected finder F—1. At contacts 1412, key K—9 removes ground potential from conductor 1440 and at contacts 1410 ground potential is removed from conductor 1449, while at contacts 1411, the battery potential, applied by way of contacts 1427 of the without key K—16 is removed from conductor 1452.

The sender link SL—2 (shown in rectangle on Fig. 16) now operates in the same manner as has been previously described, to find an idle register sender equipment and to connect the seized reg-

ister sender equipment to the finder that is connected to the calling subscriber at the substation B. The finder F—1 is marked in the banks of the link finder switch LF—2 by the absence of ground on the F conductor 1557 which is multiplied in the banks of the link finders LF—1 and LF—2. Since the link finder LF—2 is the one in use, it finds the finder selector link, composed of finder F—1 of Fig. 6 and the toll first selector TFS—1 of Fig. 7, and prepares the selector TFS—1 for operation in the same manner as has been previously described. The sender 2 pilot lamp 1600 lights when the register sender equipment has been connected to the finder selector link. The register sender equipment is now connected to the calling end of the finder link and the toll operator now depresses the digit keys DK in accordance with the trunk selecting number of the toll line extending to the desired office.

In the connection being described, the desired toll line is the toll line TL—1 of Fig. 1, which is reached by the setting of digit keys 1 and 3. Immediately after depressing the digit keys 1 and 3, the toll operator operates the sender disconnect key, which causes a disconnect relay in the sender link SL—2 to operate and prepare the sender link to disconnect the connected register sender equipment immediately after the digits registered have been retransmitted.

The toll first selector TFS—1 of Fig. 7, responds to the first set of impulses, which in this case is the digit 1, by raising its wipers opposite the first level of its associated bank contacts and automatically rotating the wipers in search of an idle toll line selector, similar to the toll line selector TLS—1 of Fig. 9. Assuming that the toll line selector TLS—1 of Fig. 9 is the first one found to be idle, it is seized by way of the terminals connected to conductors 912-915 in the banks of the selector TFS—1. The toll line selector TLS—1 of Fig. 9 responds to the second set of impulses, indicative of the second digit 3, by raising its wipers opposite the third level of its associated bank contacts and automatically rotating the wipers in search of an idle toll line circuit. It will be assumed that the toll line circuit TLC of Fig. 2 is the first one found to be idle, and is seized by way of terminals 275 shown in Fig. 2.

The toll line circuit TLC of Fig. 2 is seized in the manner previously described and the toll operator, upon noting the extinguishing of the sender 2 pilot lamp 1600 (indication that all of the digits registered have been transmitted) operates her ring call key K—13. At contacts 1421, ring call key K—13 applies battery potential by way of conductors 1446, armature 1321 of the split call relay 1320 (operated from ground at contacts 1422 of the ring call key K—13) over the tip call conductor 656 causing the operation of the ring relay 230 of the toll line circuit TLC of Fig. 2. The ring relay 230 operates and transmits ringing current over toll line TL—1 to signal the distant operator.

When the distant operator responds, the central office toll operator passes the wanted subscriber's number. The distant operator sets up the connection to the wanted subscriber and when the subscriber answers, the central office toll operator restores her talking key K—1 to normal, thereby disconnecting the holding circuit for the connect relay 670 which restores to normal and removes the operator's talking conductors from the talking conductors of the completed connection and also releases the operated relays in the position equipment. The calling

subscriber at substation B of manual office #8 may now converse with the wanted subscriber at the distant toll office. When the conversation starts the central office toll operator stamps the toll ticket to show the starting time of the conversation.

Disconnecting the A operator

The central office toll operator may now release the original connection set up by the A operator at the manual office #4. In order to do this, the toll operator operates the talking key (similar to talking key K—1 of the finder F—1), of the finder that is still connected to the manual recording trunk circuit MR of Fig. 4, seized by the A operator. This finder is marked at the central office operator's position by the lighted condition of the associated busy lamp. After the operator actuates the talking key associated with the connected finder, she then operates her release answering key K—8, thereby connecting ground potential by way of contacts 1408 and conductor 608 to shunt down the answering pilot relay 1340 (this relay being operated when the talking key of the associated finder is thrown) and the change-over relay (similar to change-over relay 630 of finder F—1). When the change-over relay falls back it prepares a circuit for the release magnet of the finder switch. The start relay of the finder (similar to start relay 660) falls back when ground is removed from start conductor 1302, responsive to the deenergization of the answering pilot relay 1340, thereby completing the circuit for the release magnet of the connected finder. When the release magnet is operated the finder switch restores to normal. Responsive to the restoration of the finder switch connected to the manual recording circuit MR of Fig. 4, ground potential is removed from the C terminal 460, thereby causing the deenergization of the cut-off relay 430. Relay 430 falls back and at armature 433 removes the shunt from around the high resistance lower winding of line relay 410, causing the supervisory lamp at the A operator's position of the manual switchboard to light to give the A operator disconnect supervision. The A operator removes her cord circuit from the calling subscriber's line jack and the jack connected to trunk line T—2.

When the A operator removes the plug from the jack connected to trunk line T—2, line relay 410 restores to normal and at armature 412 opens the locking circuit for the supervisory relay 440. Supervisory relay 440 falls back and again restores the circuit to normal. The central office toll operator restores the release answer key K—8 and the talking key of the released finder when the link busy lamp is extinguished.

Switchhook supervision from the manual calling subscriber

If the calling manual subscriber at substation B (Fig. 1) should desire to recall the central office toll operator, he will momentarily operate the switchhook a few times, thereby momentarily opening and closing the circuit of back-bridge relay 2340 in the repeater R—1, Figs. 23 and 24. Battery and ground potential from the windings of line relay 2310 are momentarily applied to the conductors of trunk T—3, by way of the differential relay 2330 and the left-hand windings of repeating coil 2360, thereby causing the momentary operations of supervisory relay 1070 in the toll office selector TOS, Fig. 10. As has been pointed out hereinbefore, each time the supervisory relay 1070 falls back ground potential is

applied to the incoming EC conductor. This ground potential is extended through the delay call selector (which selector is the same as the toll first selector TFS—1 of Fig. 7), by way of its EC wiper and incoming EC conductor 774, to the EC1 wiper of the wiper set 618 of the finder F—1, Fig. 6. In the finder F—1, the ground potential is further extended by way of the normal post contacts 627, normally closed contacts controlled by armature 664, to the answering supervisory lamp 602 and battery. This lamp is momentarily lighted each time the supervisory relay 1070 is energized. The central office operator may connect her talking conductors to the connection by operating the talking key K—1.

The calling subscriber may now converse with the central office toll operator.

Controlling the toll line pad

When the connection is completed between the central office toll operator and the distant toll operator over the toll line TL—1 the toll line pad 214 of the toll line circuit TLC of Fig. 2 is connected in the toll line circuit for the purpose previously described. The controlling circuit being the same as before, that is, the simplex circuit from ground at the pad control relay 220 over the negative and positive talking conductors to the 44,000-ohm resistors and battery at the left-hand windings of the repeating coil 1000 in the toll office selector TOS, Fig. 10. This circuit maintains the pad control relay 220 in an energized position, thereby preventing the pad cut-out relay 210 from operating, in order to maintain the pad 214 in the toll circuit to increase the transmission quality.

Disconnect supervision

When the calling subscriber at the manual office #4 hangs up his receiver, to terminate the conversation, the back bridge relay 2340 of the repeater R—1, Figs. 23 and 24, falls back and again applies battery to the conductors of trunk T—3 causing the operation of the supervisory relay 1070 in the selector TOS, Fig. 10. The supervisory lamp 602 is lighted steadily to give the central office toll operator the disconnect supervision and she again stamps the toll ticket to indicate the length of time the calling subscriber has been using the toll line.

The toll operator at the distant toll office rings over the toll line TL—1 when the called subscriber hangs up, thereby causing the operation of AC relay 270 and the subsequent deenergization of the signal relay 260. When signal relay 260 deenergizes, the circuit is completed for the upper winding of the combination supervisory and start relay 280, which upon operating connects ground potential to the EC conductor 279. This ground potential is extended by way of the EC conductors of the toll line selector TLS—1, toll first selector TFS—1, Figs. 9 and 7, respectively, thereby causing the lighting of the call supervisory lamp 601.

Having received the disconnect signal by the lighting of the answering and call supervisory lamps 602 and 601, respectively, the toll operator may now operate the talking key K—1 to associate her equipment with the connection and then operate the release answering and call key K—11 to clear out the connection. Since the clearing out of the equipment used in the above described connection has been previously pointed out, it will suffice to state that the momentary operation of the release answer and call key

K—11 restores the entire connection to normal.

Transferring a call

This type of connection generally takes place responsive to repeated attempts by a point-to-point operator at the central office toll board to complete a connection from a calling subscriber in local office of the central office area to a subscriber in a distant office reached, for example, by way of toll line TL—1, and is generally made on a person-to-person call basis. When the point-to-point operator reaches the wanted station, but is unable to get in touch with the wanted person, she may leave word at the called station for the called subscriber to call her when he returns. The central office point-to-point operator then informs the calling subscriber that she will recall him when the wanted subscriber is reached. Therefore, when the wanted subscriber at the distant end of toll line TL—1 extends her call to the toll operator at his exchange, he informs her that a point-to-point operator in the central office has a call for him.

Incoming calls over toll line TL—1, as has been pointed out hereinbefore, are handled by inward operators at the central office switchboard. Therefore, when the answering inward operator is informed that the call is for a particular point-to-point operator, she extends the connection to that particular point-to-point operator. The point-to-point operator then extends the call to the original calling subscriber and supervises the connection from her position.

It will now be assumed that such a connection has been attempted by the point-to-point operator at the central office switchboard, and that the wanted subscriber is located in an exchange reached by toll line TL—1, and is absent when the call is extended to his station. However, it will further be assumed that the point-to-point operator has left word at the wanted subscriber's station that he should call her when he returns.

When the wanted subscriber returns, and makes the call, the operator at the distant end of the toll line TL—1 extends the connection and rings over the toll line TL—1 causing the operation of the AC relay 270 in the toll line circuit TLC, Fig. 2. A finder, selected by the operation of a talking key by an operator at an inward position of the central office switchboard, finds the calling toll line circuit TLC of Fig. 2. The operator at the inward position receives the information from the distant operator and operates her digit keys to extend the connection to the desired point-to-point operator whose number is, for example, 942.

It will be assumed that the inward operator operates the digit keys at her switchboard position to set up the digits 9, 4, and 2, thereby causing the toll first selector TFS—2, Fig. 1, (which is the same as the toll first selector TFS—1 of Fig. 7) to raise its wipers to the ninth level and rotate the wipers over its banks in search of an idle transfer selector TS, Fig. 1, (which selector is the same as the toll line selector TLS—1 of Fig. 9). The transfer selector TS raises its wipers to the fourth level of its banks in response to the four impulses indicative of the digit 4, and rotates the wipers two steps, in response to the impulses of the digit 2, to select the interposition transfer circuit ITC, Figs. 1 and 5, which is individual to the wanted point-to-point operator's position.

The operation of the toll first selector TFS—2, Fig. 1, which is the same as the toll first selector

TFS—1, Figs. 1 and 7, has been previously described. It will be assumed that the wipers 770 are rotated over the bank contacts of the ninth level to find an idle transfer selector TS, Fig. 1. It will also be assumed that the first idle transfer selector is the transfer selector TF, Fig. 9 (this transfer selector is the same as the toll line selector TLS—1, Fig. 9). The operation of the selector shown in Fig. 9 has been described in detail under the heading of "Operation of toll line selector TLS—1". In the description of the connection under the above-mentioned heading, the selector responded to one digit to raise its wipers to a selected level and then automatically rotated the wipers to search for an idle one of several trunk lines. In the description about to be given, the selector, operating as a transfer selector, responds to raise its wipers to a selected level and to rotate its wipers to a particular set of bank contacts to select a particular interposition transfer circuit, such as shown in Fig. 15.

The transfer selector TS, Fig. 9, having been selected by the stopping of the wipers 770 on the terminals to which conductors 912–915, inclusive, are connected, vertical series relay 930 is energized over the grounded C conductor 914 through the off normal contacts 991, and line relay 910 is energized over the talking conductors and through the impulse contacts of the sender link pulse relay. Release relay 920 operates responsive to the operation of line relay 910. Also sequence relay 940 is operated from the grounded C conductor 914 through armature 932 of the vertical series relay 930.

When the impulses indicative of the second digit 4 are received by the line relay 910, it falls back momentarily four times. Vertical magnet VERT. responds to the impulses delivered by relay 910 through armatures 911, 924, and 923, and raises the wipers 990 to the fourth level of its bank. The lower winding of the slow-releasing vertical-series relay 930 maintains the relay operated after its upper winding has been disconnected at off-normal contacts 991 upon the first vertical step of the wipers.

At the end of the impulse series, vertical-series relay 930 restores and opens the initial circuit of the sequence relay 940 at armature 932, but this relay remains operated in its locking circuit including armatures 942 and 946. At armature 933, relay 930 transfers the operating circuit from the vertical magnet VERT. to the rotary magnet ROT. by way of relay 950, armature 944, and the normally closed contacts controlled by armature 964.

When the impulses of the final digit 2 are received by the line relay 910, the circuit of the rotary magnet ROT. is closed two times. Rotary magnet ROT. rotates the wipers 990 two steps to engage the contact set 560 of the interposition transfer circuit ITC—2, Fig. 5. Slow-releasing rotary series relay 950 operates in series with the rotary magnet ROT. upon the first rotary impulse. Upon operating, relay 950 disconnects the C wiper 990 at armature 951 and operates the auxiliary relay 960 at armature 952. Relay 960 disconnects the BC wiper 990, and it opens the locking circuit of sequence relay 940. The front contact of armature 964, relay 960 closes a new rotary stepping circuit exclusive of armature 944 of the sequence relay 940.

At the end of the rotary controlling series of impulses, relay 950 falls back and at armature 952 it disconnects the operating circuit for auxiliary relay 960. At armatures 951 and 965 the

C wiper 990 is reconnected to the test (top) winding of switching relay 980.

Assuming that the interposition transfer circuit ITC—2, Fig. 5, is idle when the wipers 990 arrive on terminals 560, the test winding of switching relay 980 becomes energized over the C conductor through armatures 541, 532, and the winding of line relay 510. Upon operating, relay 980 terminates the rotary movement and it extends the incoming negative, positive, and EC conductors to the interposition transfer circuit ITC—2, in addition to closing a holding circuit for its middle winding, and applying ground potential to the C wiper 990 by way of armatures 983, 931, 941, 951, 965, and 971, in shunt of its test winding to guard the interposition transfer circuit from further seizure.

Relay 910 restores, and at the end of a momentary interval release relay 920 restores. The selector remains held by the ground potential supplied over the incoming C conductor 914 from the preceding selector.

Responsive to the operation of line relay 510, a circuit is completed at armature 511 for lighting the position answering lamp 561 at the desired point-to-point operator's position, thereby indicating to the operator that a call is being transferred to her. At armature 512, line relay 510 prepares a circuit for the lower winding of start relay 520; at armature 513, it prepares a locking circuit for start relay 520; and at armature 514 it prepares a circuit for grounding the start conductor 524 in the first level of the finders associated with the wanted point-to-point operator's position.

When the inter-position answering lamp 561 is lighted, the point-to-point operator throws a talking key associated with an idle finder link. It will be assumed that the talking key K—1 associated with the finder F—1, Fig. 6, is the one selected by the point-to-point operator. When the key K—1 is actuated, relay 670 operates as usual and the following circuit is completed from ground at the lower winding of start relay 520, Fig. 5, armature 512, emergency start conductor 515, through Fig. 11 to armature 1363 of Fig. 13, armature 1344, start conductor 1302 and cable 1, armature 677 of the operated connecting relay 670, winding of start relay 660, to battery. Start relay 660 operates in series with start relay 520 to start the finder in search of the interposition trunk circuit ITC—2 of Fig. 5. Start relay 520, upon operating, completes a locking circuit for its upper winding; at armature 523 it extends ground potential over start conductor 524 to mark the first level of the vertical bank contacts associated with the finder of Fig. 6; and at armature 522 it connects battery from the upper winding of cut-off relay 530 to the C terminal 570 to mark the line as calling in the banks of the finder switch, Fig. 6.

Since this call is being received by an operator at a point-to-point switchboard position of the toll board, the delay key K—3 is in an operated condition in order to prevent the operator from receiving regular calls. Attention is called to the fact that the start conductor 524 and the trunk conductors of the inter-position trunk circuit are common to all the finders accessible to the point-to-point switchboard position only.

The finder F—1 of Fig. 6 responds to the operation of start relay 660 and raises its wipers to the first level, where the vertical test wiper 617 encounters the grounded start conductor 524, thereby terminating the vertical movement of the

switch and causing the rotary action to take place. The wipers are rotated one step, to the first bank contact set in the first level, wherein the trunk conductors of the inter-position transfer circuit of Fig. 5 are connected. The battery potential encountered on the C conductor of the bank terminals 570 by the C2 wiper of the wiper set 618, causes the operation of the switch 2 electropolarized relay 620, thereby connecting up the negative 2, positive 2, C2, and EC2 wipers of the wiper set 618 which are now engaging terminals 570 of the inter-position transfer circuit, Fig. 5. The circuit including the upper winding of the cut-off relay 530 and the upper winding of the electro-polarized relay 620 causes both relays to operate in series. The finder F-1 operates in the same manner as has been previously described, causing the lighting of the link busy lamp 603, thereby indicating to the point-to-point operator that the connection has been received.

When the connection, extended by the inward operator, seizes the inter-position transfer circuit, Fig. 5, by way of the terminals 560, the ground potential applied to the incoming EC conductor at armature 531, lighted the call supervisory lamp associated with the finder used by her in setting up the connection. The lighting of the call supervisory lamp is an indication to the inward operator that the connection has been extended to the point-to-point operator's position. When the finder F-1 at the point-to-point operator's position finds the inter-position trunk circuit, Fig. 5, and causes the operation of the cut-off relay 530, ground potential is removed from the EC conductor causing the call supervisory lamp at the inward operator's position to be extinguished as an indication that the point-to-point operator has answered.

As a further result of the operation of cut-off relay 530, line relay 510 is restored and opens the locking circuit for start relay 520 which also restores. The answering lamp 561 at the point-to-point operator's position is extinguished, and the start conductor 524 is ungrounded. At armature 533, cut-off relay 530 completes a circuit for operating relay 540, which relay locks itself to the incoming C conductor by way of armature 542. The resistance of relay 540 is sufficiently high to prevent seizure of the inter-position transfer circuit by another transfer selector, thereby guarding the transfer circuit of Fig. 5 from seizure while it is busy. At armature 534, cut-off relay 530 prepares a circuit for its lower winding. Responsive to the energization of high-resistance relay 540, at armature 543 a multiple locking circuit is completed for the upper winding of cut-off relay 530, thereby shunting the circuit including its lower winding, armature 534 and resistance R-10.

When the call supervisory lamp at the inward operator's position is extinguished, the operator immediately disconnects her headset from the established connection by restoring the talking key associated with the connected link to normal, thereby extending the connection received over the toll line TL-1 straight through to the point-to-point operator's switchboard position. The operator at the point-to-point switchboard position answers the call and receives the necessary information from the originating toll operator.

The point-to-point operator ascertains from her toll ticket what subscriber in the central office area originally attempted to extend a call to the

subscriber at the distant toll office. She then sets up the subscriber's number on her digit keys to extend the connection to that subscriber's line and then operates her ring-call key K-12, to ring the wanted subscriber's telephone.

When the subscriber answers, the operator informs the subscriber that she has now completed the connection as originally requested. The operator disconnects from the talking conductors of the trunk by restoring her talking key K-1 and the subscribers start conversation. The point-to-point operator stamps the toll ticket to indicate the starting time of the conversation and supervises the connection in the usual manner.

It will be noted that the point-to-point operator supervises the end of the connection that is being charged for the call, that is, the subscriber in the local office in the central office area that originally attempted to establish a connection with a subscriber reached by way of the toll line TL-1. The inward operator receives her disconnect supervision from the point-to-point operator.

The operation of the equipment required to extend a connection from the point-to-point operator's position to a calling subscriber in either a local manual or automatic exchange in the central office area is exactly the same as has been previously described.

Disconnect supervision

The local subscriber in the central office area hangs up his receiver after the conversation is completed, thereby causing the call supervisory lamp 601 at the point-to-point operator's position to be lighted to give the usual disconnect supervision. The operator then operates the talking key K-1 of the connected finder F-1 to make certain that the subscribers have disconnected.

After challenging the line and finding that the connection has been released by both subscribers the point-to-point operator may operate her release answering and call key K-11, thereby causing the answering and calling ends of her switch train to restore to normal.

It has been pointed out previously that the local central office subscriber, the called end of the present connection, is actually the calling subscriber, since he originally tried to establish a connection with the subscriber at the distant toll office. Accordingly, the point-to-point operator again stamps the toll ticket to indicate the time the conversation terminated in order to charge the local central office subscriber for the completed toll connection.

The finder F-1, Fig. 6, restores to normal when the key K-11 is actuated and removes the ground potential from the C terminal 570 of the interposition transfer circuit ITC-2, Fig. 5. When this occurs, cut-off relay 530 falls back, and at armature 531 applies ground potential to the incoming EC conductor. The application of ground potential to the EC conductor causes the call supervisory lamp at the inward operator's position to light to give disconnect supervision.

Before breaking down the connection at her position, the inward operator rings over the toll line TL-1 to give the distant toll operator a disconnect signal. She then operates her release answer and call key (similar to key K-11, Fig. 14), and the switch train controlled by her is released in the usual manner. When this key

is actuated the finder restores as usual and removes ground from the C conductor connected to terminal 297, Fig. 2, thereby releasing the toll line circuit TLC, Fig. 2. As a further result of the operation of the release answering and call key, the toll first selector TFS—2 (which is the same circuit as the toll first selector TFS—1, Fig. 7), restores to normal and disconnects its wipers from the transfer selector TS (which circuit is the same as the toll line selector TLS—1 of Fig. 9). When the wipers of the selector TS are restored to normal, ground potential is removed from the C terminal 560 of the interposition transfer circuit, Fig. 5, thereby permitting the high resistance relay 540 to restore.

Monitoring an established connection

In the event that the operator wishes to monitor an established connection, she throws the monitoring key K—2, thereby connecting the tip and ring talking conductors of the connection with the tip and ring monitoring conductors 1366 and 1365, respectively, by way of springs 693 and 691, respectively, of the monitoring key K—3 and ground potential is applied to the switching lead 1357 by way of springs 692. The ground potential on switching lead 1357 is extended by way of cable 1, armature 1334, conductor 1182, armature 1134 of the deenergized talk relay 1130, (deenergized when the talking key K—1 is in its normal position), winding of monitoring relay 1120, to battery. The operation of the monitoring relay 1120 connects the operator's receiver across the secondary winding of repeating coil RC instead of in its normal relation to the secondary winding of the induction coil I, thereby providing the usual efficient monitoring connection. The toll operator may now listen in on the conversation of the established connection to make sure that the connection is satisfactory, without disturbing the connected subscribers. When the monitoring key K—2 is restored to normal, the monitoring relay 1120 falls back to normal and disconnects the operator's receiver from the secondary winding of repeating coil RC.

Emergency provisions

Emergency provisions are made for by-passing the distributor of Fig. 12; for cutting either of the two sender links SL—1 of Fig. 15 and SL—2 of Fig. 16 out of service in the event that one of them becomes temporarily defective; and for transferring the operator's control leads to an adjacent position in the event that a position is vacated during a period calls remain to be cleared.

In the event that the distributor of Fig. 12 (comprising relays 1220, 1230, 1240, etc. to 1270, inclusive) develops a fault, the operator can control her equipment so that a selected finder can be operated to find a calling line. As has been pointed out hereinbefore, start relay 1210 of Fig. 12 is operated when a call comes in, thereby lighting the answering lamps at the operator's positions. It will be assumed that the operator having access to the finder F—1 of Fig. 6, has operated the talking key K—1 to enable the finder to find a calling line. However, due to some trouble in the distributor of Fig. 12, ground potential is not applied to the position start conductor 1187 to cause the operation of the finder start relay 660. The operator noting that the calling line is not connected to position, throws the non-locking emergency start key K—10.

Ground potential is now applied to conductor 1449 by way of springs 1413 of key K—10, conductor 1449, armatures 1363 and 1344, start conductor 1302 and cable 1, armature 677 of the operated connect relay 670, winding of start relay 660, to battery. The operation of the start relay causes the finder F—1 to operate in the usual manner to find the calling line. When the wipers 618 have been raised to the level in which the calling line is located change-over relay 630 operates and locks itself to battery at armature 632 and resistance R—4, in addition, this battery potential is extended by way of the release answer conductor 608 and cable 1, to the winding of answering pilot relay 1340 and ground. Relay 1340 operates over this circuit and at the front contact of armature 1344 applies direct ground to start conductor 1302. The operator is informed when this operation takes place, by the lighting of the busy supervisory lamp 603, which is controlled at armature 636 of relay 630, and restores her emergency key K—10 to normal. The subsequent operations of the finder are the same as have been described. As has been pointed out above, the starting of an operator-selected finder is controlled by the application of ground potential to start conductor 1302. This ground potential is automatically applied by way of position start conductor 1187 of the distributor of Fig. 12. When the distributor fails, the operator can control the application of ground potential to start conductor 1302 by operating her emergency key K—10 and holding it in the operated position until the busy lamp of the finder selected is lighted. Therefore, each operator can control this starting circuit of the finders assigned to her position by operating her emergency start key.

In the event that the sender link SL—2 becomes defective, the operator may note by observing the sender #2 pilot lamp 1600 that the link is not operating properly. When this occurs she may actuate key K—4 of Fig. 16 to open the normally closed contacts of the springs designated sender cut-out #1, thereby preventing relay 1620 from operating to prepare the circuit of relay 1630. Since no locking circuit now exists for relay 1610 (which locking circuit included the left-hand winding of relay 1620), relay 1610 operates each time the sender control conductor 1304 is grounded in the position equipment, thereby causing sender link SL—1 to operate each time, instead of alternating with the sender link SL—2. When this condition exists, the operator must refrain from operating a talking key, during a busy period, of an idle link pursuant to the acceptance of a new call until the dimly lighted pilot lamp 1500 has become extinguished by the restoration of the operated relay 1530 to indicate that the previously recorded number has been completely retransmitted and that the sender link has cleared out.

In the event that the sender link SL—1, instead of the sender link SL—2 has become defective, the operator may throw the key K—4 in the opposite direction, to close the normally open contacts of the sender cut-out #2. In this event, relay 1620 is maintained operated at all times from the grounded conductor 1190 (which conductor is grounded by relay 1110 as long as the operator's headset is inserted in the jack). Each time sender control conductor 1304 becomes grounded, sequence relay 1630 will operate by way of contact 1623 of the operated relay 1620.

With relay 1630 operating alone each time the sender control conductor becomes grounded, the sender link SL—2 is used for each call instead of alternating with the sender link SL—1.

5 If an operator at any position of the switchboard finds it necessary to vacate her position at a time when a call is remaining to be cleared, she operates her position grouping key K—17, Fig. 13, thereby causing the operation of transfer relay 1330. At armatures 1331 to 1335, inclusive, 10 relay 1330 transfers the conductors 1366, 1365, 604, 1357, and 605 to the adjacent operator's position so that the succeeding operator can talk or monitor on the vacated position for the clearance 15 of existing calls.

What is claimed is:

1. In a telephone system, an operator's position, a plurality of links controlled from said position by the operator for completing connections, means controlled by the operator for selecting 20 any one of said links for use, each of said links having an answering switch and a calling switch, incoming trunk lines accessible to said answering switches, toll lines accessible to said calling switches, selector switches accessible to 25 said answering switches, means responsive to a call on any one of said trunk lines for marking such trunk line in the banks of said answering switches and for starting the operation of the answering switch of an operator's selected link 30 to find the marked calling trunk line and to connect the trunk line to the operator's position, operator controlled means for operating the calling switch of the selected link to select any one of 35 said toll lines, means controlled at will by the operator for preventing any one of the answering switches from operating to answer calls when a link is selected, and operator controlled means for operating the answering switch of any selected 40 link to function as a calling switch to find an idle one of said selector switches.

2. In a telephone system, an operator's switchboard position, link circuits at said position, one end of each of said links terminating in answering 45 switches and the other end of each of said links terminating in calling switches, incoming two-conductor trunk lines from local exchanges accessible to said answering switches, toll lines accessible to said calling switches, means for operating 50 any one of said answering switches as a finder to find any calling one of said incoming trunk lines, means controlled by the operator for operating the calling switch of the link connected to the operated answering switch to extend 55 the incoming call to any one of said toll lines, selector switches accessible to said answering switches and having access to said toll lines and to outgoing trunk lines to local exchanges, means controlled at will by the operator for preventing 60 all of said answering switches from operating as finders to find a calling trunk line and for controlling any one of said answering switches as a calling switch to find an idle one of said selector switches.

3. In a telephone system, an operator's switchboard position, a plurality of operator-controlled link circuits individual to said position, an answering switch for each of said links, incoming 70 trunk lines accessible to said answering switches, means controlled by the operator at said position for selecting any one of said links to prepare it to connect with any one of said incoming trunk lines, means effective when there is a call on any one of said trunk lines for operating the 75 answering switch of any selected link to find and

connect with the calling trunk line only, outgoing trunk lines accessible to said answering switches, means controlled by the operator for preventing any answering switch at said position from operating to find any incoming trunk line, and means for operating any link and associated answering switch to select and connect with an idle one of said outgoing trunk lines.

4. In a telephone system, an operator's switchboard position, operator-controlled switching apparatus individual to said position normally enabling said operator to receive a plurality of successive calls from calling subscribers and to extend them to called subscribers in accordance with CLR operation, and operator-controlled means at 10 said switchboard position for changing the normal operation of said switching apparatus to enable said operator to set up a plurality of successive tail-to-tail connections in accordance with point-to-point operation as long as said operator-controlled means is retained operated. 20

5. In a telephone system, a manual exchange, trunk lines incoming from a central office switchboard and terminating in plug-ended cord circuits in said manual exchange, means operative 25 when a call is received for displaying the called member and for identifying the cord circuit in use, a visual signal at said manual exchange lighted steadily when the manual exchange operator is to test for a busy condition on the called line, and means controlled over the incoming trunk lines by the operator at the central office switchboard for causing said visual signal to light 30 intermittently when said manual exchange operator is to extend the connection to a called line without making a busy test. 35

6. In a telephone system, a manual exchange, a two-conductor trunk line incoming from a distant office and terminating in a plug-ended cord circuit in said manual exchange, a local subscriber's line terminated at said manual exchange, means operative when a call is received over said trunk line for said subscriber's line for displaying 40 said subscriber's line number and for identifying said cord circuit, a relay in said cord circuit operated when said number is displayed, a lamp, means responsive to the operation of said relay for lighting said lamp as a signal to the manual exchange operator to test said subscriber's line for a busy condition, and a second relay controlled 50 over said trunk line for causing said lamp to flash as a signal to the manual exchange operator to extend the connection to said subscriber's line without testing the line for a busy condition.

7. In a telephone system, a calling trunk line, a called line, means including a cord circuit for connecting said calling trunk line with said called line, means controlled over said trunk line for preparing a circuit in said cord for applying a source of ringing current to the called line when 60 said cord circuit is connected thereto, a flashing lamp signal, and means controlled over said trunk line for preventing the application of said ringing current to said called line and for operating said flashing lamp signal as an indication that 65 the cord circuit is to be connected to the called line in the event that it is busy.

8. In a telephone system, a first exchange and a second exchange, two-conductor trunk lines connecting said exchanges, automatic switches in 70 the first exchange, means responsive to a call by a calling operator for operating a plurality of said switches to seize an idle one of said trunk lines, said trunk lines terminating in plug ended cord circuits in said second exchange, means common 75

to said cord circuits operative when a call is received for displaying the called number and for identifying the cord circuit in use, means in the seized cord circuit operated automatically over the associated trunk line for preparing an automatic signalling circuit for the called subscriber, and means responsive to the insertion of the plug of the seized cord circuit into the line jack of the called subscriber's line for connecting said signalling circuit thereto.

9. In a telephone system, a first exchange and a second exchange, two conductor trunk lines connecting said exchanges, automatic switches in said first exchange, means responsive to a call by a calling operator for operating a plurality of said switches to seize an idle one of said trunk lines, said trunk lines terminating in plug-ended cord circuits in said second exchange, means common to said cord circuits operative when a call is received for displaying the called number and for identifying the cord circuit in use, means in said cord circuit for applying a source of ringing current to the called subscriber's line, means for disconnecting said ringing current from the called line when the called subscriber answers, and means in said cord circuit controlled at will by said calling operator over said trunk line for controlling said ringing current applying means as desired.

10. In a telephone system, a first exchange and a second exchange, two conductor trunk lines connecting said exchanges, automatic switches at said first exchange, an inward operator's position and a recording operator's position at said first exchange, means at each of said operator's positions for operating a plurality of said switches to seize an idle one of said trunk lines to extend calls, said trunk lines terminating in plug-ended cord circuits in said second exchange, means common to said cord circuits operative when a call is received for displaying the called number and for identifying the cord circuit in use, means in each cord circuit for applying a source of ringing current to a called subscriber's line, means in each cord circuit automatically controlled over a trunk line when a call is extended by an operator at said inward position for preparing said ringing current applying means for operation, said last mentioned means adapted to be controlled manually when a call is extended by an operator at said recording position and also adapted to be controlled manually by the operator at said inward position to ring a called subscriber.

11. In a telephone system, an operator's position, toll lines and line circuits thereof, means at said operator's position operative responsive to an incoming call on any one of said toll lines for finding and connecting the calling one of said toll lines to said operator's position, means at each of said line circuits for connecting a tone to the associated toll line in the event that the toll line is defective, said last mentioned means controlled by the operator at said operator's position over one of the talking conductors of said line circuit.

12. In a telephone system an operator's position, a plurality of toll lines, a line circuit for each of said toll lines, means at said operator's position for receiving and extending calls over said toll lines and associated line circuits, a relay in each of said line circuits for placing a tone on its associated toll line and for preventing the seizure of the line circuit to extend or receive calls, a lamp signal for each of said toll lines, each of said lamp signals lighted responsive to the opera-

tion of the relay in its associated line circuit, means at said operator's position momentarily actuated when a defective toll line is encountered for operating the relay in the associated line circuit, said relay maintained operated in a circuit including its associated lamp signal.

13. In a telephone system, an operator's position, a toll line, means controlled by the operator at said position for receiving and extending calls over said toll line, a test panel, a trouble lamp at said test panel individual to said toll line, means controlled by the operator at said position for placing an audible tone on said toll line as an indication that said toll line is defective, for lighting said trouble lamp, and for preventing the extension of calls over said toll line from said position.

14. In a telephone system, an operator's position, a toll line, automatic switching means controlled by the operator at said position for receiving or extending calls over said toll line, a test panel, a trouble lamp at said test panel individual to said toll line, a device for placing an audible tone on said toll line as an indication that said toll line is defective, for lighting said trouble lamp, and for preventing the extension of calls over said toll line, a key at said position, said device actuated responsive to a momentary operation of said key, and means at said test panel for restoring said device to normal.

15. In a telephone system, a first and second automatic exchange, an operator's position at said first exchange, trunk lines to said second exchange, a register sender in said first exchange controlled from said operator's position to register digits of a called line terminating in said second exchange and for retransmitting the digits of the called line number, switches in said first exchange responsive to certain of the retransmitted digits to select an idle one of said trunk lines, the remainder of the retransmitted digits controlling the automatic switches in said second exchange to complete the connection to the called line, a level hunting switch included in the switch train at said first exchange adapted to search in more than one level of its associated bank for an idle one of said trunk lines, and means in said register sender controlled by said hunting switch for delaying the retransmission of said remaining digits until an idle trunk to said second exchange is seized.

16. In a telephone system, a plurality of automatic switches, a level hunting switch, a register sender for transmitting successive digits for operating successive ones of said switches to complete a connection to said level hunting selector switch and for transmitting a digit to operate said hunting switch and means for delaying the transmission of further digits by said sender until said level hunting switch has seized a succeeding switch.

17. In a telephone system, two automatic exchanges, an operator's position and a register sender in the first of said exchanges, toll lines accessible to automatic switches in said first exchange and terminating in automatic switches in the second of said exchanges, means at said operator's position for controlling the registers of said register sender to register the digits of a wanted subscriber's telephone number located in said second exchange, means in the sender equipment of said register sender for transmitting the registered digits thereby controlling the automatic switches in said exchanges to extend a connection to the wanted subscriber's line, one of

the automatic switches included in building up of said connection adapted to search for an idle one of said toll lines, and means controlled from said switch for delaying the retransmitting of succeeding digits by said sender until an idle toll line is seized.

18. In a telephone system, a register sender controllable from an operator's switchboard and having registering capacity of a given number of digits, means in said register sender for determining the spacing time between the retransmissions of succeeding registrations on said registers, and additional means for automatically increasing the spacing time between the retransmissions of succeeding registrations.

19. In a telephone system, a register sender controllable from an operator's switchboard and having means for registering and retransmitting series of impulses, each series corresponding in number to each of the digits registered, automatic switches operated in response to said impulses, means in said sender for spacing the time between one impulse series retransmission and the next, and additional means in said sender controlled from said automatic switches for automatically increasing the spacing time as required.

20. In a telephone system, a toll switchboard including two positions, link circuits at the first position, each of said links comprising an answering and a calling switch, each of said answering switches accessible to toll lines from distant exchanges, link circuits at the second position, an answering switch for each of the links at said second position accessible to trunk lines from local exchanges, a calling switch individual to each of the second position links, said toll lines and said trunk lines accessible to the answering switches at both of said positions.

21. In a telephone system, a toll switchboard including two positions, link circuits at said positions, each of said link circuits including an answering and a calling switch, toll lines from distant exchanges accessible to the answering switches at the first position, trunk lines from local exchanges accessible to answering switches at the second position, said toll lines and said trunk lines accessible to the calling switches at both positions, means for selecting an idle one of said links at said first position to answer a call received over one of said toll lines and to extend the call to complete the connection, and means for selecting an idle one of said links at said second position to answer a call received over one of said trunk lines and to extend the call to complete the connection.

22. In a telephone system, a toll switchboard including two positions, link circuits at the first position, each of said links comprising an answering and a calling switch, toll lines from distant exchanges accessible to said answering switches, link circuits at the second position, an answering switch for each of the links at said second position accessible to trunk lines from local exchanges, a calling switch individual to each of the second position links, said toll lines and said trunk lines accessible to the answering switches at both of said positions, an interposition transfer trunk for each of said positions accessible to the answering switches thereat, transfer selectors accessible to all of said calling switches and having access to said interposition transfer trunks, means effective when a call is received via an answering switch at either of said positions for extending the call to the other operator's position by way of the associated calling switch, a

transfer selector and the wanted operator's interposition transfer trunk, and means at the selected position for operating an answering switch to find and connect with the calling transfer trunk and for preventing the operator thereat from answering other incoming calls until the call received over the interposition transfer trunk has been completed.

23. In a telephone system, a toll switchboard including two positions, link circuits at both of said positions, each of said links comprising an answering and a calling switch, two-way toll lines from distant exchanges accessible to the answering switches at the first of said positions, outgoing trunk lines to local exchanges accessible to the calling switches at said first position, an interposition transfer trunk, transfer selectors accessible to the calling switches at said first position and having access to said interposition transfer trunk, incoming trunk lines from local exchanges, the answering switches at the second of said positions accessible to said incoming trunk lines and said transfer trunk, the calling switches at the second of said positions having access to said toll lines and said outgoing trunk lines, means at said first position for causing an idle one of said answering switches to find a calling toll line and for extending the call by way of an idle outgoing trunk or by way of a transfer selector and said interposition transfer trunk to said second position, and means at the second position for answering the call received via the interposition transfer trunk and for extending the call in the desired direction.

24. In a telephone system, a switchboard including an inward position and a point-to-point position, means at the inward position for receiving incoming toll calls and for extending said calls either to other toll exchanges or to local exchanges, means at said point-to-point position for receiving incoming local exchange calls and for extending said calls to other local exchanges or to toll exchanges, an interposition transfer trunk means at said inward position for extending a received toll call to the point-to-point position via said interposition transfer trunk, and means at said point-to-point position for preventing incoming local calls from being answered until the call received over said transfer trunk is answered and extended in the desired direction.

25. In a telephone system, a first operator's position, a link circuit thereat extending between an answering and a calling switch, incoming toll lines accessible to said answering switch, means effective when there is a call on any one of said incoming toll lines for operating said answering switch to find and connect with the calling toll line, an interposition trunk line, operator controlled means for operating said calling switch to extend the calling toll line connection over said interposition trunk, a second operator's position, a link circuit extending between an answering and a calling switch at said second operator's position, said interposition trunk accessible to the answering switch at said second position, means in said second position answering switch effective when said calling switch at said first position seizes the interposition trunk for finding and connecting with said interposition trunk, and means at said second operator's position for operating the second position calling switch to further extend the connection that was received from a toll line accessible only to the answering switches at said first position.

26. In a telephone system, a multi-position

operator's switchboard, a separate group of line finders allotted to each position of the switchboard, separate branch start conductors at the respective positions of the switchboard and means for extending such branch conductors selectively to the finders allotted to the respective associated positions, a common start conductor, a distributor interposed between the common start conductor and the position branches thereof for connecting the position branches selectively to the common start conductor, and means for use in the event that the distributor becomes defective for selectively controlling the branch start conductor individual to each position.

27. In a telephone system, a switchboard including several operator's positions, a group of line finder links at each position, a group of lines accessible to all of said links, a start circuit common to all of said lines for controlling the starting of the finders, operator-controlled means for selecting a finder allotted to her position, a distributor interposed between the common start circuit and the finders for allotting the common start circuit to any position in which a finder has been selected, and means controlled by the operator at any position for preventing the distributor from allotting the common start circuit to a selected finder at her position.

28. In a telephone system, a plurality of link circuits individual to an operator's position, a plurality of incoming toll lines, a busy signal at the position for each of said links, a supervisory lamp for recall and disconnect supervision for each of said links, operator controlled means effective when a call is received over any one of said lines for connecting the calling line with an idle one of said links, means responsive to such connection for operating the busy signal corresponding to the connected link, means in the link for answering the call and for extending the call in the desired direction, means controlled over the toll line for lighting said supervisory lamp, and means for maintaining said lamp lighted until the operator again answers the call.

29. In a telephone system, a plurality of link circuits individual to an operator's position, a plurality of incoming toll lines, a supervisory lamp for recall and disconnect supervision for each of said links, operator controlled means effective when a call is received over any one of said lines for connecting the calling line with an idle one of said links, a supervisory relay for controlling said supervisory lamp, means responsive to such connection for maintaining said relay operated to prevent the lighting of said supervisory lamp, means momentarily controlled over the connected toll line for releasing said relay to light said supervisory lamp, and means for preventing the reoperation of said relay until the operator again answers the call on said toll line.

30. In a telephone system, an operator's position, a link assigned to said position, connecting means associated with said link for enabling the operator to connect with and answer calls from calling lines, automatic switching apparatus associated with said link for enabling the operator to extend a connection from a calling to a desired called line, a register sender, means at said operator's position for associating said register sender with said switching apparatus, means controlled by said operator for operating said register sender to record the number of the called line, means in said register sender for transmitting impulses to control said automatic switching apparatus in accordance with the registered number to extend

the connection, and means responsive to the registration of the first digit for automatically starting the sender to transmit switch operating impulses.

31. In a telephone system, an operator's link through which answered calls may be extended to desired called lines, a busy lamp individual to said operator's link and means for lighting it when a call has been answered, automatic switching apparatus operable to extend a connection from said operator's link to a desired call line responsive to impulses, a register sender, a sender link operated responsive to the answering of a call for automatically associating said register sender with said operator's link, an operator's key set for controlling said register sender to register the digits of a called number and to retransmit switch operating impulses to bring about the desired connection, and a disconnect key operated immediately after the last digit of a called number has been registered for causing the sender link to disconnect register sender from the operator's link after the impulses of the last registered digit have been retransmitted.

32. In a telephone system, a register sender for registering and retransmitting a plurality of digits, a register having registering capacity of a given number of digits, some of the telephone numbers containing digits in excess of said registering capacity, means for operating said registers in sequence to store certain of the digits in a telephone number, a sender device, means for operating said sender to successively retransmit the digits stored under control of said registers, means for releasing each of said registers in turn responsive when the digit stored thereon has been retransmitted, and means responsive to the storing of a digit on the last register for enabling the released registers to be operated in sequence to store the remaining digits in said telephone number.

33. In a telephone system, a register sender for storing and retransmitting a plurality of digits, a register having storage capacity of a given number of digits, some of the telephone numbers containing digits in excess of said storage capacity, means for operating said registers to consecutively store certain of the digits in a telephone number, a sender device, means responsive to the storing of the first digit of said number for starting the operation of said sender to retransmit the digits in the same order that they were stored, means responsive to the retransmission of a stored digit for releasing the storage device therefor, and means effective when the last storage device in the register is operated for enabling released storage devices to be reoperated consecutively to store additional digits in said telephone number.

34. In a telephone system, a register sender controllable from an operator's switchboard and having registering capacity of a given number of digits, some of the telephone numbers containing digits in excess of said registering capacity, means for controlling the register sender to register some of the digits in a telephone number, a sender for transmitting a separate series of impulses for each digit registered on successive registers respectively, means responsive to the registration of a first digit for starting said sender, means for releasing each successive register in turn responsive to the completion of the transmission of the digit registered thereon, means effective immediately responsive to the registration of a digit on the last register for enabling the first register to be reoperated to register an additional digit in the

telephone number, and means effective as each of the remaining registers are released for preparing the released register to receive and register an additional digit in the telephone number.

5 35. In a telephone system, a register sender controllable from an operator's switchboard and having registering capacity of a given number of digits, some of the telephone numbers containing digits in excess of said registering capacity, means controlled by the operator at
10 said switchboard for setting the registers in said register sender to record a telephone number, a sender for retransmitting impulses corresponding to the registrations on said registers, means in
15 said sender responsive when the sender catches up with the registrations on said registers for delaying further transmission of impulses until another digit is registered, means controlled by
20 said sender for releasing each of the registers consecutively responsive to the retransmission of the digit registered, and means responsive each time a digit is registered on the last register for recycling the registers so that each register may be reoperated successively to register another digit in said telephone number as soon as
25 the register is released by said sender control means.

36. In a register sender, a plurality of registers, means for registering a digit of a number of each
30 of said registers consecutively, means responsive to the setting of the last register for passing said registering means to the first register to enable the registers to be reset consecutively a second time, a sender, means responsive to the registration of the first digit for starting said sender to
35 transmit impulses corresponding to the digits registered and for continuing the transmission of impulses until all of the said registered digits have been transmitted, and means operated after
40 all the digits of a number have been registered for preparing the release of said register sender responsive to the transmission of the last registered digit.

37. In a telephone system, a register sender,
45 registers in said register sender, the number of registers being less than the total number of

digits in a telephone number to be registered, means for registering successive digits of a telephone number on each successive register until the last register is set, means for successively
5 transmitting impulses corresponding to each of the registered digits, means for releasing each of said registers after the digit registered is transmitted, and means for enabling the further digits in said telephone number to be successively registered on said released register in response to the
10 setting of said last register.

38. In a telephone system, toll and local lines, a switch, an incoming line circuit for each of said toll and local lines accessible to said switch, a control circuit in said switch for enabling said switch
15 to be connected to the incoming line circuit of a calling one of said lines, a supervisory relay in said switch operated over said control circuit when a connection is made with a line circuit, means in the incoming line circuit of a toll line
20 and controlled over the toll line responsive to alternating current for releasing said relay, and means in the incoming line circuit of a local line and controlled over the local line responsive to a reversal in current flow for releasing said relay.
25

39. In a telephone system, toll and local lines, a switch having access to said lines, a control circuit in said switch for enabling the same to be connected with a calling one of said lines, a
30 supervisory relay in said switch, and means for controlling said relay in one manner over the control circuit when a connection is made to a toll line and in another manner over the control circuit when a connection is made to a local line.

40. In a telephone system, a trunk line, automatic switches, a link circuit, means including
35 said link for controlling said switches to select said trunk line to extend a call, signalling means in the last switch for applying ringing current to said trunk line, a source of direct current, means
40 associated with said link for automatically connecting said current source to operate said signalling means momentarily, and manually controlled means associated with said link for controlling said signalling means at will.
45

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