

Feb. 16, 1937.

J. H. VOSS ET AL

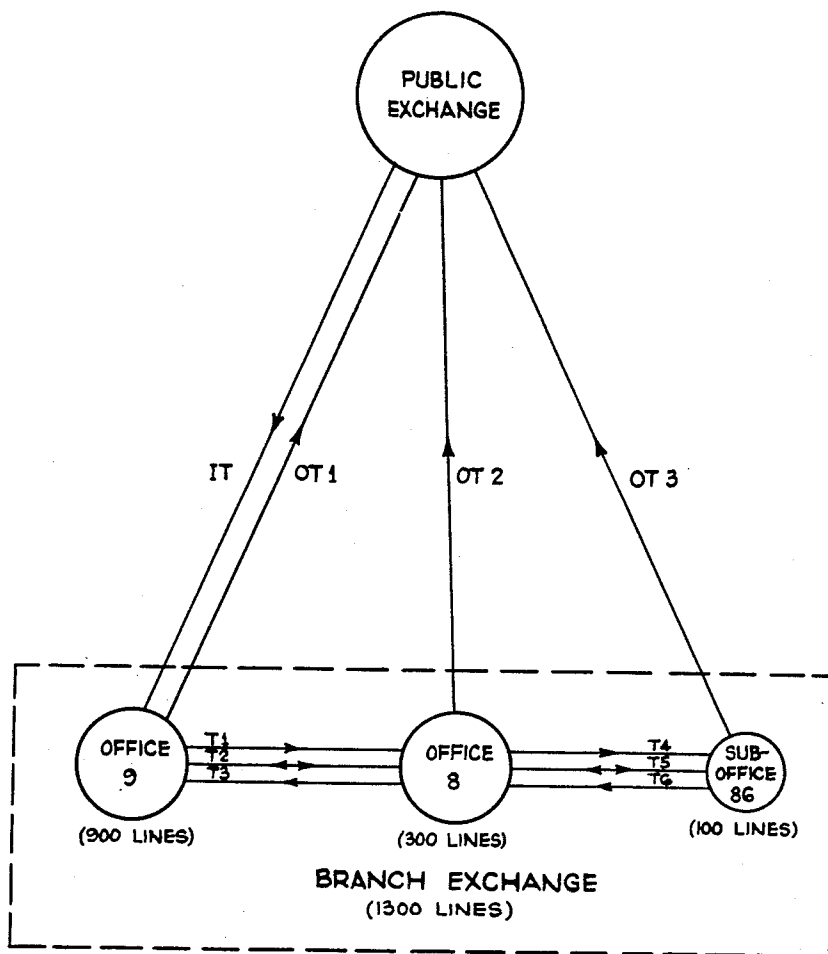
2,070,874

TELEPHONE SYSTEM

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FIG. 1



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Feb. 16, 1937.

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PUBLIC EXCHANGE

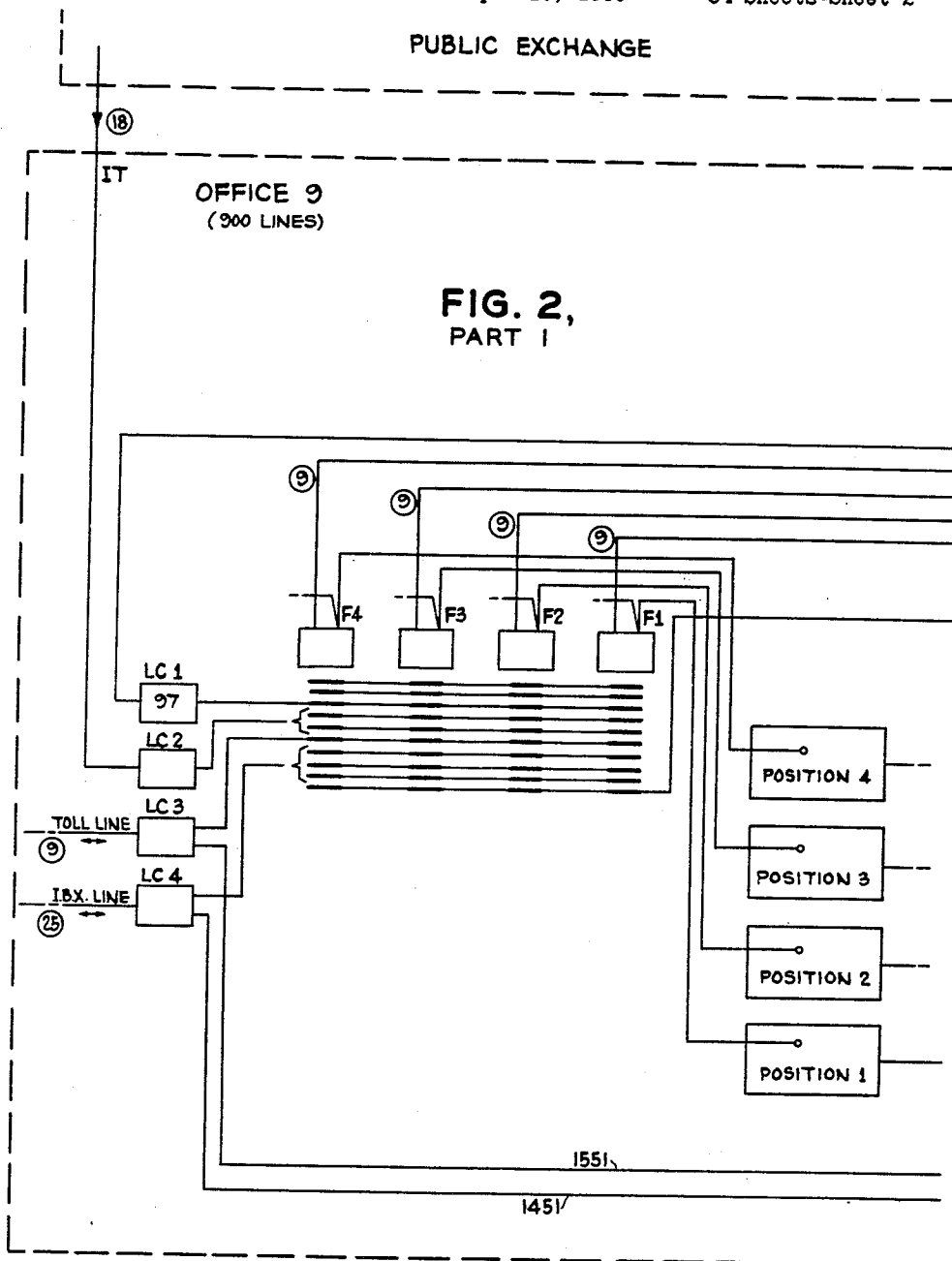


FIG. 2,
PART I

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Feb. 16, 1937.

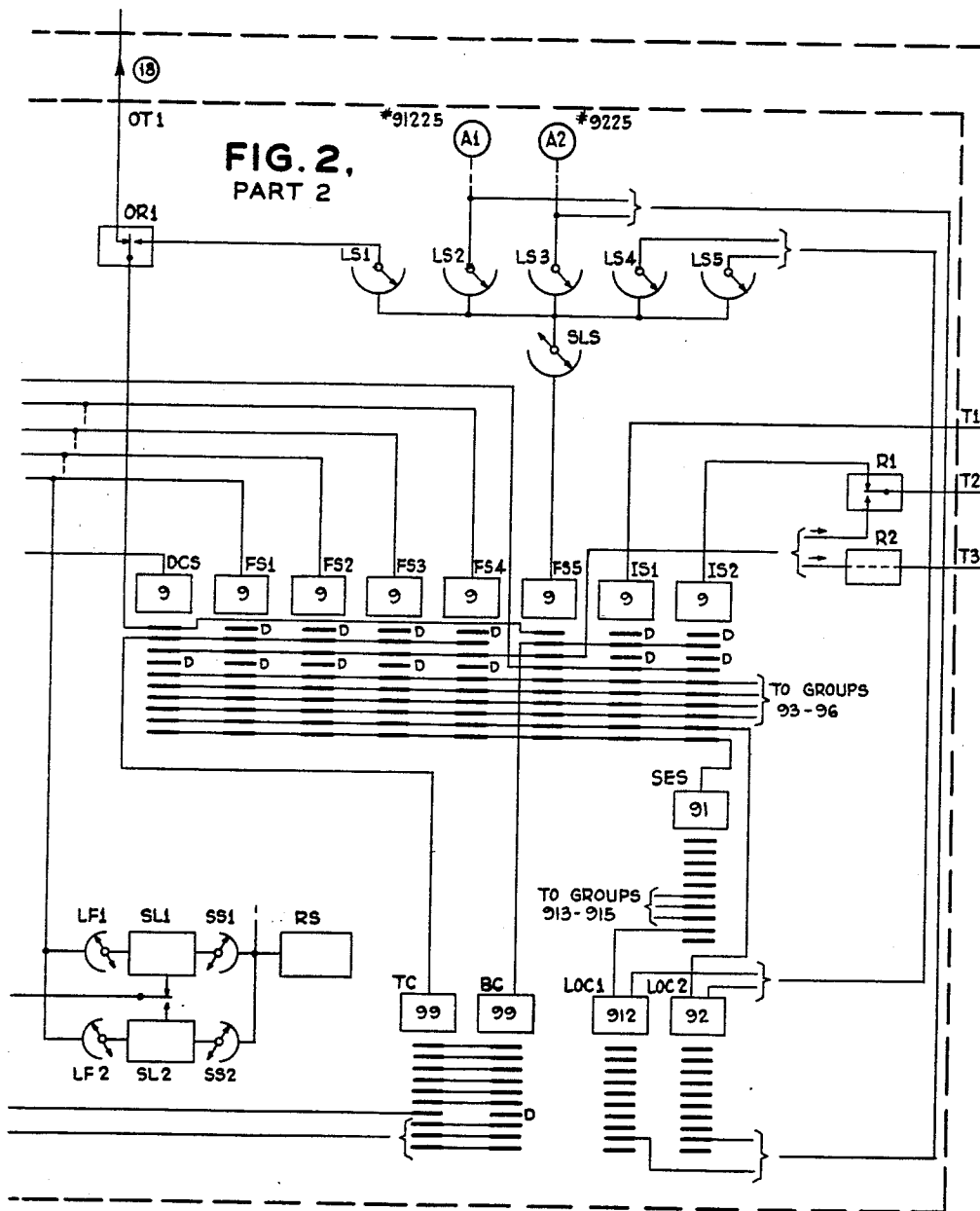
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INVENTOR.
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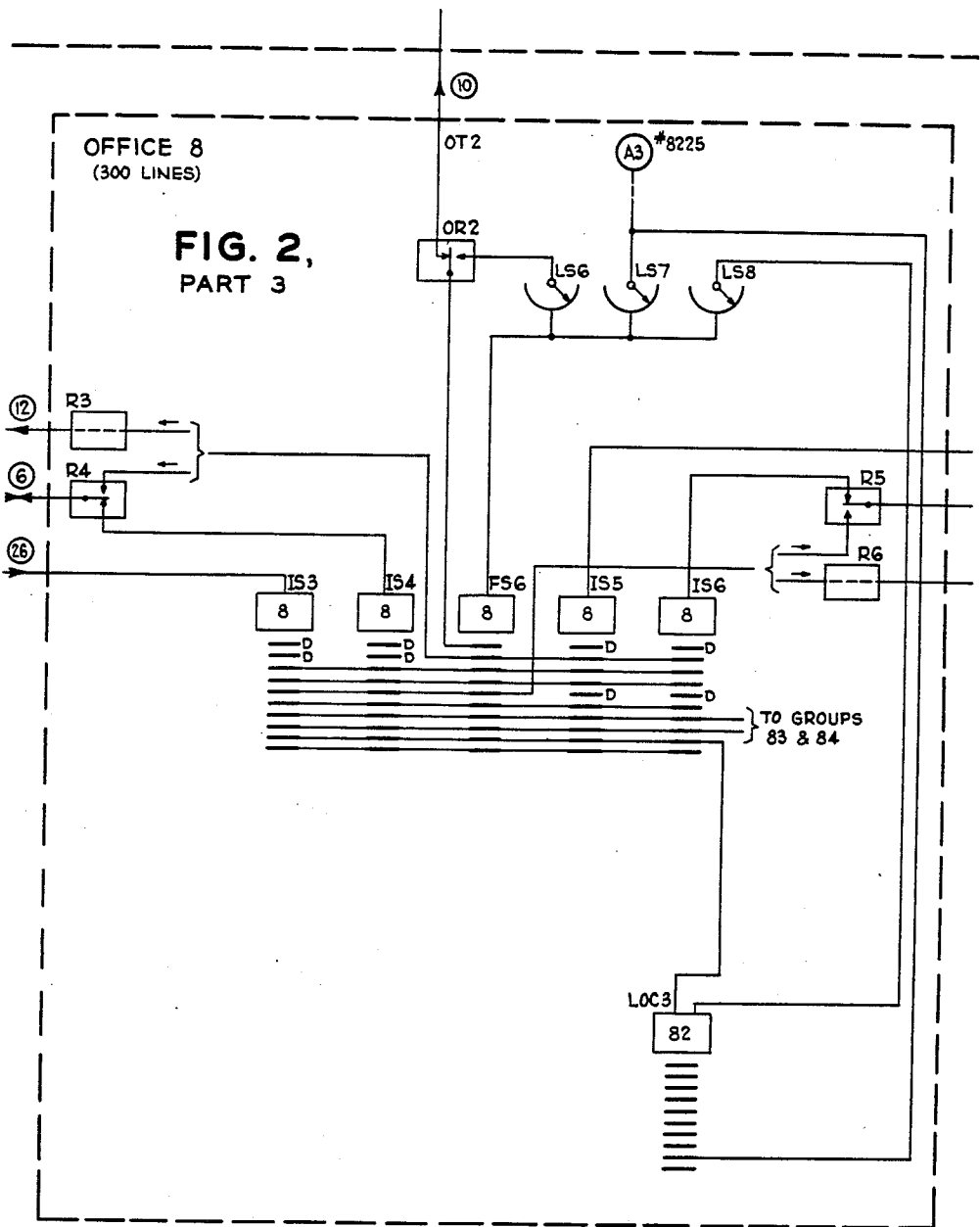
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INVENTOR.
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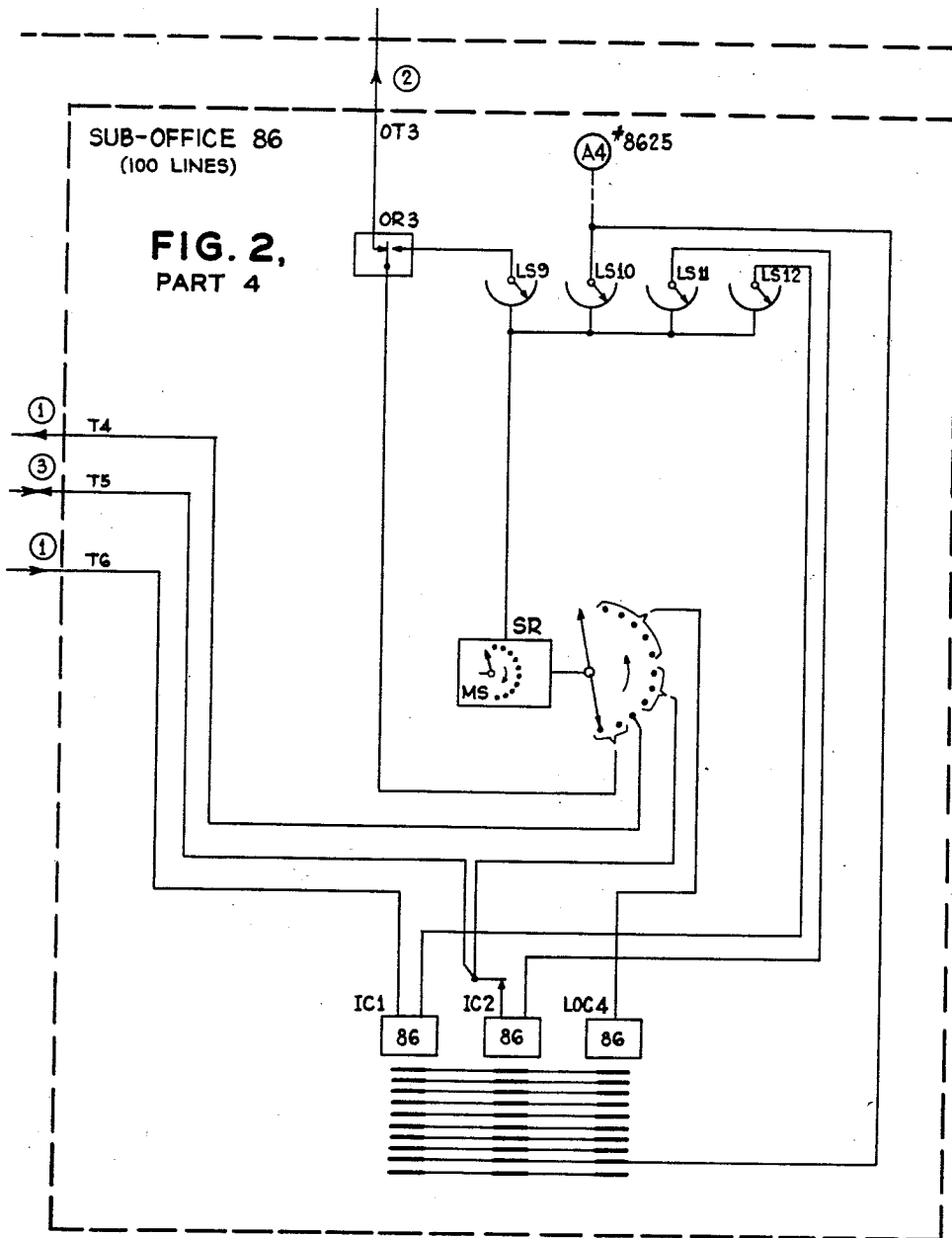
J. H. VOSS ET AL

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INVENTOR.
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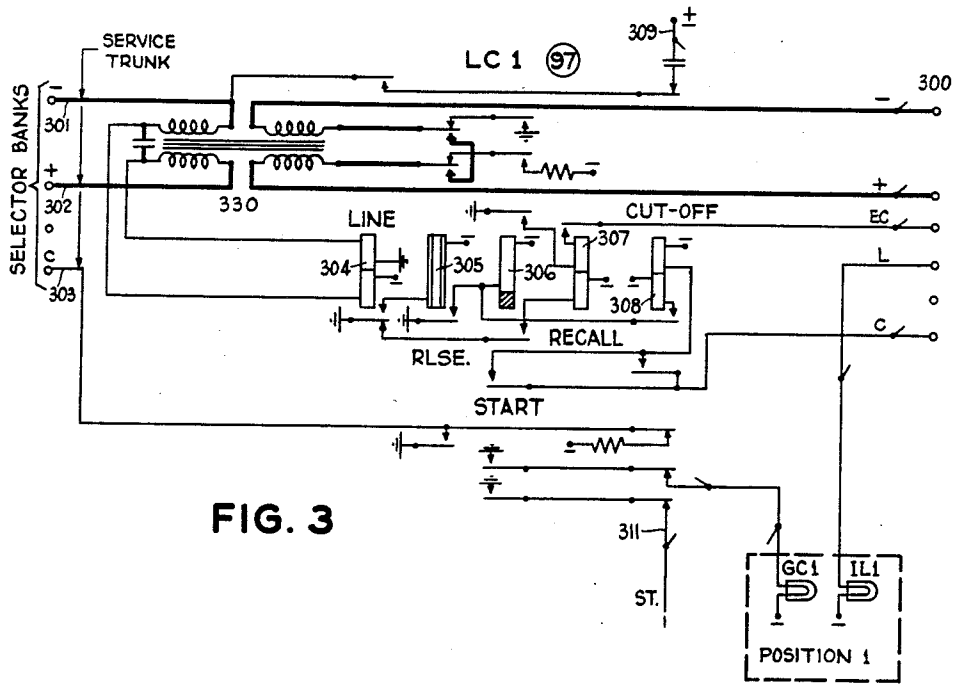


FIG. 3

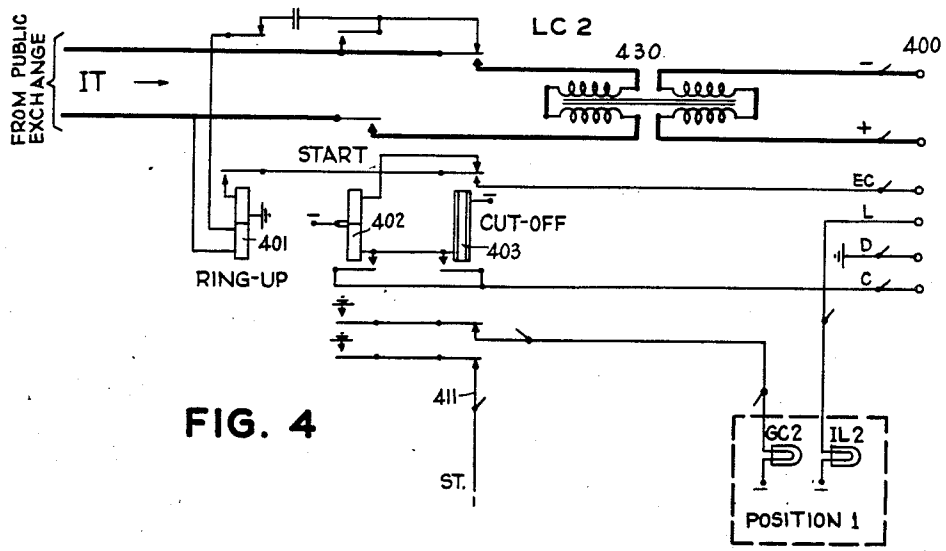


FIG. 4

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Feb. 16, 1937.

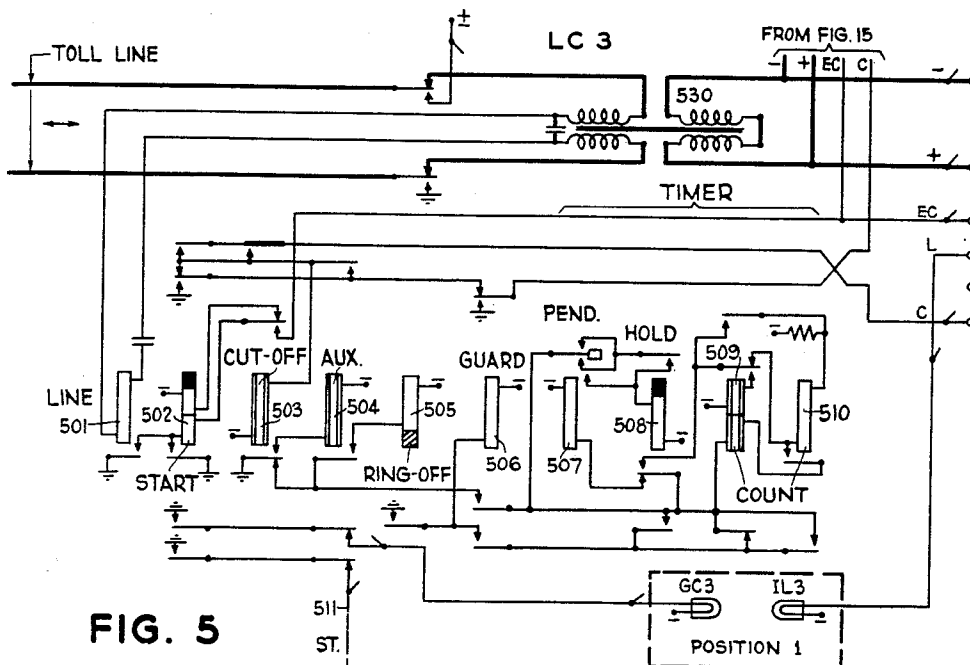
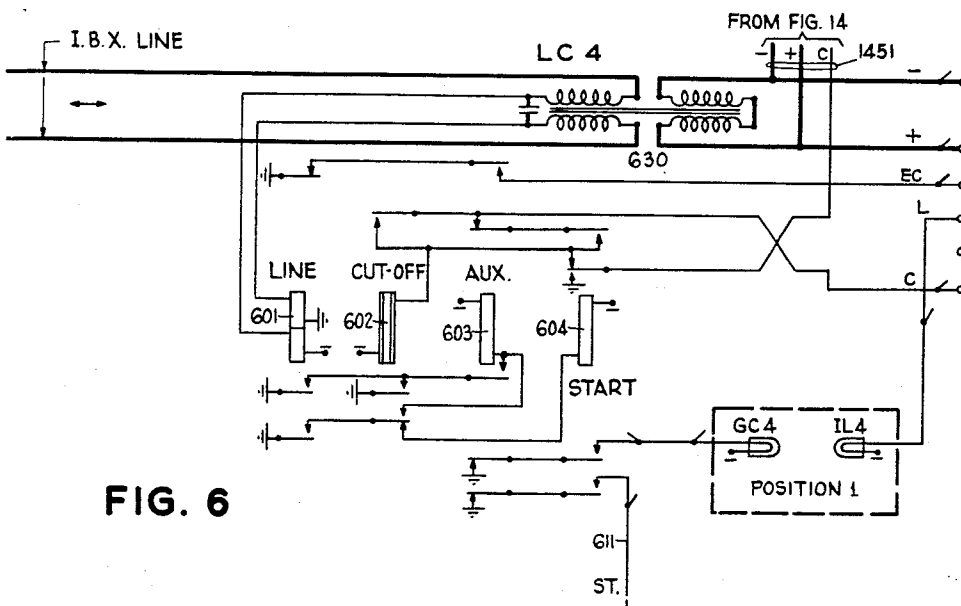
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INVENTOR.
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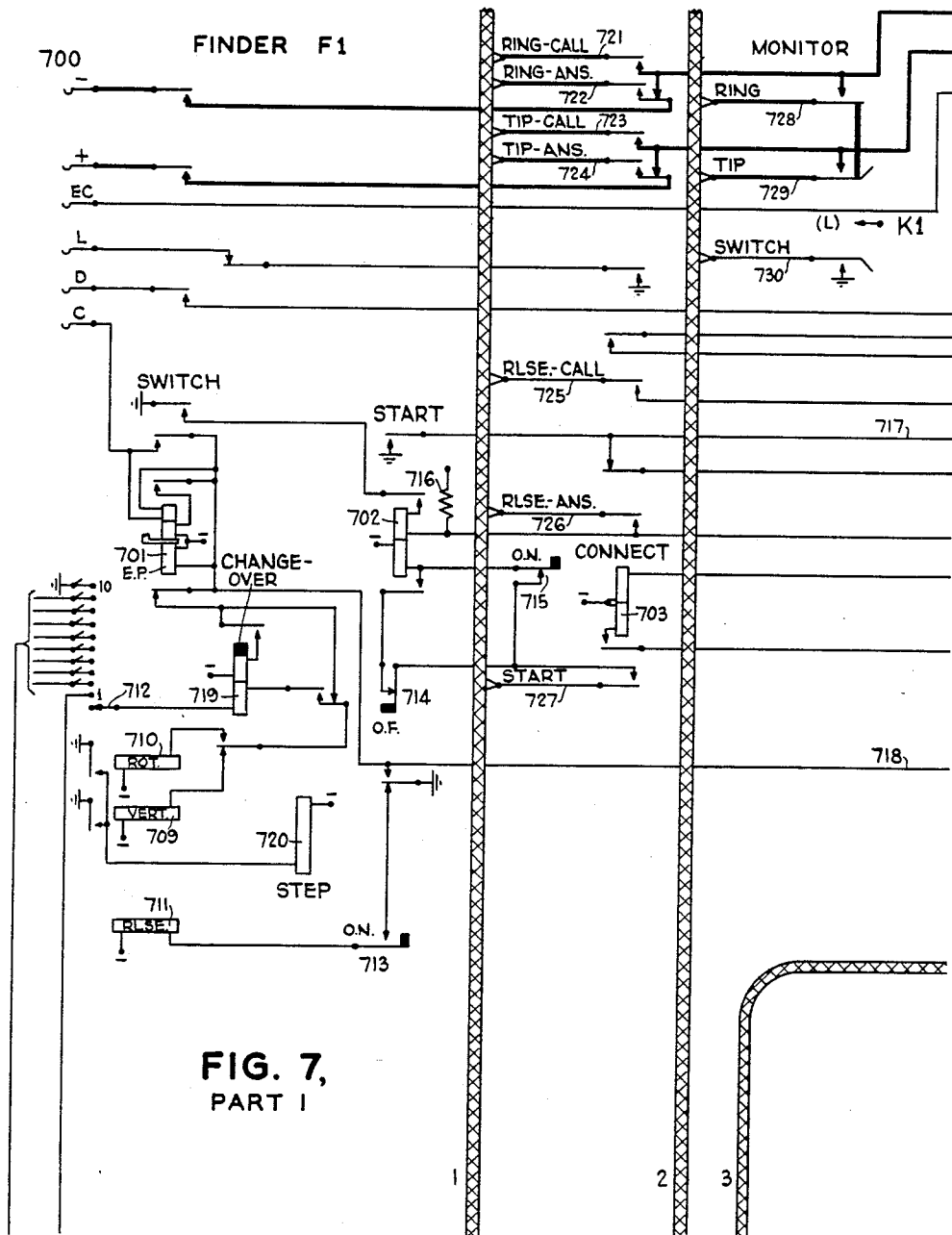
J. H. VOSS ET AL

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FIG. 7,
PART IINVENTOR.
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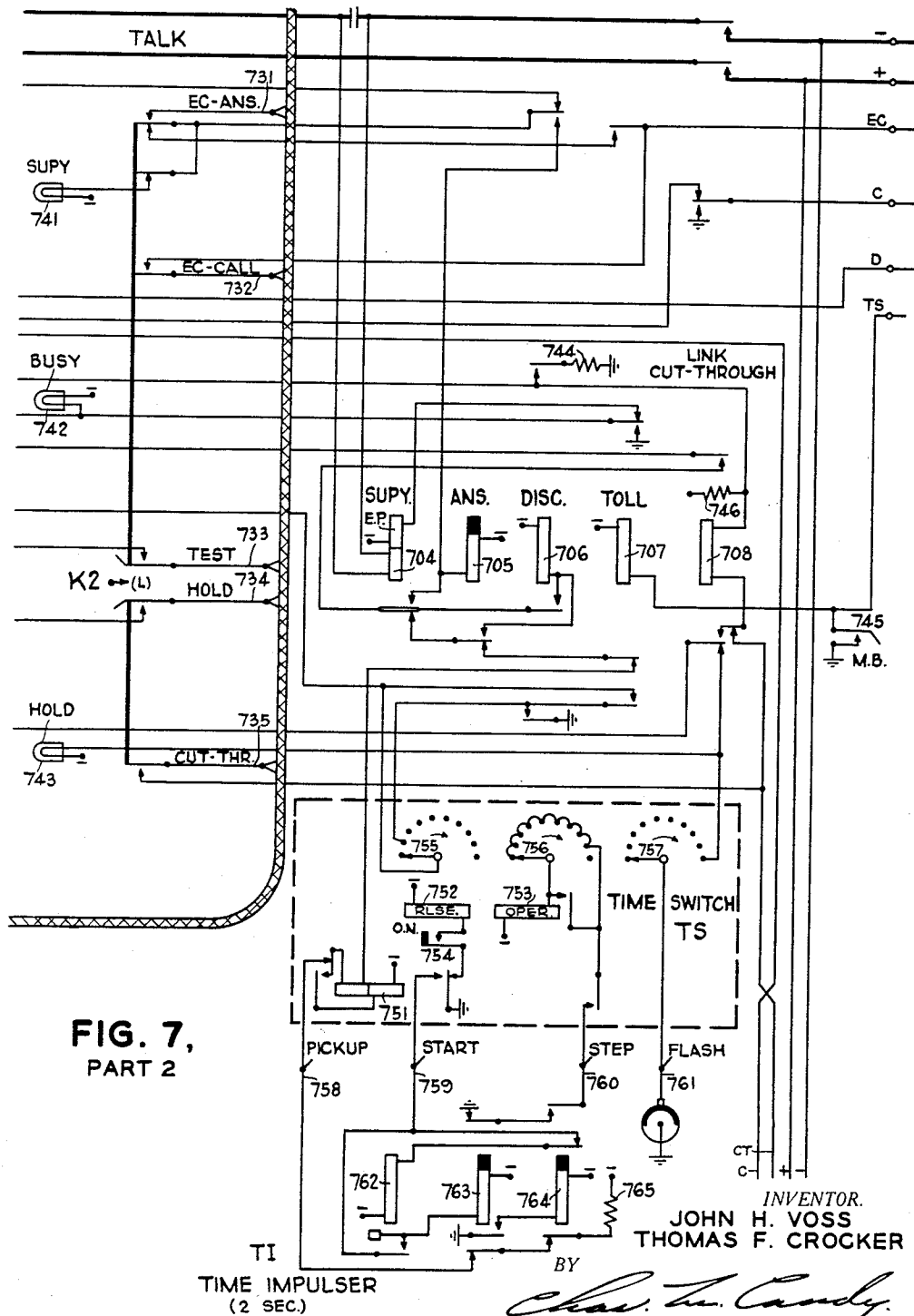
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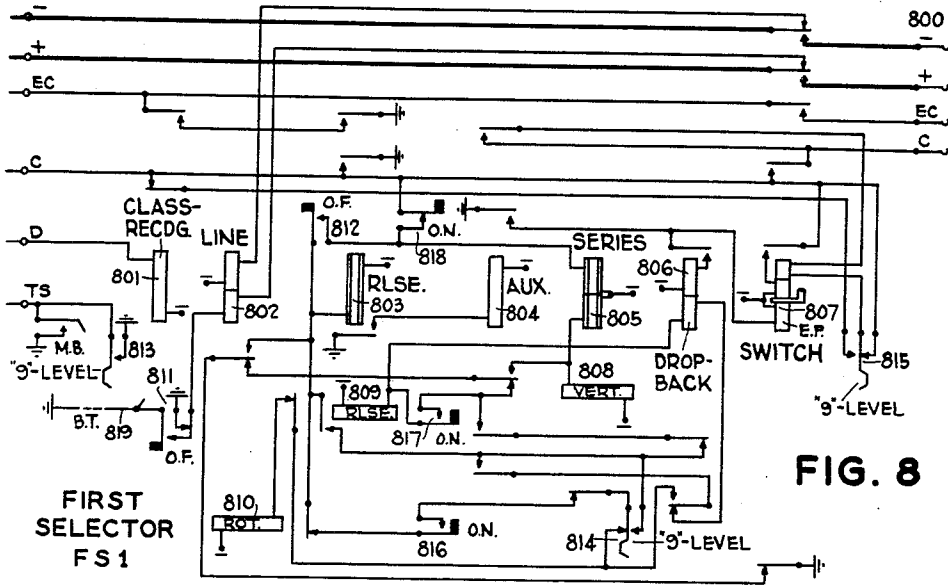
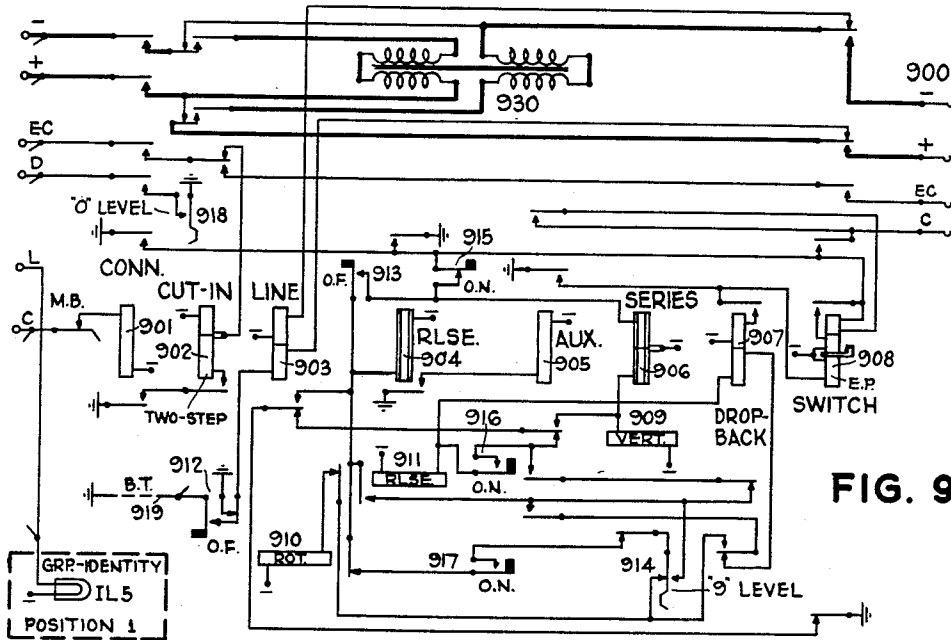
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DELAYED-CALL
SELECTOR
DCS

INVENTOR.
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Feb. 16, 1937.

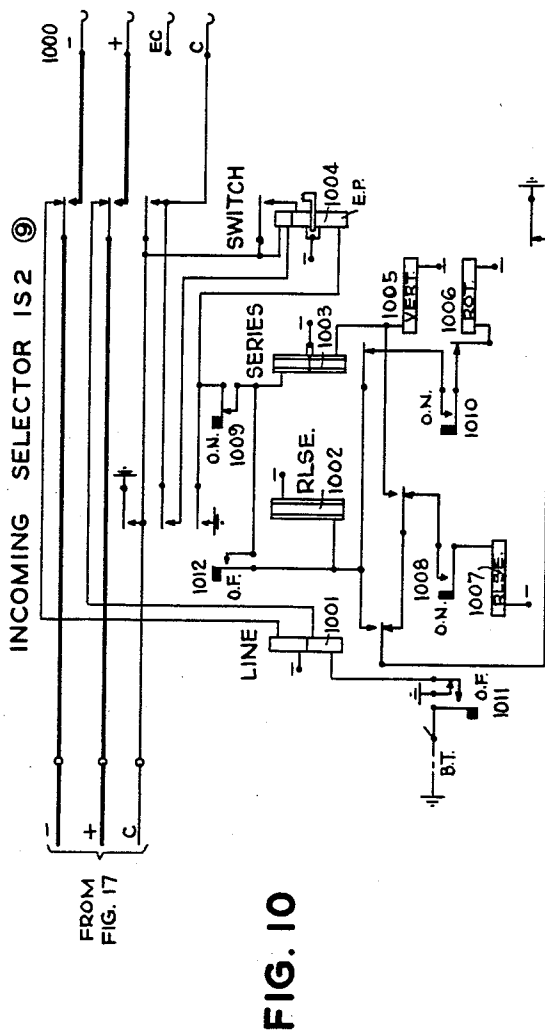
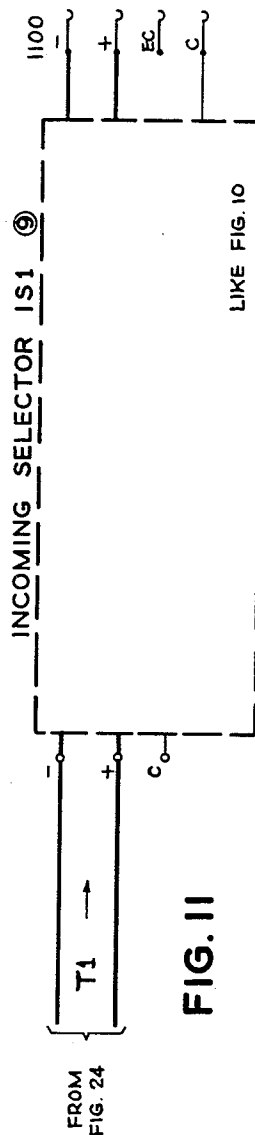
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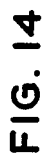
INVENTOR.
JOHN H. VOSS
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B. X. CONNECTOR B.C 99

BY

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Chas. L. Candy
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Feb. 16, 1937.

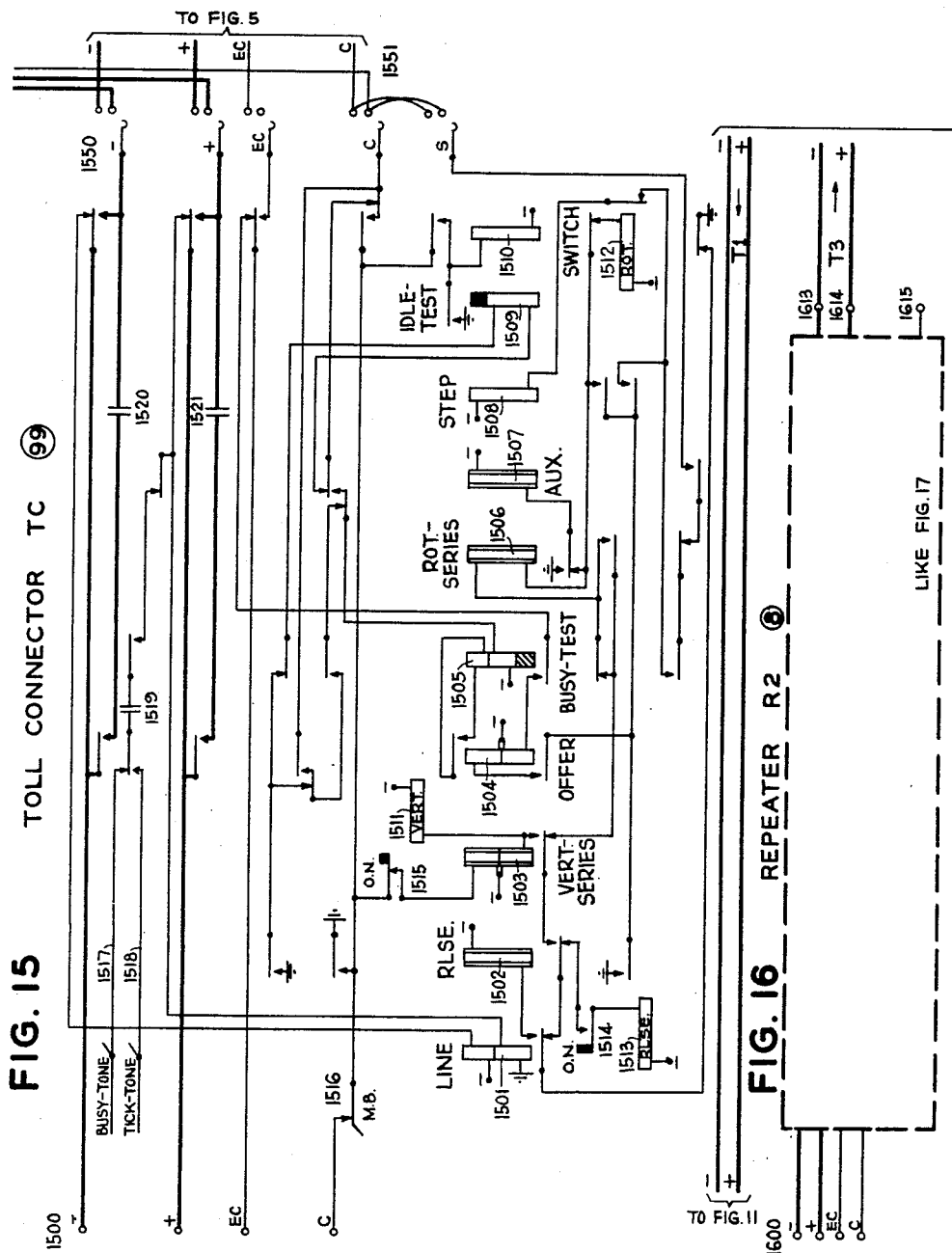
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INVENTOR.
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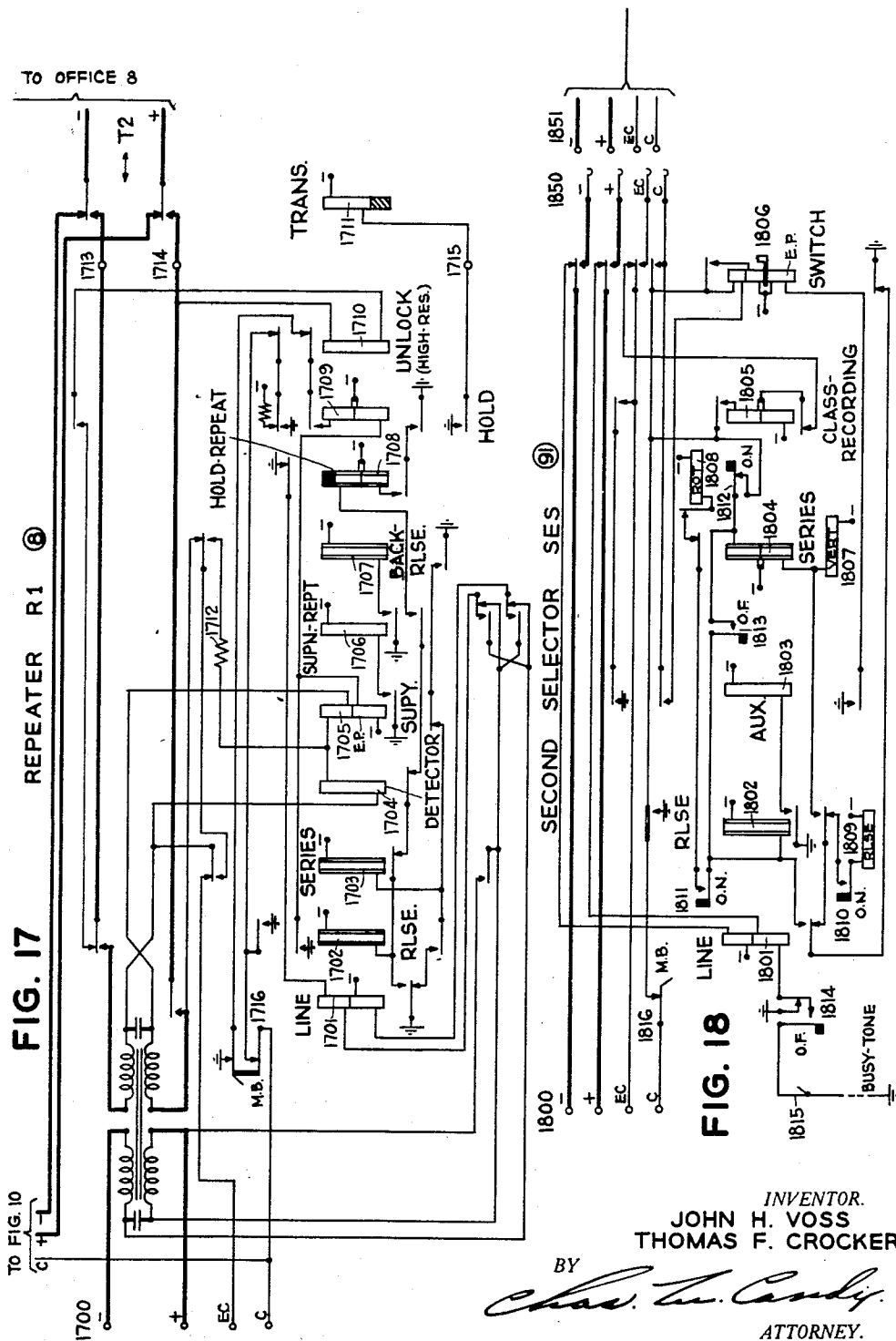
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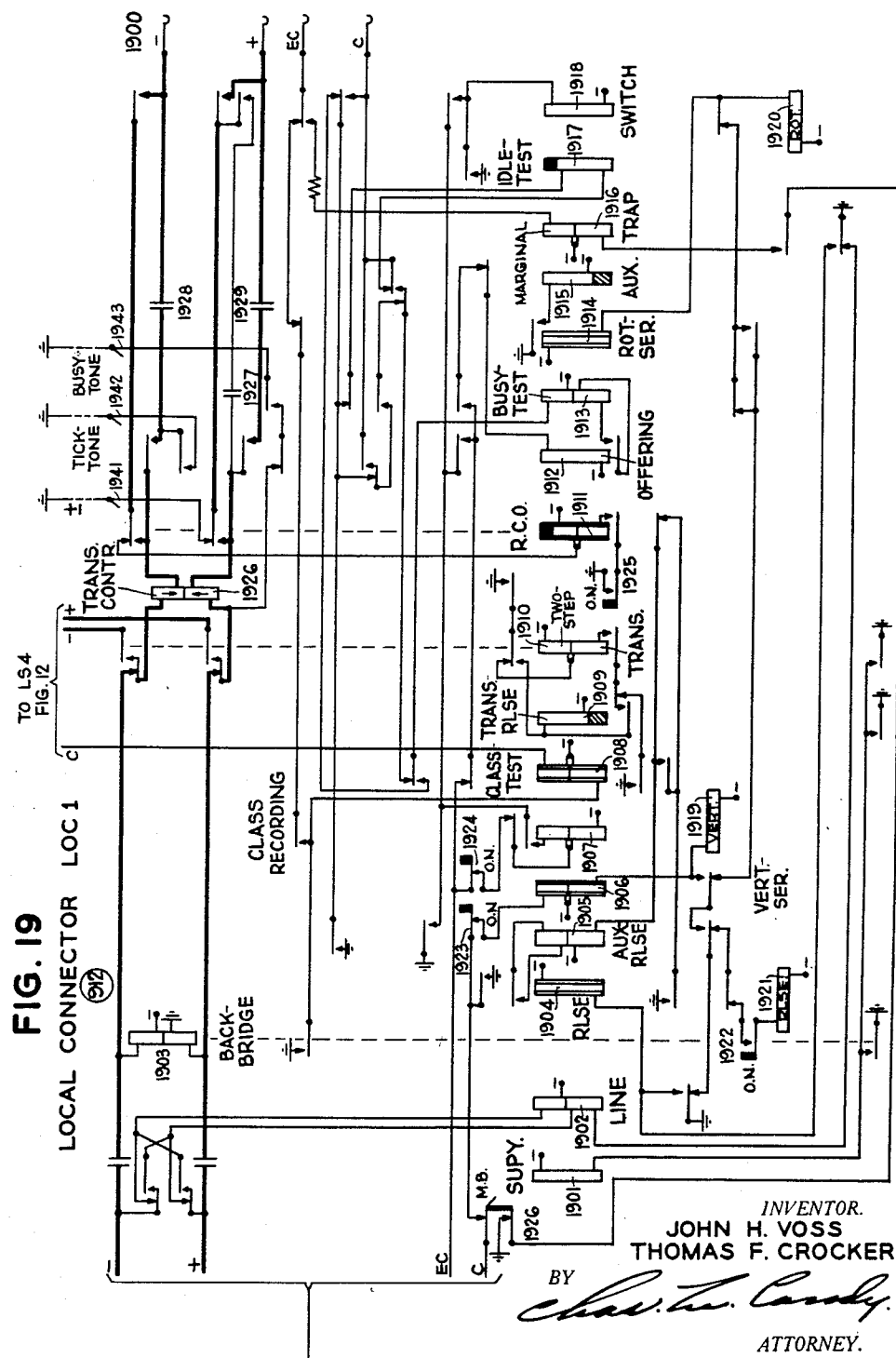
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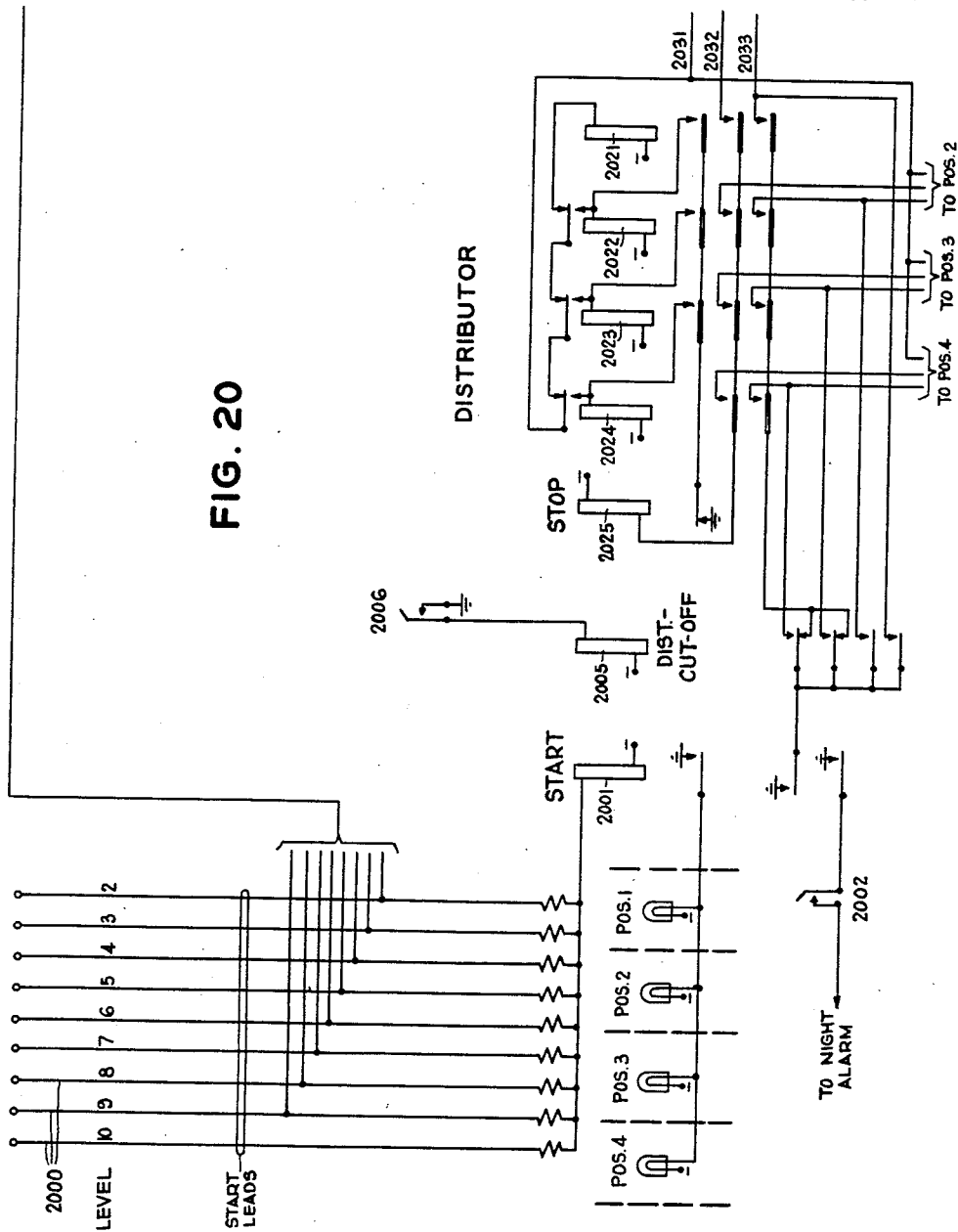
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INVENTOR.

JOHN H. VOSS
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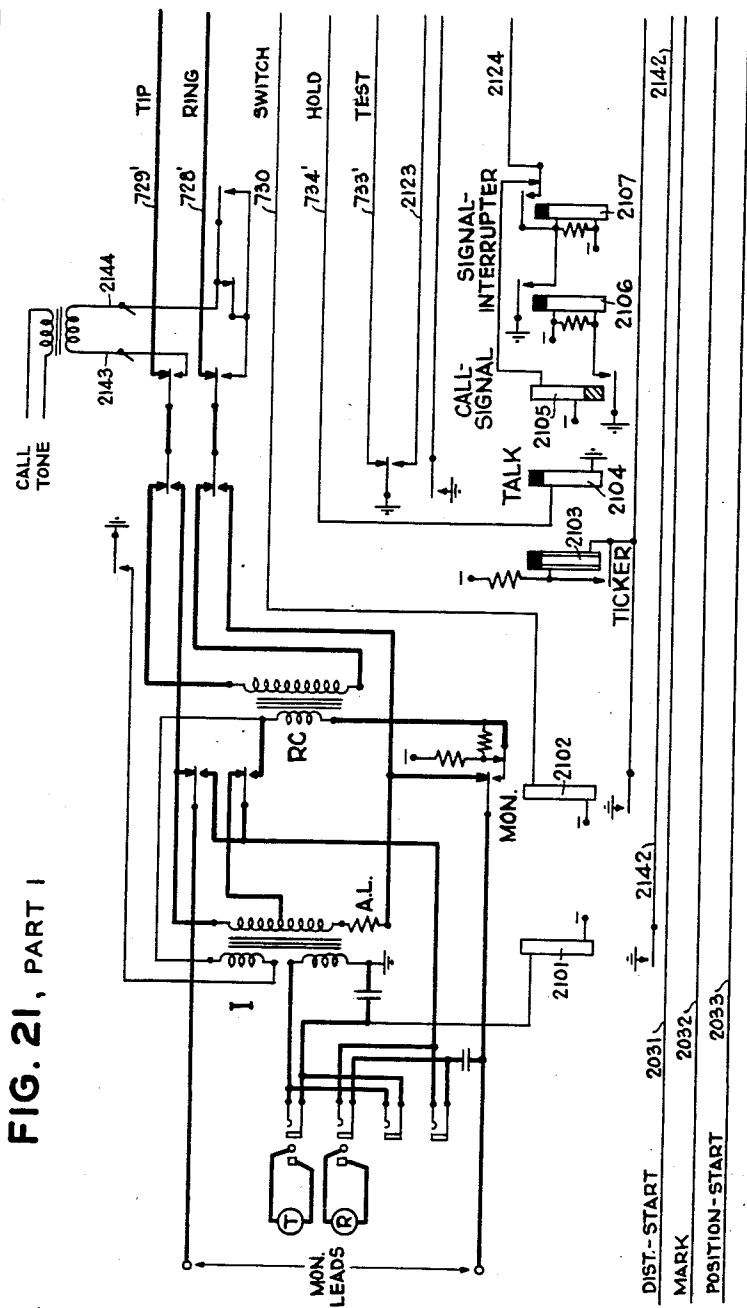
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FIG. 21, PART I



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Feb. 16, 1937.

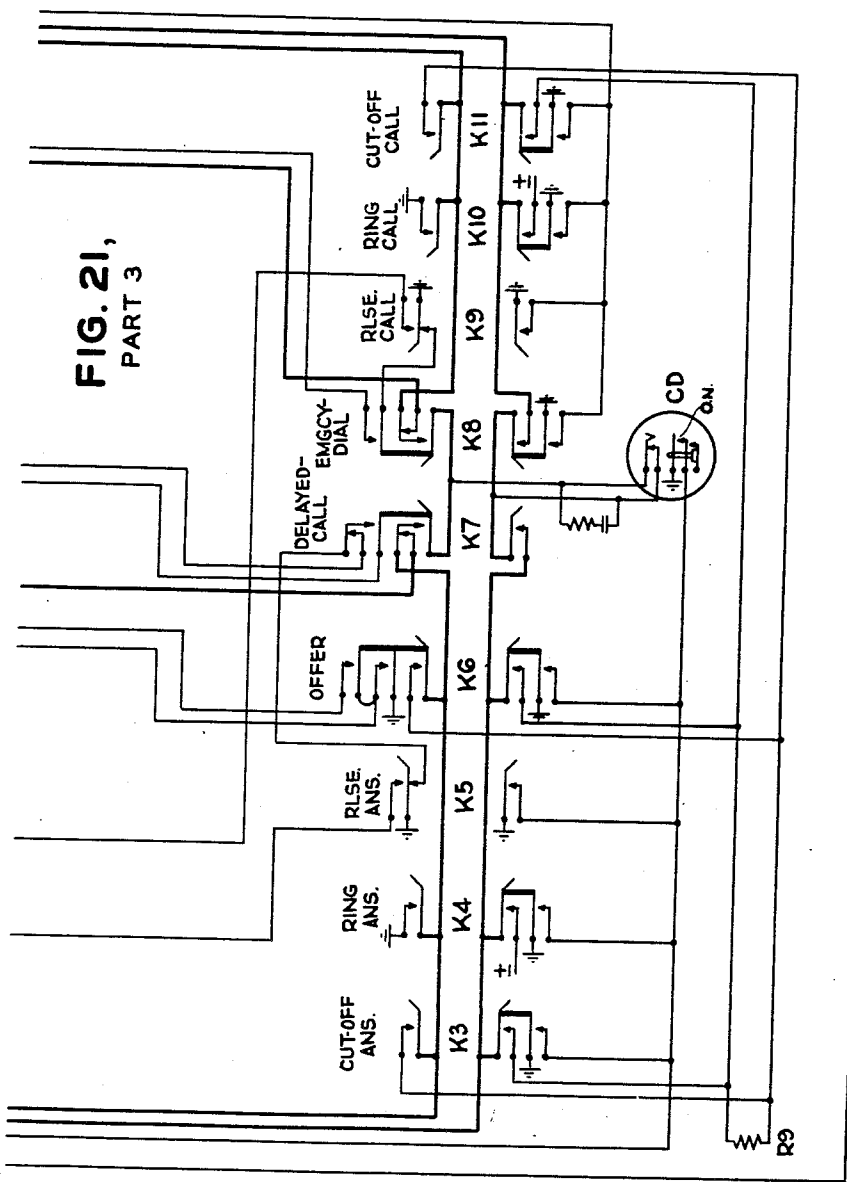
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INVENTOR.
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Feb. 16, 1937.

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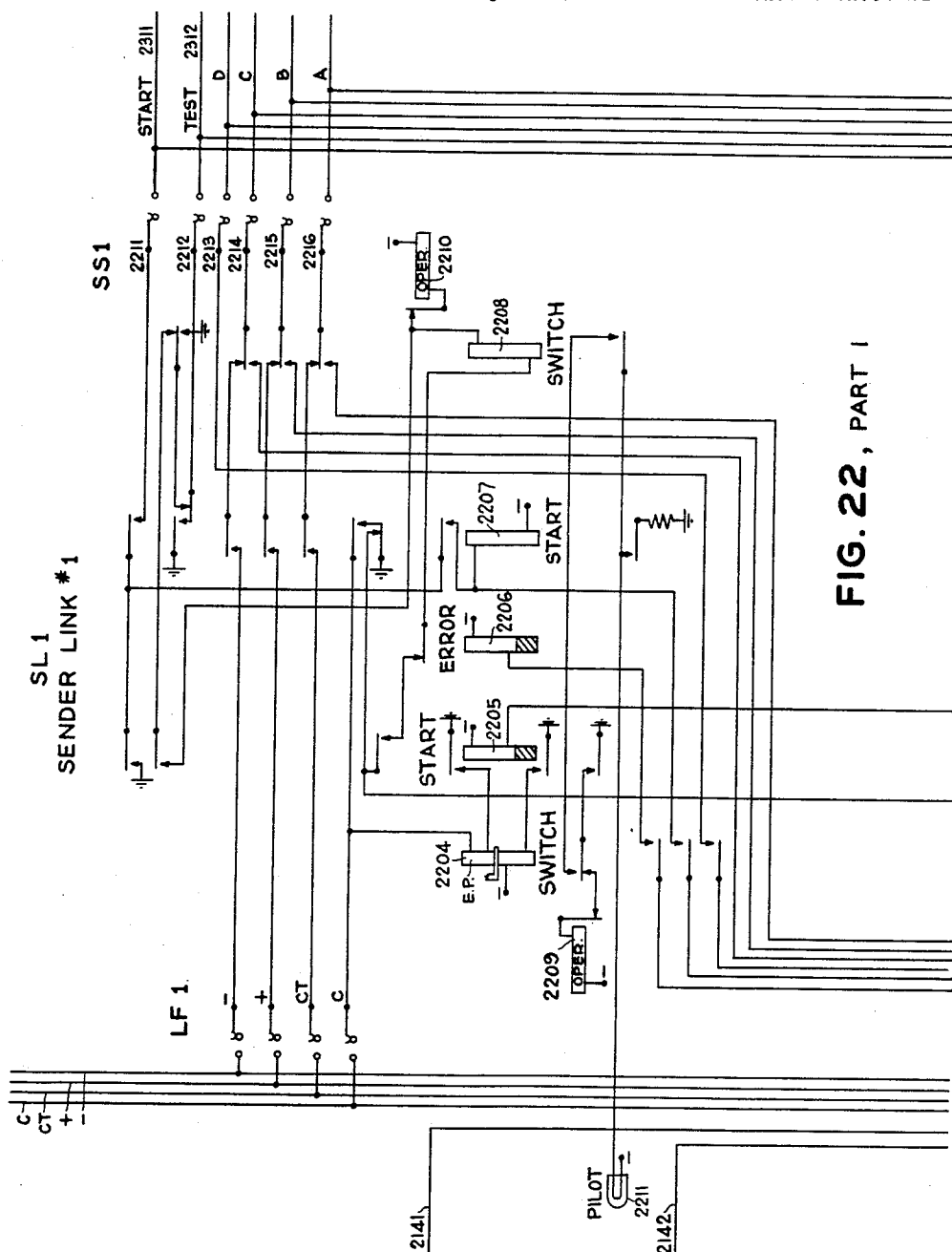


FIG. 22, PART I

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Feb. 16, 1937.

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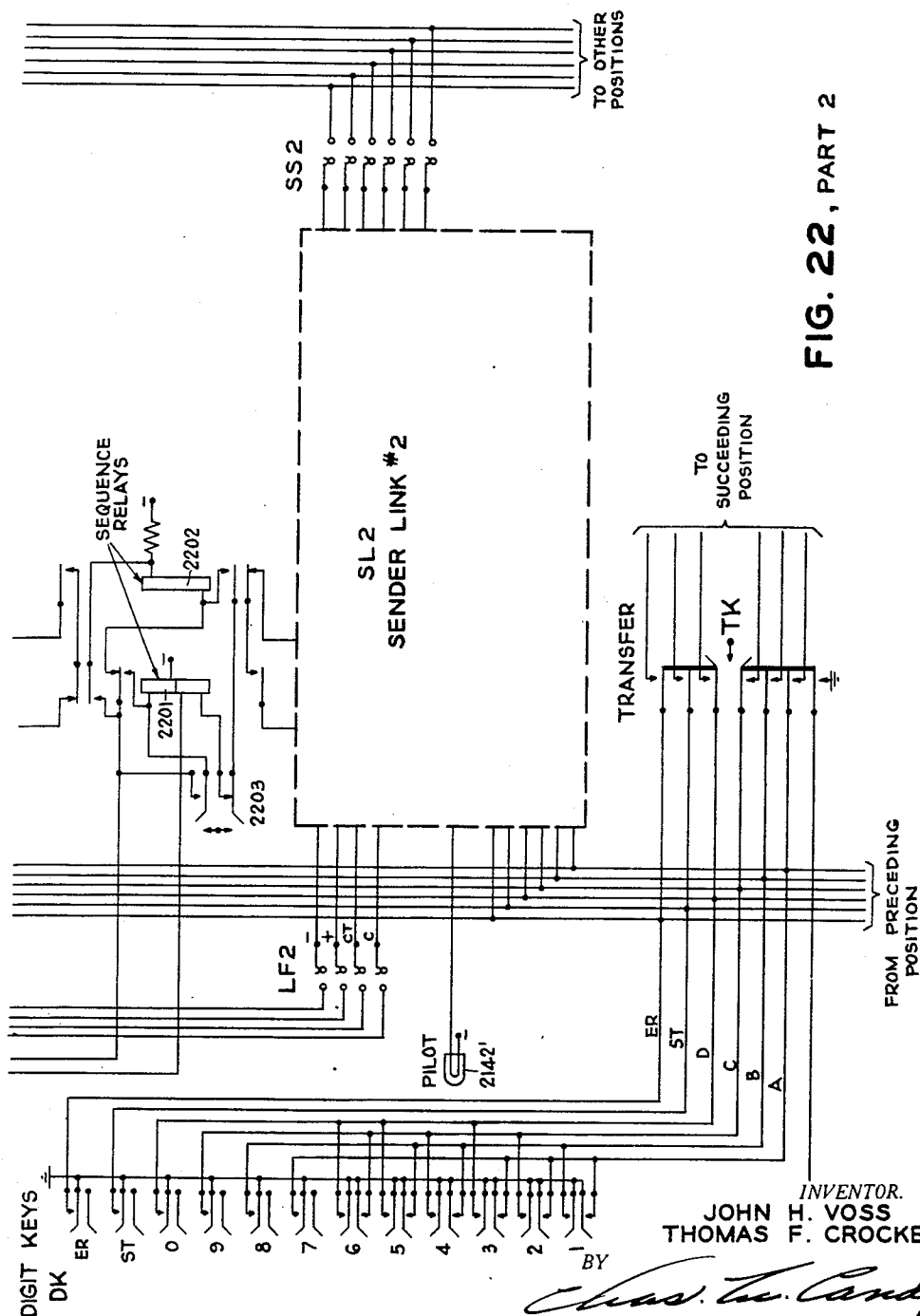


FIG. 22, PART 2

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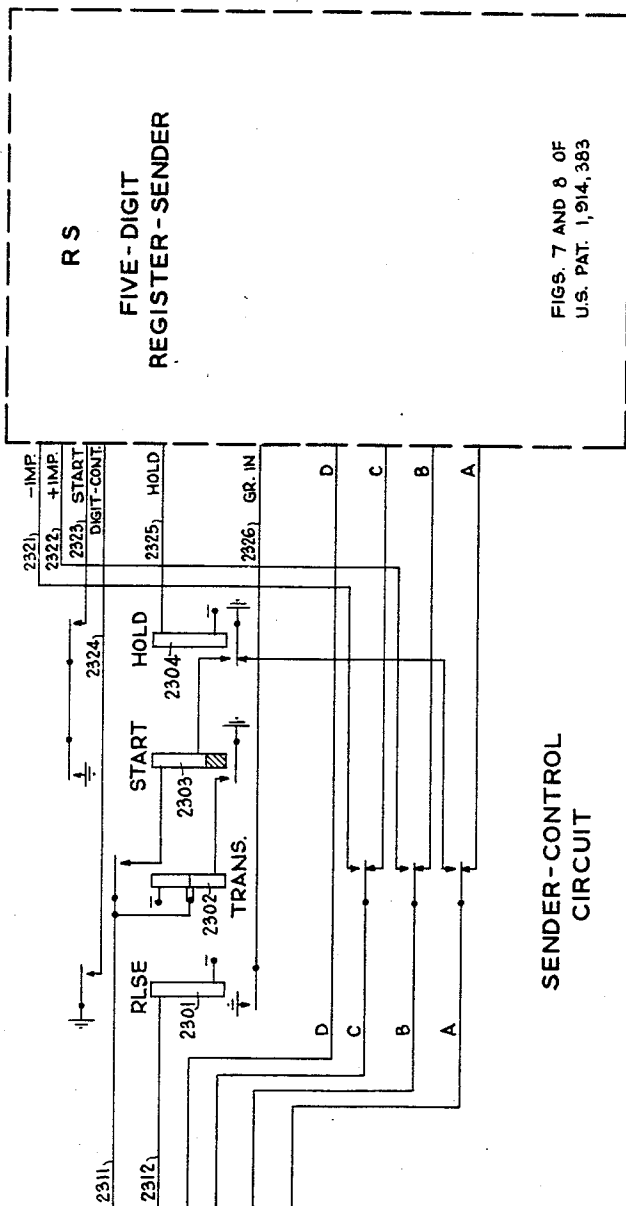


FIG. 23

SENDER-CONTROL
CIRCUIT

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Feb. 16, 1937.

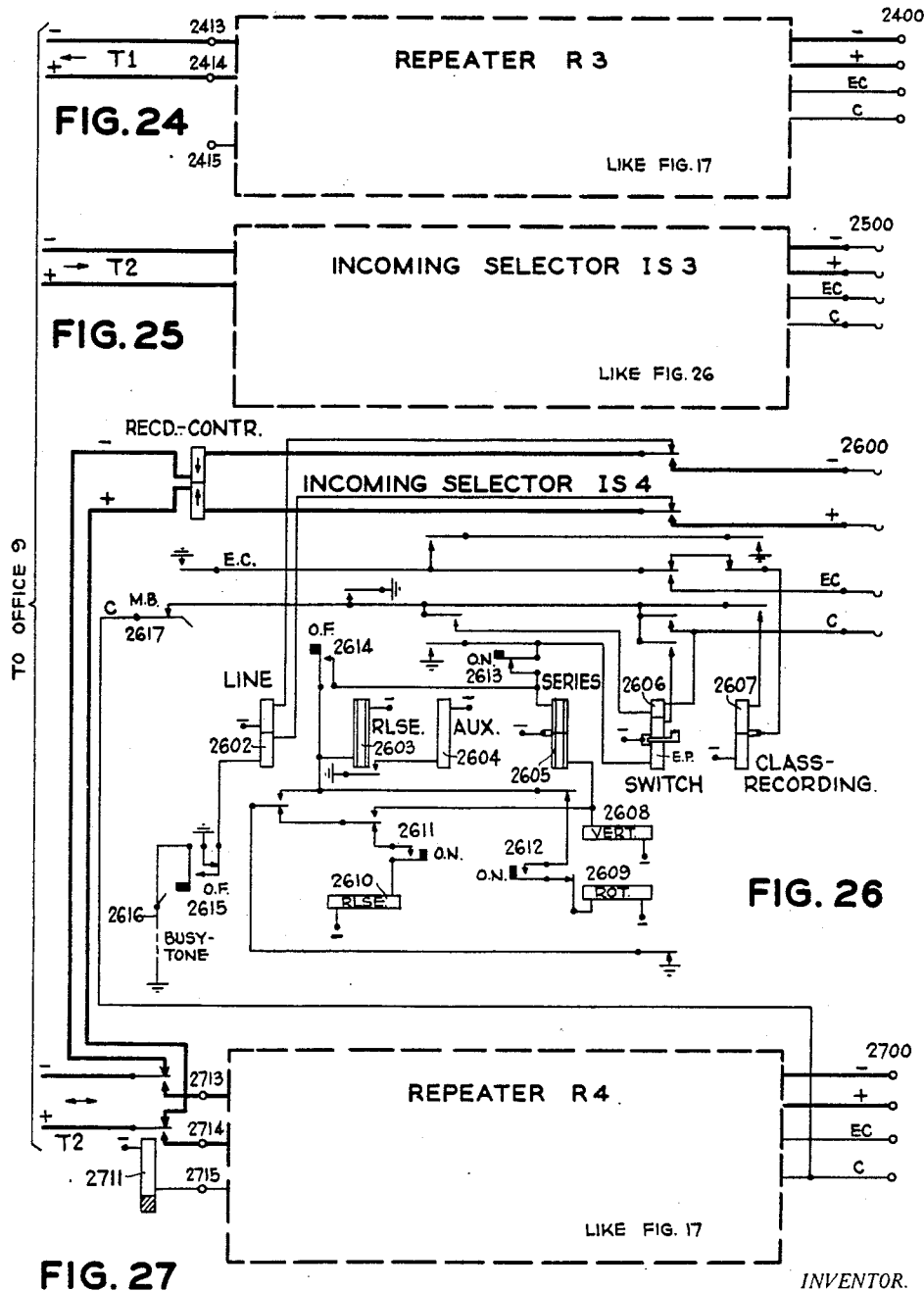
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INVENTOR.
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Feb. 16, 1937.

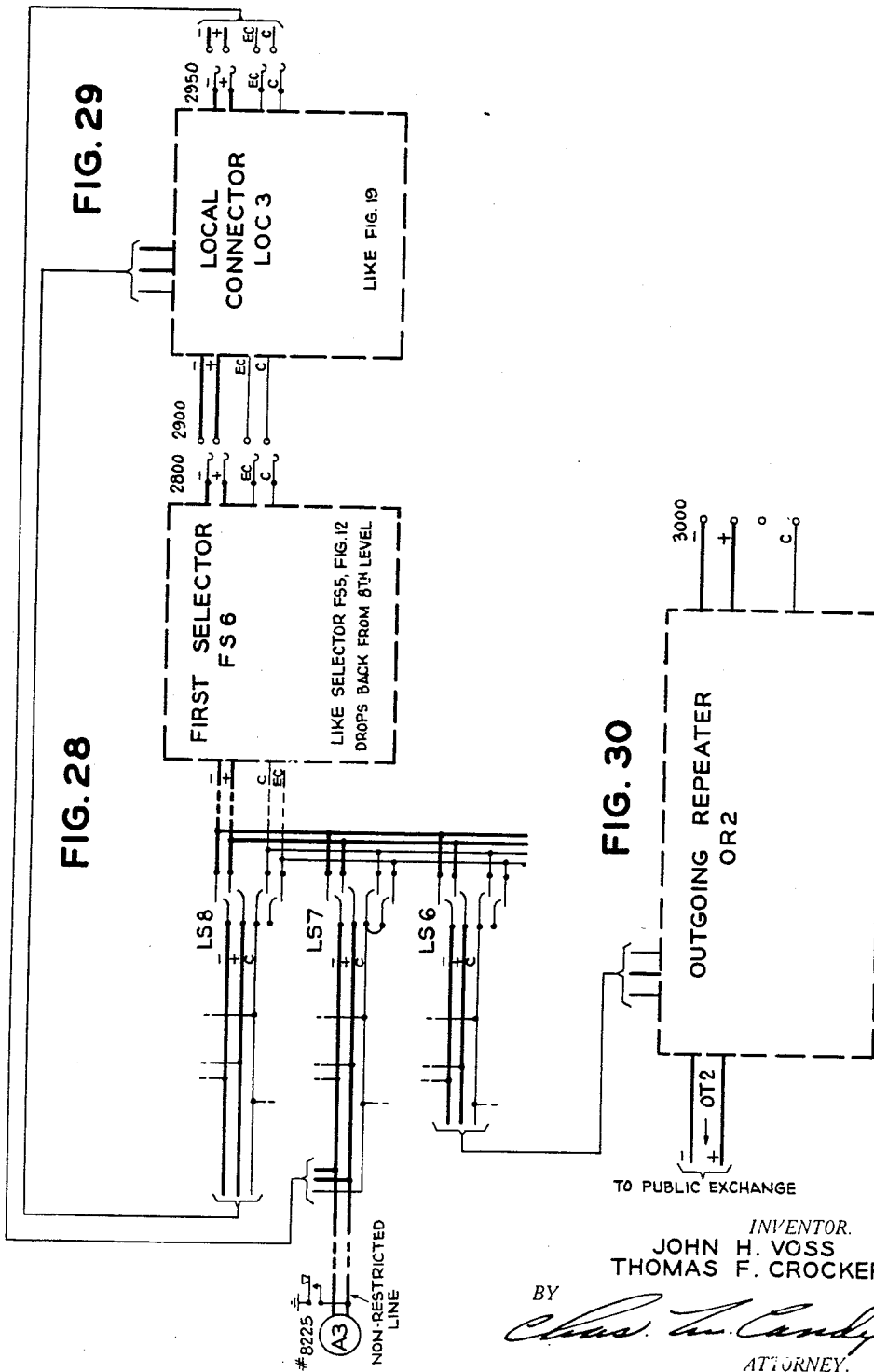
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INVENTOR.
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Feb. 16, 1937.

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FIG. 31

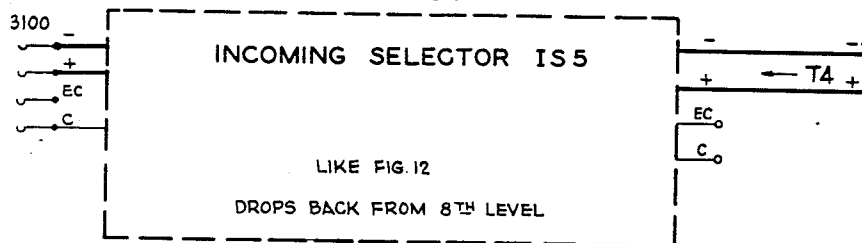


FIG. 32

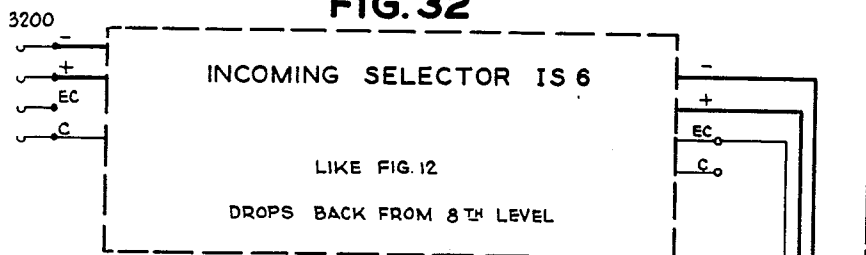


FIG. 33

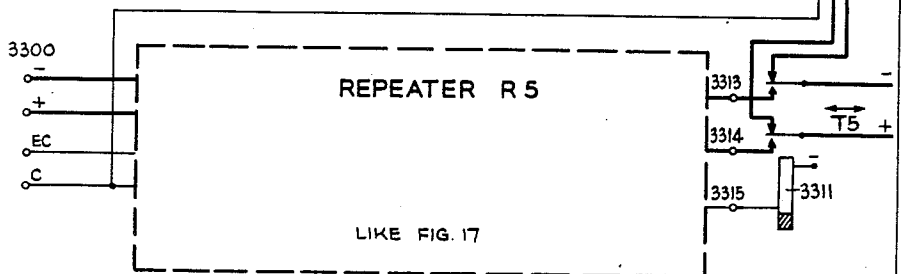
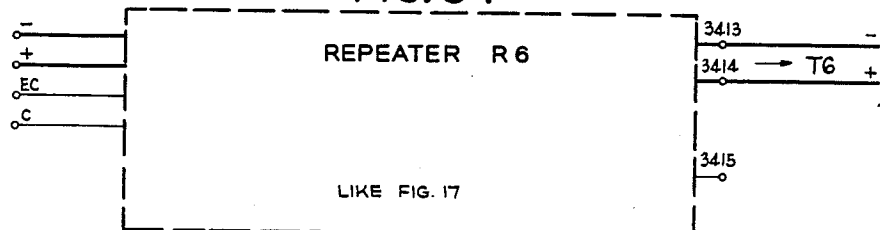


FIG. 34



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Feb. 16, 1937.

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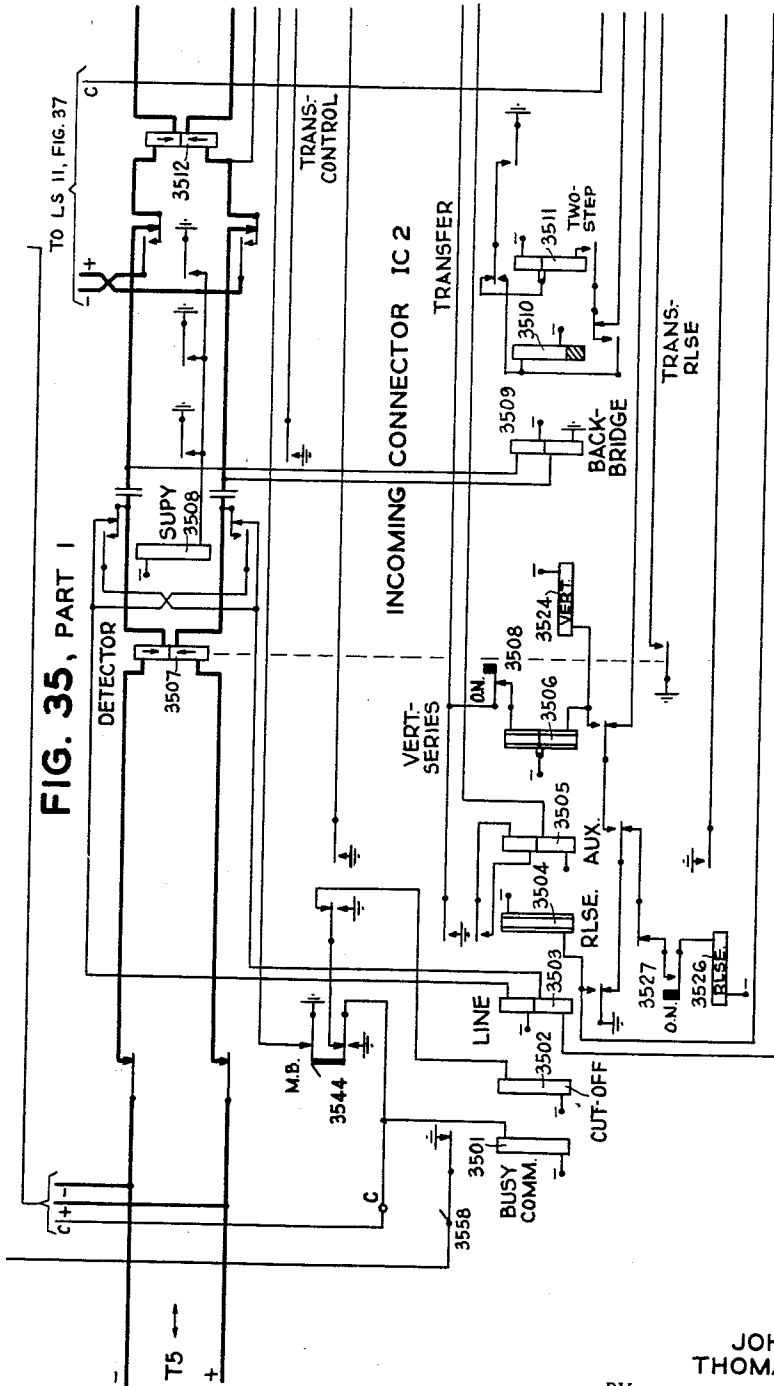


FIG. 35, PART I

FIG. 36, PART I

INCOMING CONNECTOR IC 1

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Feb. 16, 1937.

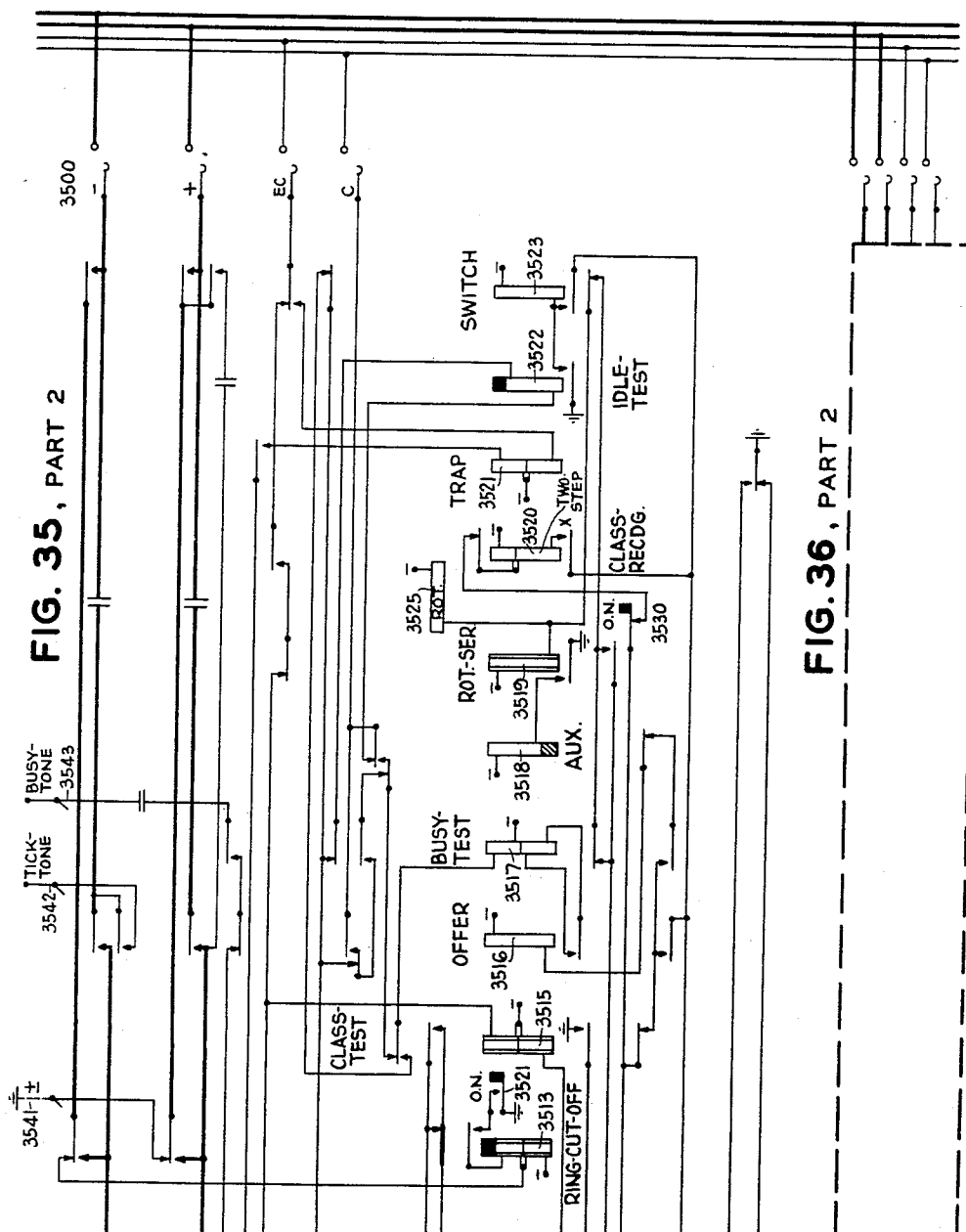
J. H. VOSS ET AL

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TELEPHONE SYSTEM

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Feb. 16, 1937.

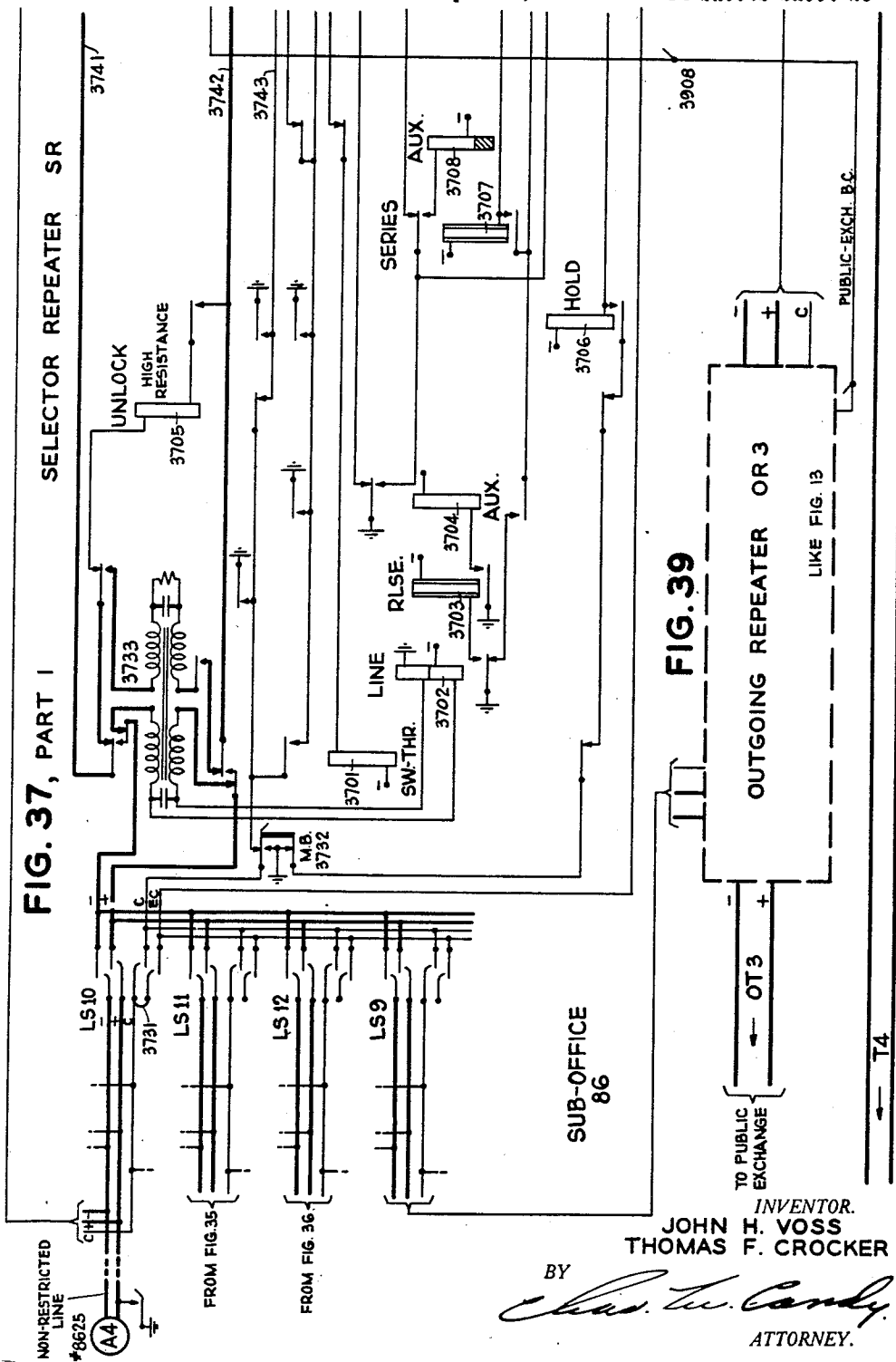
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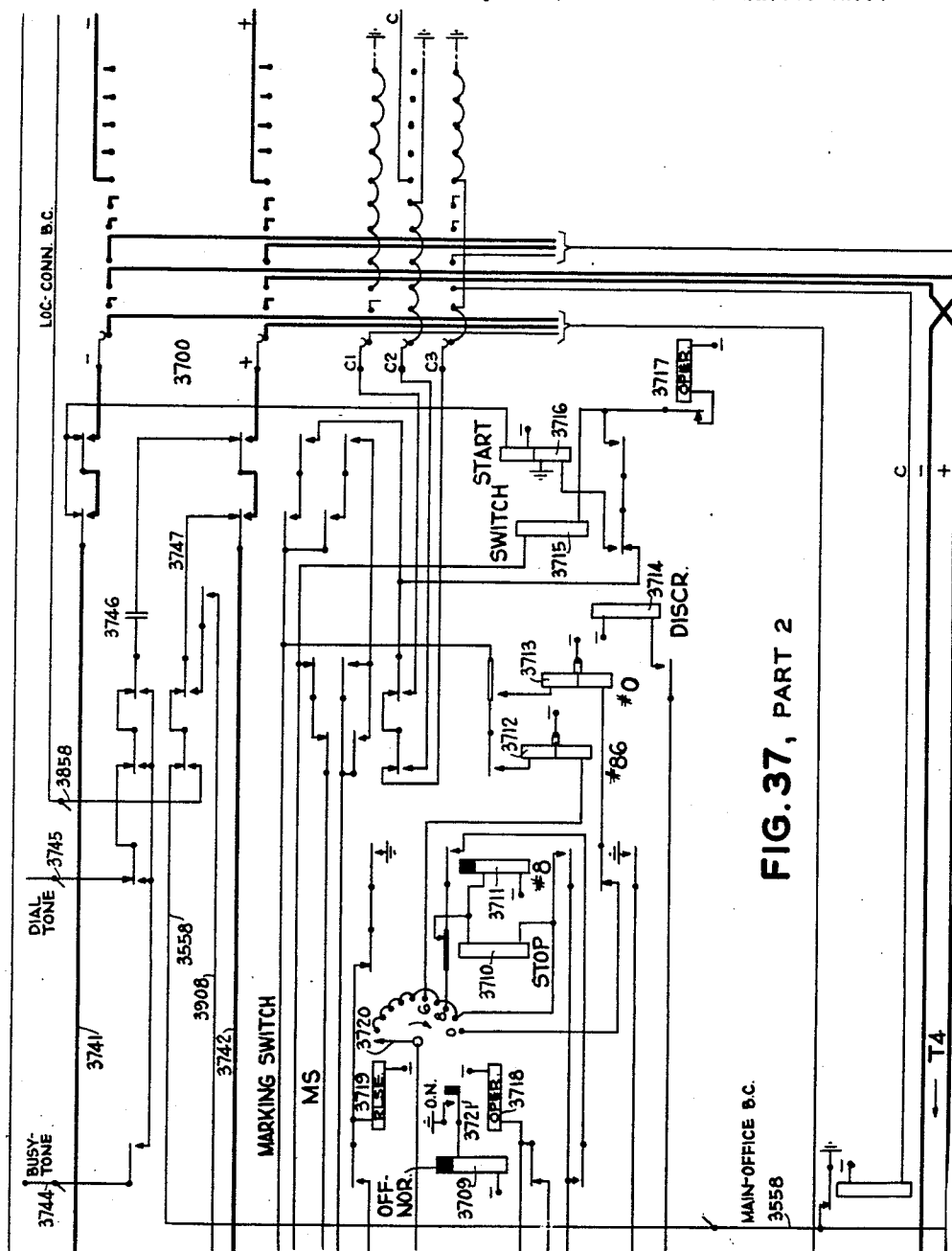
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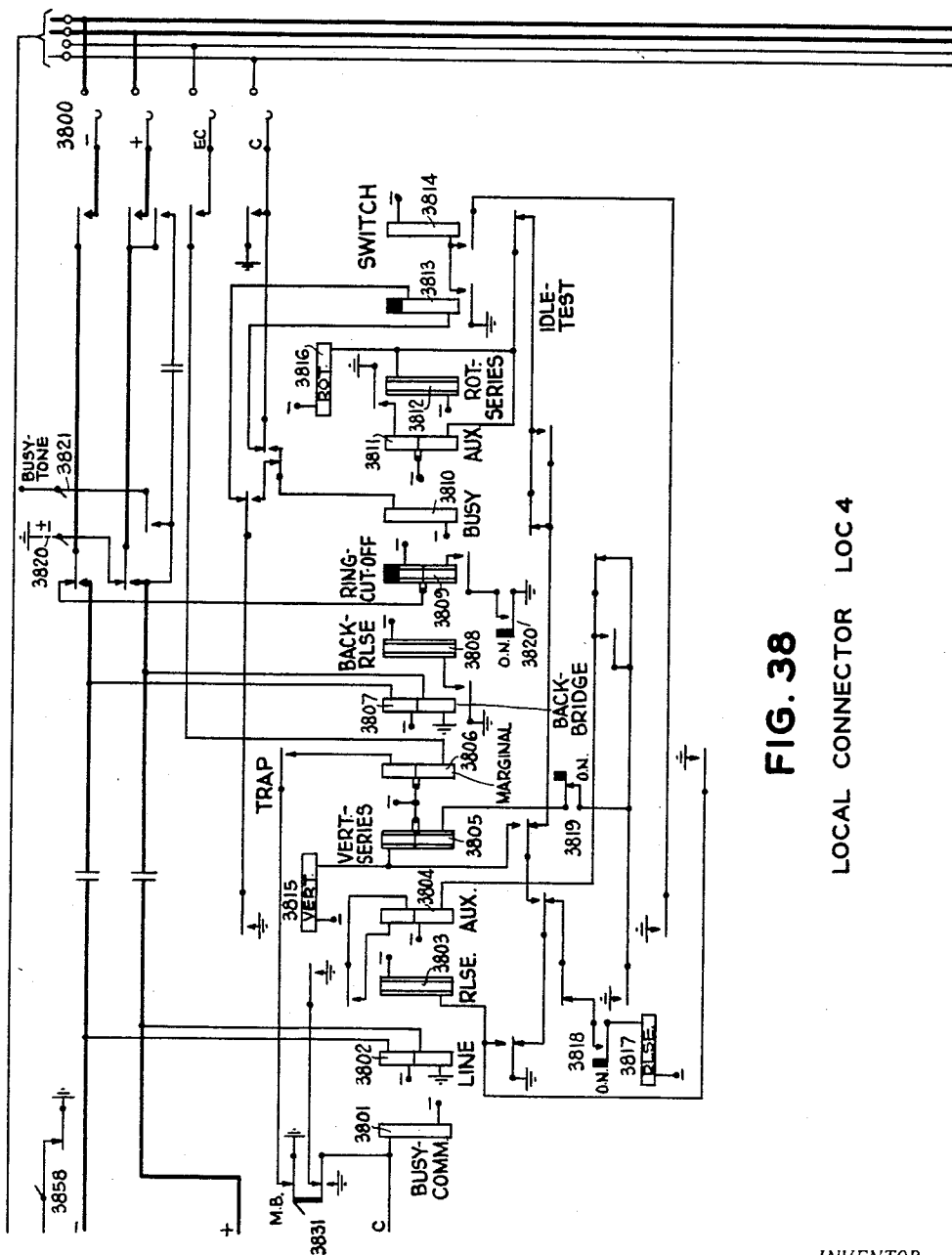


FIG. 38

LOCAL CONNECTOR LOC 4

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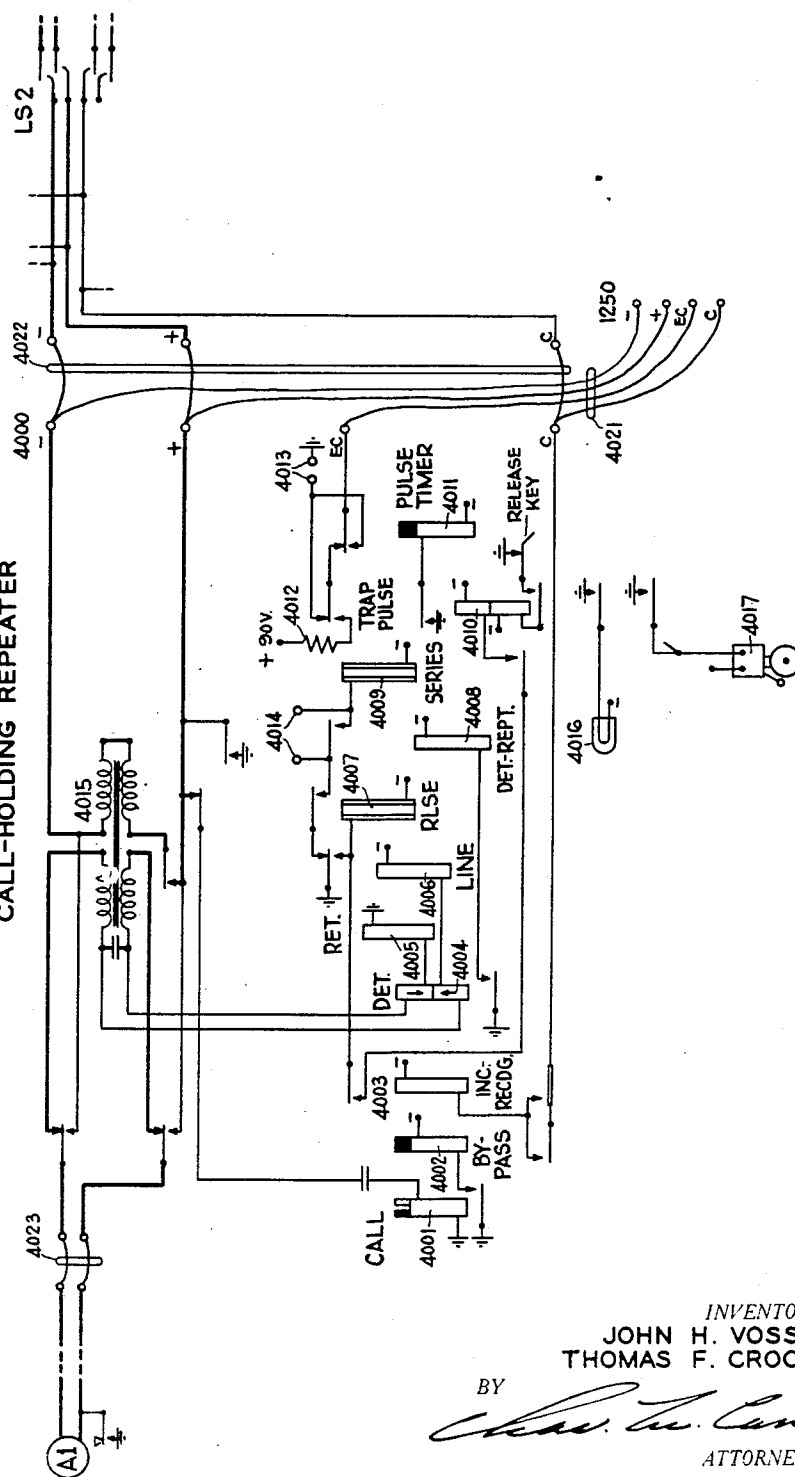
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FIG. 40

CALL-HOLDING REPEATER



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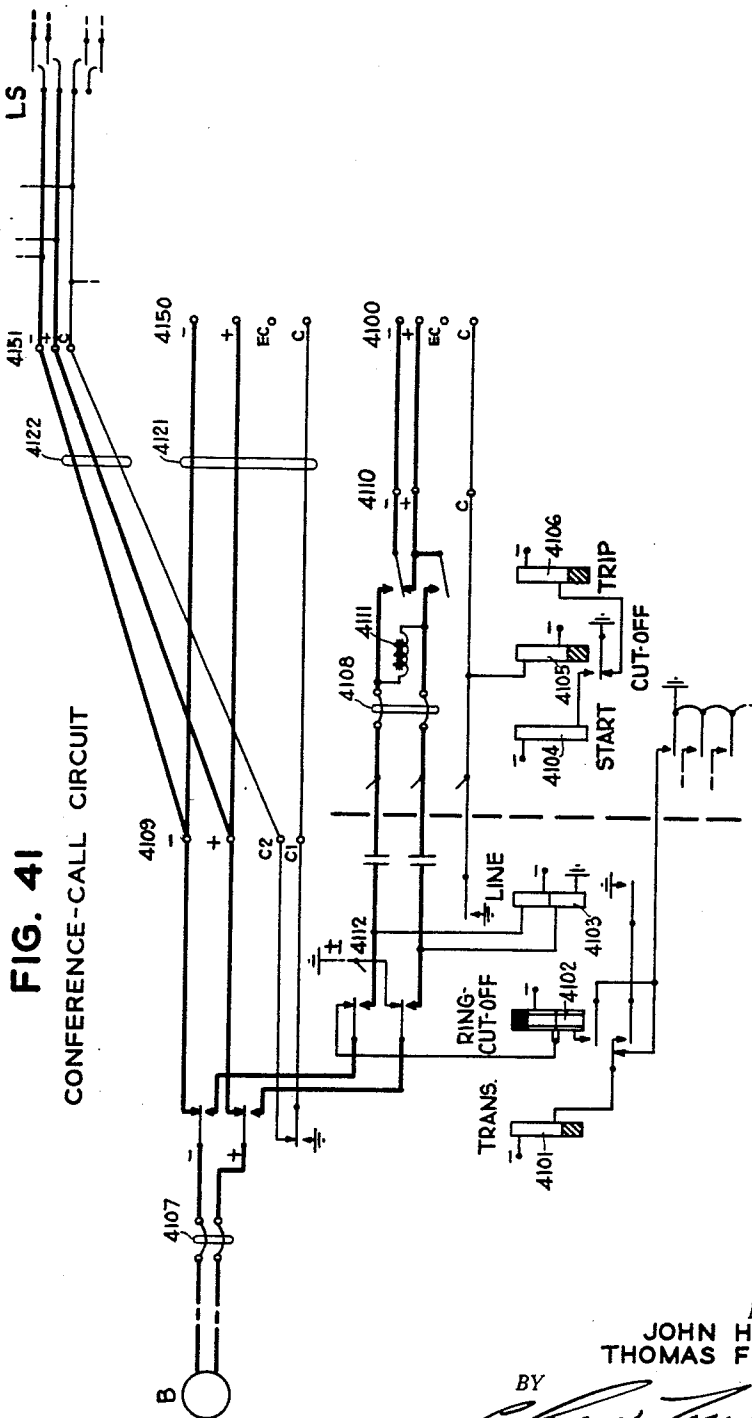
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TELEPHONE SYSTEM

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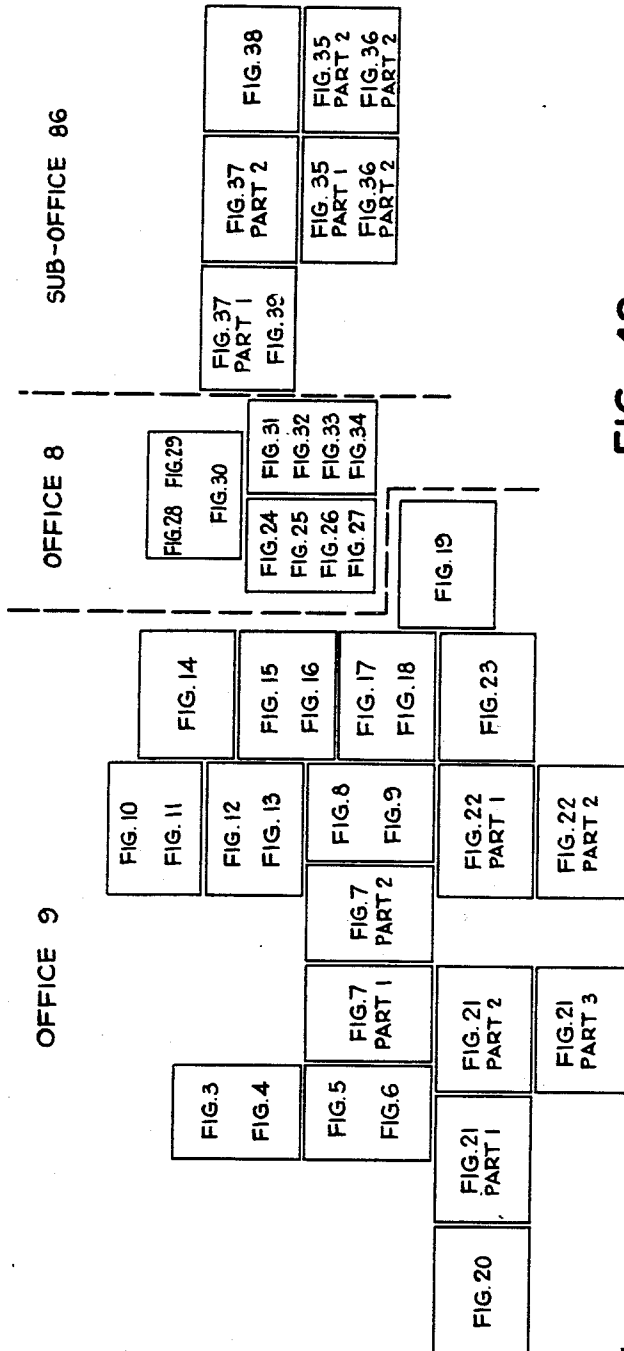
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TELEPHONE SYSTEM

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UNITED STATES PATENT OFFICE

2,070,874

TELEPHONE SYSTEM

John H. Voss, Downers Grove, and Thomas F. Crocker, Chicago, Ill., assignors to Associated Electric Laboratories, Inc., Chicago, Ill., a corporation of Delaware

Application September 16, 1935, Serial No. 40,686

66 Claims. (Cl. 179—27)

The present invention relates to telephone systems in general, but is concerned more particularly with telephone systems including a main exchange and a branch exchange.

- 5 The broad general object of the invention is the provision of new and improved circuit arrangements for use in a branch exchange to enable the several desired features of branch exchange service to be given more efficiently and satisfactorily.
- 10 An additional object may be stated to be the provision of new and improved circuit arrangements to enable satisfactory service to be given in a multi-office branch exchange.

General description

- 15 It has been chosen to illustrate the invention as applied in meeting the requirements of a specific installation wherein the branch exchange includes two offices and a sub-office interconnected with each other by trunk lines. The branch exchange is also interconnected with a public exchange by way of trunk lines outgoing from each of the branch offices to the public exchange and trunk lines incoming from the public exchange to the branch exchange, as is illustrated in Fig. 1 of the accompanying drawings, and is interconnected with other branch exchanges and with toll lines.

- 20 Of the forty-two figures of accompanying drawings, Fig. 1 is a map showing the public exchange and the relative locations of the offices of the branch exchange;

- 25 Fig. 2 is a trunking diagram showing the interrelation between the several circuits and groups of switching apparatus of the multi-office branch exchange.

Figs. 3 to 41 are circuit diagrams; and

- 30 Fig. 42 shows the way in which Figs. 3 to 39 should be arranged in order that they be understood best.

- 40 Referring now particularly to Fig. 1, the public exchange, shown above the branch exchange, may be a single-office exchange or a multi-office exchange, and it may be either a manual exchange or an automatic exchange. In the actual installation here being illustrated, however, the public exchange is a multi-office automatic exchange.

- 50 The branch exchange, it will be noted, contains offices 9 and 8, which may be referred to as main offices, and office 86, which is subsidiary to office 8.

- 55 In addition to the illustrated multi-office branch exchange, the system being described includes other branch exchanges located some dis-

tance away from the one illustrated and associated respectively with other public exchanges. The illustrated branch exchange is interconnected with these distant branch exchanges by means of two-way inter-branch-exchange lines, such as the one associated with the line-circuit LC4, Figs. 2 and 6.

The branch exchange also terminates two-way toll lines, extending to a distant toll office, one such toll line being shown associated with the line circuit LC3, Figs. 2 and 5.

Traffic between offices 9 and 8 passes over one-way and two-way trunk lines, of which the trunk lines T1 to T3 are shown, while traffic between office 8 and sub-office 86 also passes over one-way and two-way trunk lines, of which trunk lines T4 to T6 are shown. As will be pointed out subsequently, and as is disclosed elsewhere in the drawings, traffic between office 9 and sub-office 86 is handled by way of office 8, which is from this standpoint a tandem office.

Calls from the three offices of the branch exchange to the public exchange are handled over trunk lines passing directly from the respective branch exchanges to the public exchange. Of these trunk lines, outgoing trunk lines OT1, OT2, and OT3 are indicated in Fig. 1.

All calls incoming from the public exchange to the branch exchange are routed to the desired branch exchange line through automatic switching apparatus controlled from an operator's switchboard in office 9. For this reason, all of the trunk lines incoming from the public exchange to the branch exchange extend from the public exchange to office 9. This is indicated by the incoming trunk IT in Fig. 1.

It is to be noted that the capacity of the branch exchange as installed is approximately 1300 lines, as indicated in Fig. 1, and that office 9 terminates 900 of these lines, office 8 terminates 300, and sub-office 86 terminates 100.

Referring now particularly to Fig. 2, office 9 of the branch exchange is indicated as lying within the dotted rectangle shown in parts 1 and 2; office 8 of the branch exchange is indicated as lying within the rectangle shown in part 3; and sub-office 86 is indicated as lying within the rectangle shown in part 4; while the public exchange is indicated as lying above the dotted line extending across the four parts of Fig 2, near the top.

As is indicated by the number 18 associated therewith, the incoming trunk IT is one of a group of eighteen incoming trunks. Similarly, the outgoing trunk OT1 is one of eighteen trunks

outgoing from office 9 of the branch exchange to the public exchange, as is indicated by the number 18 associated therewith. In addition, outgoing trunks OT2 and OT3, offices 8 and 86 are representative, respectively of a group of ten outgoing trunks and a group of two outgoing trunks. It will be understood, of course, that in each instance the number of trunks chosen is the number calculated to handle the estimated traffic.

It will be noted further that the trunk T3 is one of twenty-six one-way trunks which handle traffic from office 9 to office 8; the trunk T1 is one of twelve one-way trunks which handle traffic from office 8 to office 9; and trunk T2 is one of six two-way trunks which handle traffic in the two directions interchangeably.

Between office 8 and sub-office 86, one-way trunk T6 handles traffic from office 8 to office 86; the one-way trunk T4 handles traffic from office 86 to office 8; and the three two-way trunks represented by the illustrated trunk T5 handle traffic in the two directions interchangeably.

Of the 1300 branch-exchange lines, those of sub-stations A1 to A4 are indicated in Fig. 2, their respective numbers being 91225, 9225, 8225, and 8625. Each of the subscriber lines extends to a line switch of the well known plunger type (commonly referred to as a Keith line switch). The line switches LS2 and LS3, for example, are assigned to the lines of substation A1 and A2 in office 9.

Office 9

The primary line switches in office 9 have access to first selectors by way of secondary rotary line switches, of which the secondary line switch SLS is shown.

One of the first selectors accessible to the secondary line switch SLS is the first selector FS5. This selector, in common with the other selectors, finders, and connectors, is of the well-known Strowger type of two-motion switch having the bank contacts arranged in horizontal rows or levels.

It is to be noted that the selector FS5 is indicated by a small rectangle having ten short heavy lines located thereunder. These lines are indicative of the ten levels, respectively, of the contact bank of this switch. The selector FS5 is representative of the several selectors which are accessible to subscriber lines by way of primary and secondary line switches.

For the purpose of making possible a universal numbering system for the branch exchange numbers (so that the number of each branch-exchange line is the same regardless of from what office it is called), the first selector FS4 is arranged to absorb or cancel the first digit dialled when such first digit is the digit 9. This fact is indicated by the digit 9 placed within the rectangle indicating the first selector FS5. The same arrangement is indicated in each of the selectors DCS and FS1 to FS4, while the digit 9 placed within each of the rectangles indicating the incoming selectors IS1 and IS2 indicates that these selectors are seized from the ninth level of the preceding selectors (in office 8).

Of the ten levels of the first selector FS5, the first six levels are used for directing traffic to subscriber lines of the local office 9; the seventh level is used for extending calls to the operator's switchboard when the number 97 is dialled; the eighth level is employed in directing calls to office 8; the ninth level, following the absorbing of the first digit 9 is used when the second digit dialled

is 9 to direct calls to distant branch exchanges by way of branch-exchange connectors such as BC; and the tenth level is employed when the digit 0 is dialled to extend calls to the public exchange by way of outgoing trunk lines such as OT1.

Of the six levels of the first selector FS5 assigned to the completion of calls to local subscriber lines, levels 2 to 6 are assigned to connector groups 92 to 96. Of these connector groups, connector group 92 is indicated by local connector LOC 2, which is one of approximately ten connectors of the group.

With 500 of the 900 lines of the office provided for by levels 2 to 6 of the selector FS5, the remaining 400 lines must be reached by way of the first level of selector FS5. For the purpose of expanding the first level of the first selectors to permit four hundred-line groups to be reached, a group of second selectors, indicated by the second selectors SES, is reached when the digits 9 and 1 are dialled (the digit 9 being absorbed). These second selectors have access by way of their levels 2 to 5 to groups 912 to 915. The connectors in group 912 are indicated by the local connector LOC 1. The necessary introduction of the second selectors such as SES necessitates that four of the hundred-line groups of subscriber lines have five-digit numbers, while five of the hundred-line groups of subscriber lines have four-digit numbers, the numbers of the two lines being exemplified by the numbers assigned to sub-stations A1 and A2 (No. 91225 and No. 9225).

The four-position manual switchboard indicated at Fig. 2, part 1, is provided primarily for the handling of calls incoming from the public exchange over the eighteen incoming trunks exemplified by the trunk IT. The operator's switchboard and associated automatic equipment are generally similar to the corresponding equipment of the commercially known Strowger dial toll board. One embodiment of the Strowger dial toll board is shown in the United States application of Thomas F. Crocker, 755,263, November 30, 1934. An outstanding feature of this type of switchboard system is that the operator is provided with links terminating in automatic switches instead of with cords terminating in manual-switchboard plugs. This is indicated in Fig. 2, wherein the finder F1, linked with the first selector FS1, represents one of the links at position 1, of which there are 9. The finders FS2, FS3, and FS4, linked with first selector FS2, FS3, and FS4, represent links at positions 2, 3, and 4, there being in the illustrated system nine such links for each operator's position. The arrangement is such that when an operator is in position to accept a call and has the talking key of the link operated the finder of such link is in readiness to find a calling line, which may be subsequently extended by the associated first selector.

In addition, the individual links are simplified as much as possible at the expense of position equipment common to the nine links of a position.

The inter-branch-exchange lines, of which there are assumed to be twenty-five, are indicated by the single two-way line shown terminating in the link circuit LC4, one line circuit for each of the twenty-five inter-branch-exchange (I. B. X.) lines. The I. B. X. lines are accessible to the finders, such as F1 to F4, by way of the second, third, and fourth levels thereof.

The fifth level of the finders accommodates

the toll lines, of which there are nine. Each toll line terminates in a line circuit such as LC3, through which it is reached by the finders.

The eighteen trunks incoming from the public exchange are accommodated through the sixth and seventh levels of the finders, there being a line circuit such as LC2 interposed between each incoming trunk and the banks of the finder.

The eighth level of the finders accommodates the selector trunks incoming from the seventh level of the first selectors by way of individual circuits such as LC1, while the ninth and tenth levels of the finders are at present unused.

In addition to the foregoing, it will be observed that trunks from the first level of the finders extend to delayed-call selectors of which the delayed-call selector DCS is one. The purpose of this arrangement will be brought out subsequently.

For the purpose of enabling the operators at the four indicating 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 register senders and for associating them with links over which their impulses are to be delivered, each operator is provided with two sender links, of which the sender links SL1 and SL2 for position 1 are shown. The digit keys at the operator's position may be connected interchangeably to either of these two links, the choice of sender links being automatic, as will subsequently appear.

Sender link 1 has link-finder LF1 associated therewith, which finder has access to the nine links of position 1. The sender selector SSL, associated with link SL1 has access to the register sender RS and to the other register senders, all of which are provided for the common use of all the operators. The sender link SL2 is similarly provided with link finder LF2 and sender selector SS2.

Generally, all of the selectors in exchange 9 (with the exception of the second selectors, such as SES) have their levels of bank contacts assigned in the same way as the subscriber first selectors, exemplified by the hereinbefore discussed first selector FS5. There are certain variations, however, which will now be pointed out. All of the first selectors and incoming selectors have their first six levels of bank contacts connected similarly for the handling of calls to the local subscriber lines. The seventh level is unused at the operator first selectors FSL to FS4, and at the delayed-call selector DCS. This is for the reason that the seventh level provides access to the operator's switchboard, and there is no occasion to put up a call to the switchboard over the selectors just mentioned as these selectors themselves are reached only from the operator's switchboard.

The eighth level is unused at the incoming selectors IS1, IS2, as this level accommodates the trunks outgoing to office 8, while selectors IS1 and IS2 are incoming selectors accessible only from office 8.

As to the ninth level, the subscriber selectors FS5, IS1, and IS2 have access to connectors in group 99, exemplified by the branch-exchange connector BC, while the operator selectors DCS and FS1—FS4 have access by way of the ninth level to toll connectors (such as TC) of group 99. By this arrangement, when the number 99 is dialled from a subscriber line a connector such as BC is taken for use, while if the number 99 is called from the operator's switchboard a toll

connector such as TC is taken for use, as the ninth level multiple is divided into two parts, one for each of the two classes of selectors. One reason for this arrangement is that the toll connector TC is especially designed to cooperate with circuit arrangements used in a call set up by way of the operator's switchboard, while the connector TD is particularly suitable for use in handling a call from a subscriber. In addition, the toll lines, such as the one associated with the line circuit LC3, are accessible only from the toll connectors TC. This arrangement is made for the purpose of necessitating that a subscriber desiring to extend a call over one of these toll lines do so by getting into communication with the branch exchange operator (by dialling the number 97).

Regarding the tenth level of the selectors, selectors FS1—FS4 may not use this level because it is required that the operator be unable to extend an incoming toll call or an incoming call from a distant branch-exchange to the public exchange; distant branch-exchange subscribers are required to call their local public exchanges. Selectors IS1 and IS2 do not use the tenth level because they are selectors incoming from office 8 whereat outgoing trunk lines are provided extending directly to the public exchange. The delayed-call selectors such as DCS, however, have access through the tenth level to outgoing trunks such as OT1 to the public exchange. This provision is made to enable an operator to set up a delayed-call or tail-to-tail connection between a public-exchange line and a branch-exchange line when requested to do so.

Arrangements have been provided so that a branch-exchange subscriber may obtain local transfer service when he is conversing with a public exchange subscriber. In the event that the call is an incoming call, the branch exchange subscriber obtains transfer service by way of the connector, but if the call is an outgoing call the branch-exchange subscriber obtains transfer service by way of the outgoing repeater. For example, local connectors LOC1 and LOC2 in office 9 are provided with line switches LS4 and LS5, respectively, which have access through secondary line-switches to first selectors such as FS5, while the lineswitch LS1 is similarly associated with the outgoing repeater OR1. Through the transfer lineswitches, temporary connections may be set up to other branch-exchange lines, while the public exchange connection is held, as will be explained in detail hereinafter. A similar transfer service in a single-office private exchange, wherein it is unnecessary to equip the connectors with transfer line-switches, is disclosed in the United States patent application of John H. Voss, 29,863, July 5, 1935.

It is to be noted that trunk T3, outgoing from office 9 to office 8, is accessible by way of the eighth level of the selectors through the repeater R2, while the two-way trunk T2 extending between offices 8 and 9 normally extends by way of the repeater R1 to the incoming selector IS2, but may be seized by way of the eighth level of the selectors through the repeater R1. Since each two-way trunk is provided with double equipment and is therefore more expensive than a one-way trunk, the usual graded-multiple arrangement is employed to insure that a two-way trunk is taken for use only after all of the available one-way trunks have been tested and found to be in use. In this way, a two-way trunk may be treated as an overflow trunk and

made common to a larger number of selectors than is a one-way trunk, as is well known.

Office 8

Referring now particularly to office 8, part 3 of Fig. 2, the incoming selectors IS3 and IS4 are associated with the trunks T3 and T2, respectively, while incoming selectors IS5 and IS6 are similarly associated with trunks T4 and T5, respectively, to handle traffic incoming to office 8 from sub-office 86. The first selector FS6, like the first selector FS5 of office 9, handles traffic originating on the lines of local subscribers. The subscriber at substation A3, for example (No. 8265), obtains connection with the first selector FS6 by way of his line-switch LS7, which lineswitch also has access to other similar first selectors.

The three 100-line groups of subscriber lines are accessible from levels 2, 3, and 4 of the selectors, connector LOC3 being representative of the connectors in group A2, accessible from the second level of the selectors. The first selector FS6, similar to the first selector FS5 of office 9, is arranged and equipped to restore to normal and thereby absorb the first digit dialled when the first digit is the one indexing the local office. This is indicated at the selector FS6 by the digit 8 placed within the rectangle indicating the mechanism of the selector. The digit 8 is also placed within the rectangles representing the incoming selectors IS3 and IS4 to indicate that these selectors are seized responsive to the dialling of the digit 8 in the office from which they are accessible.

The line switches LS6 and LS8, associated with the outgoing repeater OR2 and the local connector LOC3, respectively, are transfer lineswitches, provided for the purpose discussed in connection with lineswitches LSL, LS4, and LS5 of office 9.

The incoming selectors LS5 and IS6, which are associated with trunks T4 and T5 to handle calls incoming to office 8 from sub-office 86, are similar to the first selector FS6; they likewise are arranged to absorb the first digit dialled when such digit is the digit 8, indexing office 8. This arrangement comes about because an incoming selector in office 8 is taken for use automatically responsive to the removal of the receiver in sub-office 86, therefore responding to the first digit dialled.

The trunks, represented by one-way trunk T6 and two-way trunk T5, which handle traffic from office 8 to sub-office 86, are accessible from the sixth level of the incoming selectors IS3 and IS4 and of the first selector IS6, but the sixth level of the incoming selectors IS5 and IS6 is not used because arrangements are provided in the sub-office 86 to permit the subscribers therein to complete local calls independent of the inter-office trunks.

The eighth level of the selectors in office 8 is at present unused, but the ninth level of these selectors provides access to trunks outgoing to office 9, such as the one-way trunk T1 and the two-way trunk T2, by way of repeaters such as R3 and R4. The ninth level of the incoming selectors IS3 and IS4 is unused, as these are incoming selectors handling traffic from office 9.

The tenth level of the local first selectors, such as FS6, gives access by way of outgoing repeaters, such as OR2, to outgoing trunks, such as OT2, to the public exchange, but the tenth level of the incoming selectors is unused, as each office has its own direct trunks to the public exchange.

Sub-office 86

In sub-office 86, the subscriber lines have access by way of line switches to selector repeaters. For example, the line of substation A4 (No. 8625) has access by way of the individual line switch LS10 to selector repeaters, of which the selector repeater SR is one. The switching mechanism of this selector repeater is the same as that ordinarily employed as a rotary line switch, and it has access to trunks as indicated. Normally, when the selector repeater SR is taken for use the switching mechanism rotates until it comes into engagement with a trunk, such as T4 or T5, extending to the parent office, whereby an incoming selector such as IS5 or IS6 in office 8 is taken for use upon the removal of the receiver in the sub-office.

The arrangement is such that if the call is one to be routed through office 8 to a line therein or to office 9, the switching mechanism of the selector repeater SR operates no further, and the call is put through as the number is dialled, the selector repeater SR acting merely as an impulse repeater.

The marking switch MS is provided to direct the switching mechanism of the selector repeater in the event that the call is to be completed locally in the sub-office or to the public exchange. For example, if the first digit dialled is the digit 8 the marking switch MS restores and prepares to cause a further action of the switch mechanism of the selector repeater SR in the event that the digit 8 is followed by the digit 6. In such case, the five positions in the bank of the switching mechanism associated with local connectors such as LOC4 are marked, and the switch rotates to and connects with the first idle one of the local connectors, which connector then responds to the final two digits in the number to complete the connection.

On the other hand, if the first digit dialled is the digit 0 the switching mechanism of the selector repeater SR is caused to rotate to and seize the first idle one of the two outgoing trunks to the public exchange, such as the outgoing trunk OT3, associated with the outgoing repeater OR3.

Calls incoming to the sub-office are received over one of the two-way trunks such as T5 or over the one-way trunk T6, being handled by an incoming connector such as IC2 or by the incoming connector IC1. Each of the incoming connectors has a transfer line switch, such as LS11 and LS12, associated therewith for the purpose of making local transfer connections within the private exchange, as hereinbefore pointed out. The outgoing repeater OR3 is similarly provided in the transfer line switch LS9 for use in making a local transfer connection during an outgoing call to the public exchange. The local connector LOC4, however, is not equipped for transfer service, as it can never be used to complete a connection incoming from or outgoing to the public exchange.

The trunking arrangement as shown in Fig. 2 having been described, further attention will now be directed to the general aspects of the circuit drawings, Figs. 3 to 39, wherein the circuits of the apparatus indicated in Fig. 2 are shown in detail. As is indicated in layout drawing, Fig. 42, Figs. 3 to 23 show apparatus located in office 9; Figs. 24 to 34 show apparatus located in office; and Figs. 35 to 39 show apparatus located in sub-office 86.

The line circuits LC1 and LC4 of Fig. 2 are 75

shown in Figs. 3 to 6, while the finder F1, position 1, which has access to these line circuits in common with the other finders, is shown in Fig. 7;

Fig. 8 shows the first selector FS1 of Fig. 2, which is linked to the finder F1 to be used as the calling switch of the link, the finder F1 of Fig. 7 being the answering switch of the link;

Fig. 9 shows the delayed call selector DCS of Fig. 2, which is one of the selectors accessible from the first level of the finders to provide for the making of delayed calls.

Fig. 10 shows the incoming selector IS2, associated with the two-way trunk T2 and repeater R1, Fig. 17;

Fig. 11 shows the incoming selector IS1, which selector is similar to the incoming selector of Fig. 10 and is associated with the one-way trunk T1 incoming from office 8;

Fig. 12 shows line switches LS2 and LS3 which are associated with substations A1 and A2 respectively, and which have common access (along with line switches such as LS1 and LS4) to the first selectors such as FS5 by way of secondary line switches such as the one indicated diagrammatically at SLS;

Fig. 13 shows the outgoing repeater OR1 of Fig. 2, associated with the trunk OT1, outgoing to the public exchange;

Fig. 14 shows the branch-exchange connector BC of Fig. 2, which has access to branch-exchange lines, such as the one associated with the line circuit LC4, Figs. 2 and 6;

Fig. 15 shows the toll connector TC which has access to toll lines as indicated in Fig. 2, by way of conductors such as 1551, having access also to the branch-exchange lines, by way of conductors such as 1451;

Fig. 16 shows a rectangle indicative of the repeater R2 associated with the one-way trunk T3 outgoing to office 8;

Fig. 17 shows the repeater R1 associated with the two-way trunk T2 extending between offices 9 and 8 and associated also with the incoming selector IS2, Fig. 10. The repeater R1 is like the repeater R2, Fig. 16, except that the repeater R1 is provided with a transfer relay 1711 to transfer the conductors of the trunk T2 from the selector of Fig. 10 to the outgoing conductors of the repeater when the repeater is seized;

Fig. 18 shows the second selector SES, Fig. 1, which is accessible from the first level of the first selectors and which has access to groups of connectors, such as the local connector LOC1, Figs. 2 and 19;

The local connector LOC1, Fig. 19, as one of its 100 sets of bank contacts, has the set of contacts 1250, Fig. 12, associated with the line switch LS2 of substation A1;

Fig. 20 shows the start conductors 2000 (which are joined to the individual start conductors of line circuits such as shown in Figs. 3 to 6, according to the finder-bank levels through which these circuits are reached) for controlling the common start relay 2001, and for guiding the finders to the proper levels as they search for calling lines. Fig. 20 shows also the distributor common to the four positions of the link switchboard for distributing incoming calls to the operator;

Fig. 21 (three parts) shows the position relays and keys at position 1;

Fig. 22 shows the sender links SL1 and SL2, together with the associated equipment including the digit keys DK;

Fig. 23 shows the sender-control circuit of the

register sender RS, together with a rectangle indicative of the register senders RS;

Fig. 24 shows the repeater R3 of office 8, which is associated with the trunk T1 outgoing to office 9, and which is like the repeater R1 shown in detail in Fig. 17;

Figs. 25 and 26 show the incoming selectors IS3 and IS4, associated with trunks T3 and T4 to handle traffic incoming from office 9. The selector IS3, being like the illustrated selector IS4, is indicated by a rectangle;

Fig. 27 shows the repeater R4 associated with the two-way trunk T2, which repeater also is like the one shown in Fig. 17;

Fig. 28 shows the line of substation A3 (No. 8225) of office 8, together with the associated line switch LS7 and the line switches LS6 and LS8, all having access to the first selector FS6 which is like the selector FS5, shown in detail in Fig. 12, except that the first selector FS6 (being in office 8) drops back from the eighth level instead of from the ninth level;

Fig. 29 shows the local connector LOC3, which is like the local connector LOC1, shown in detail in Fig. 19;

Fig. 30 shows the outgoing repeater OR2, associated with the outgoing trunk OT2 leading to the public exchange. This repeater is like the repeater OR1, Fig. 13;

Figs. 31 to 34 show the incoming selectors IS5 and IS6 associated with trunks T4 and T5 to handle calls incoming from sub-office 86, together with the repeaters R5 and R6 associated with two-way trunk T5 and outgoing trunk T6 to handle calls to the sub-office 86;

Fig. 35 shows the incoming connector IC2 in sub-office 86, associated with the two-way trunk T5, which has access to the local lines of the sub-office so as to complete incoming calls there to;

Fig. 36 shows the incoming connector IC1 (a duplicate of the incoming selector IC2) associated with the incoming trunk T6;

Fig. 37 shows the selector repeater SR in sub-office 86, accessible to line switches such as LS10 of the sub-office substation A4 (No. 8625), as well as to the transfer line switches LS9, LS11, and LS12;

Fig. 38 shows the local connector LOC4 of Fig. 2, which is accessible to the selector repeater such as SR of Fig. 32 and which has access to the local lines of the sub-office; and

Fig. 39 shows the outgoing repeater OR3, accessible to the selector repeater such as SR and associated with the outgoing trunk OT3, extending to the public exchange.

Special features

In order that the detailed description of operation which is to follow be more thoroughly appreciated, certain special features of a general nature which are contained in the disclosed system and which have not been especially brought out by the preceding discussion will now be enumerated.

1. As is customary, the branch exchange lines are divided into two classes, restricted and non-restricted. Non-restricted lines may make calls to the public exchange and receive calls from the public exchange; restricted lines may not. The trunk lines extending to the public exchange being accessible from the tenth level of the first selector used by the branch exchange subscribers, the first selectors are arranged so that they extend calls by way of the tenth level or not de-

pending upon the presence or absence of a jumper connection at the lineswitch of the calling line, such jumper connection being made at the lineswitch of each non-restricted line.

5 Calls coming from the public exchange to branch exchange lines are conveniently accepted or denied at the connectors having access to the branch exchange line. Each connector has a class-recording relay which becomes operated
10 automatically over the fourth of its incoming conductors when the call being extended is from the public exchange, but not otherwise. The connector has also a class-test relay which tests for the presence or absence of a ground potential on
15 the fourth conductor in the group assigned to the called line, whereby the connection from the public exchange is permitted or denied according to the class of the called line.

In addition, the selectors used by the operators
20 are provided with discriminating means for barring the extension of incoming public exchange calls to inter-branch-exchange-trunks.

2. It has been mentioned hereinbefore that the requirement has been met that the operators cannot extend a connection to a trunk line outgoing
25 to the central office over one of her regular first selectors (linked with the finders), but the operators are provided with delayed-call selectors (DCS, Figs. 2 and 9) by means of which any one
30 of them can set up a delayed call between a public-exchange line and a local branch-exchange line or between two branch-exchange lines. Now, in order to prevent the setting up a public exchange connection to a restricted branch exchange line through a delayed call selector and
35 one of the operator's links, the delayed-call selector is so arranged that when it is set on an outgoing public-exchange trunk, the operation of the class-recording relay in the local connector is brought about, as in a regular incoming call from
40 the public exchange.

3. In order to provide an additional desirable feature of the branch exchange service, the connectors which may be used to complete calls from
45 the link switchboard are each provided with an offering relay. When one branch exchange subscriber is particularly desirous of conversing with another whose line happens to be busy, the calling subscriber may communicate with the
50 branch-exchange operator who extends the connection to the desired busy line selector and then brings about the operation of the above-mentioned offering relay in the connector to make a temporary connection to a busy line. The subscriber called may then replace his receiver and
55 again remove it to accept the proffered call. It is a special feature of this arrangement that a warning tone is placed on the busy called line when the offering connection is made, so as to warn the conversing subscriber that the secrecy of their conversation has been invaded.

4. It is a special feature of the circuit arrangements herein presented that the number of interconnecting trunk conductors is kept at a minimum; the conductors extended through the selectors and connectors number only four; the
65 usual negative and positive talking conductors, the third or control conductor (abbreviated C) and the fourth or extra-control conductor (abbreviated EC). The third or C conductor is also
70 commonly called the release-trunk conductor.

The fourth conductor is used to deliver a class indicating impulse from one switch of a train to the next succeeding switch at the moment of
75 seizure; it is used to bring about the operation of

the above-mentioned offering relay in the connector when an urgent call is to be offered to a subscriber when his line is busy; and it is used as a supervisory lead to afford recall or disconnect supervision in calls between the branch exchange switchboard and a toll line or a manual branch exchange line.

5. A special feature of the disclosure resides in the novel arrangement for securing the required number of special control conditions over the
10 two-conductor inter-office trunk lines. In addition to the provision for furnishing usual control circuits for enabling connections to be set up, held, and subsequently released, as well as the provision for giving supervision by reversed current, the delivery of a class-recording impulse to
15 one of the conductors of an inter-office trunk upon the seizure of the trunk results in the momentary operation of a differential recording-control relay in the distant office to set up the required class condition; the delivery of a call-offering impulse to one of the conductors of an inter-office trunk when a connection has been set
20 up to a busy line unbalances the current flow to permit the operation of the said differential relay in the distant office to transmit a call offering impulse to the connector; and in the event that an annoyance call is to be trapped and held while the connection is traced to its source, the opening of one of the conductors in the distant office
25 causes the trapped condition to be relayed back over the two-conductor trunk to the originating office to thereby relay the holding condition. The features enumerated are effective over two inter-office trunks in tandem when a connection is set
30 up between office 9 and sub-office 86.

The foregoing and numerous other features will become apparent upon a further perusal of this specification.

Detailed description

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

An outgoing call; office 9

It will be assumed first that the subscriber at the non-restricted substation A1, Figs. 2 and 12, desires to make an outgoing call to the public exchange, for which purpose he removes his receiver (not shown) and dials the digit 0.

When the receiver is removed at substation A1, the negative and positive line conductors are bridged in the usual manner, closing a circuit for line relay 1231 of the lineswitch LS2, by way of
55 contacts controlled by the bridge-cut-off armature 1235. When line relay 1231 operates it places ground potential on the associated C lead at its lower armature, at the same time disconnecting the bridge-cut-off winding 1232 of the
60 lineswitch magnet, while at its upper armature it closes a circuit by way of the associated chain-ground conductor for the pull-down winding 1233. At this point it may be mentioned that the lineswitch LS2, as well as the other lineswitches
65 throughout the disclosure, is similar to the primary lineswitch shown in the patent to Voss et al., 1,809,086, June 9, 1931. The line switches are divided into groups, and each group has access to a different group of trunks, and is presided
70 over by a separate master switch, substantially as shown in the above-mentioned Voss et al. patent.

When the circuit for the pull-down winding 1233 is closed, the pull-down armature 1234 is 75

operated to cause the springs of the lineswitch to be pressed into engagement with the contacts of the trunk which have been preselected by the master switch (not shown), which may be conveniently assumed to be the trunk line extending to the associated secondary line switch SLS. The bridge-cut-off armature 1235 is operated also, and it disconnects the incoming line conductor from line relay 1231 and from ground, with the result that the slow-acting line relay 1231 restores shortly. The bridge-cut-off winding 1232 is now energized from the ground potential applied to the C conductor of the lineswitch by the lower armature of the line relay 1231 and through contacts closed by pull-down armature 1234.

Of the secondary line switch SLS only the wipers are shown. This secondary line switch is preferably of the well-known rotary type, being provided with the usual line relay and switching relay. The C lead of the secondary line switch SLS is grounded in the usual manner by the line relay (not shown) to maintain the bridge-cut-off winding 1232 of the line switch LS2 energized as a holding winding after the disconnected line relay 1231 has fallen back and the circuit of the pull-down winding 1233 has been opened.

It may be assumed that the first selector FS5 is the one seized by the secondary line switch SLS when it operates in the well-known manner. Under this condition, line relay 1201 operates over the incoming negative and positive conductors, and over the calling line, the upper winding thereof being connected to the negative pole of the exchange battery (not shown), while the lower winding is connected to ground by way of the normally closed overflow contacts 1213, contacts of drop-back relay 1205, conductor 1215, and the source of dial tone (indicated by the dotted connection to ground, but not shown). Upon operating, line relay 1201 closes a circuit for release relay 1202 which includes contacts of switching relay 1206. Relay 1202 operates and places a ground potential on the incoming C lead at its upper armature, thereby providing a holding circuit for winding 1232 of the line switch LS2 after the above-discussed line relay of the secondary line switch SLS has restored.

Release relay 1202 also closes a circuit for the associated auxiliary release relay 1203. Relay 1203 opens a point in the circuit of release magnet 1209 and prepares a circuit for vertical magnet 1207 at its inner lower armature, while at its middle lower and lower armatures it prepares circuits having to do with the digit-cancelling feature of the selector, involving drop-back relay 1205. Relay 1203 also energizes the polarizing winding (the lowermost one) of the electro-polarized switching relay 1206, in addition to which it prepares a test circuit for the upper winding of relay 1206 over the C wiper of wiper group 1200.

When the calling subscriber, hearing the dial-tone superimposed on the line through lead 1215, manipulates his dial (not shown) in accordance with the digit "0", assigned to the public exchange, line relay 1201 is caused to restore momentarily ten times. Each time it restores, it closes a circuit through contacts of the operated auxiliary release relay 1203 for vertical magnet 1207. Magnet 1207 is therefore operated ten times to raise the wipers 1200 step by step until they come to rest opposite the tenth level of bank contacts. The bank contacts in the tenth level of this selector, as hereinbefore discussed and

as indicated in Fig. 2, lead to outgoing trunk lines, such as the outgoing trunk line OT1, Figs. 2 and 13.

Series relay 1204 is energized by means of its lower winding when the first impulse is delivered to vertical magnet 1207. Since this relay is provided with a conducting sleeve around the core thereof, as is indicated by the additional vertical lines representing the core, this relay (like release relay 1202 and other similarly indicated relays throughout the drawings) is slow releasing. Series relay 1204 therefore operates and remains operated throughout the series of impulses, from which operation it derives its name.

Upon the cessation of the series of impulses, relay 1204 restores and completes a circuit at its lower armature for rotary magnet 1208, which circuit includes contacts of line relay 1201, self-interrupting contacts of the rotary magnet 1208, off-normal contacts 1210, the above-mentioned contacts of series relay 1204, "9"-level spring 1217 and its left-hand contact, and contacts of release magnet 1209.

The self-interrupting rotary magnet 1208 is now operated in a buzzer-like manner to drive the wipers 1200 across the tenth level of bank contacts in search of an idle outgoing trunk.

It may be assumed that the outgoing trunk OT1, Fig. 13, is the first one found to be idle, and is consequently seized by the wipers 1200 at terminals such as 1300. The conductors leading to the repeater OR1 from the terminals 1300 are marked to indicate the correspondence between the terminals 1300 and the wipers 1200, which procedure is followed throughout the drawings to show the correspondence between the terminals and the wipers having access to them. When the terminals 1300 are reached, the C wiper of the selector encounters a negative potential on the C terminal of group 1300 by way of contacts of the make-busy key 1307, contacts of release relay 1302, and resistor 1309. The upper winding (the test winding) of the electro-polarized switching relay 1206 is thereupon energized in a circuit between the C wiper and the grounded incoming C lead of the selector (grounded at the upper contacts of release relay 1202).

Since the wipers of the selector have been raised to the tenth or "0" level, "0"-level shaft spring 1216 has been shifted to its alternate position, transferring the left-hand terminal of the test winding of relay 1206 from the incoming C conductor to the EC conductor incoming to the selector FS5. By this provision, the test circuit of relay 1206 is effective only in the event that the calling line switch has a strap (such as the strap 1236 of the line-switch LS2) to enable the EC conductor of the selector to obtain a ground potential from the C conductor thereof. By virtue of the strap 1236, the EC conductor incoming to the selector FS5 is grounded, extending a ground potential through the right-hand contact and "0"-level springs 1216, and by way of the upper contacts of the auxiliary release relay 1203, to the left-hand terminal of the test winding of relay 1206.

When the test winding of relay 1206 becomes energized in series with resistor 1309, relay 1206 operates and closes a circuit for the middle or holding winding of the relay from the grounded C lead; connects the incoming C lead to the C wiper, thereby by-passing the test winding of the relay; disconnects ground potential from the armature of line relay 1201 to terminate the rotary movement and to prevent a premature re-

lease of the selector; and it disconnects the incoming negative and positive conductors from the winding of line relay 1201 and extends them by way of the negative and positive wipers in group 1200 to the corresponding conductors incoming to the outgoing repeater OR1.

In the repeater OR1, line relay 1301 now energizes over the calling line and through the differential transfer-control relay 1305 and closes a circuit for release relay 1302, whereupon relay 1302 applies ground potential to the incoming C conductor, thereby affording a holding circuit for relay 1206 of the selector FS5 and for the line switches LS2 and SLS before the slow-acting release relay 1202 of the selector has had time to restore. Relays 1202 and 1203 restore shortly.

Line relay 1301 also closes a bridge across the outgoing conductors of trunk OT1 by way of the left-hand windings of the repeating coil 1330 and the associated resistance, thereby preparing the switching apparatus in the public exchange for operation.

It will be recalled that dial-tone current was transmitted from the common dial-tone conductors 1215 associated with the selector FS5 to signal the subscriber at substation A1 to begin dialling. This dial tone is no longer heard after the selector FS5 has operated to seize the outgoing repeater OR1. Since the subscriber is calling to the public exchange, he may now receive further dial tone from the public exchange over the trunk OT1, or not, depending upon the nature of the switching apparatus in which the trunk OT1 terminates at the public exchange, as is well understood.

At any rate, the subscriber at substation A1 next dials the public-exchange number of the desired line, causing line relay 1301 of the repeater OR1 to repeat the dialling impulses at its lower contacts and thereby cause the public-exchange automatic equipment to complete the desired connection. The conversation may now begin.

Transfer service during an outgoing call

For the purpose of explaining the transfer service which is available during each call from the branch exchange to the public exchange, it is now assumed that the subscriber at substation A1 desires to obtain some additional information from another branch-exchange subscriber before completing the conversation with the public exchange subscriber. In this event, after requesting the public exchange subscriber to wait a moment, the branch exchange subscriber at substation A1 momentarily depresses the push-button at his substation, thereby placing a ground potential on the positive conductor of the line. The momentary operation of the grounding push-button at the calling substation momentarily unbalances the current flow in the differential transfer-control relay 1305, causing relay 1305 to operate momentarily. Relay 1305 closes a circuit through contacts of relay 1304 for the upper or first-step winding of the latter relay. Two-step relay 1304 accordingly energizes sufficiently to close its first-step contacts (its lightly adjusted inner lower contacts) but none of the other contacts is affected at this time. A locking circuit for the two windings of the relay in series by way of contacts of transfer release relay 1303 and contacts of release relay 1304 is now closed, but this locking circuit is ineffective as long as

the initial circuit for the upper winding of relay 1304 remains closed.

When the push-button is released at the calling sub-station and transfer-control relay 1305 restores, the two windings of relay 1304 are energized in series, whereupon the relay operates fully. With relay 1304 fully operated, the negative and positive conductors of the repeater OR1 are disconnected from the left-hand windings of repeating coil 1330 and are transferred to the corresponding conductors of the line switch LS1, while a holding circuit for release relay 1302 is prepared over the C lead of the line switch LS4.

Line relay 1301 now restores, but no harm results as the lower contacts of the line relay are now held closed at the lower contacts of transfer relay 1304, and release relay 1302 is held operated over the C lead of the line switch LS1, which line switch now operates over the calling line to take another first selector similar to the first selector FS5 for use to enable the subscriber at substation A1 to set up a connection with any desired other branch exchange subscriber. It will be understood that the line switch LS4 is not shown fully, as it is similar to LS2.

Releasing the transferred connection

When the subscriber at substation A1 has completed the transfer connection and desires to release this connection and return the public exchange connection, he again momentarily depresses the push-button at his substation, again grounding the line to bring about a momentary operation of transfer-control relay 1305. At this time, when relay 1305 operates it closes a circuit through contacts of transfer relay 1304 for the transfer-release relay 1303. Relay 1303 closes a new locking circuit for transfer relay 1304, opening the initial locking circuit of this relay. As a result, when transfer-control relay 1305 restores and opens the circuit of transfer-release relay 1303, it opens the circuit of transfer relay 1304 also. Transfer-release relay 1303 is slow acting and thereby maintains the locking circuit of relay 1304 open long enough to permit this relay to release and transfer the connection back from the line switch LS1 to the outgoing trunk OT1. The line switch LS1, as well as the remaining part of the transfer connection, releases. Line relay 1301 now reoperates, holding release relay 1302 operated locally, and holding the bridge across the outgoing trunk at its lower contacts. Relay 1303 has a pair of lower contacts for holding the bridge closed during the transition period when the connection is being transferred back from the line switch LS1.

Releasing the public-exchange connection

When the subscriber at substation A1 has completed the conversation with the public-exchange subscriber, he replaces his receiver (not shown) whereupon line relay 1301 restores and opens the outgoing trunk OT1 to permit the automatic equipment in the public exchange to release at the same time. Relay 1301 also opens the circuit of the associated slow-acting release relay 1302, permitting this relay to restore after a short interval and remove ground potential from the associated C conductor. Relay 1206 in the first selector FS5 now restores, and the bridge cut-off winding 1232 of the line switch LS2 deenergizes, permitting the armatures 1235 and 1234 to restore. Armature 1234 permits the connection between the line switch LS2 and the secondary line switch SLS to open.

At the first selector FS5 a circuit is closed for release magnet 1208 at the lower contacts of switching relay 1206, by way of contacts of line relay 1201 and auxiliary release relay 1203, as well as off-normal contacts 1211. Release magnet 1209 now energizes and causes the first selector FS5 to restore to normal in the usual manner, whereupon the circuit of the release magnet is opened at off-normal contacts 1211.

With further reference to the outgoing repeater ORI, it will be noted that there is a relay 1306 associated therewith and connected to the C conductor thereof. This relay may be used when it is desired to control the application of ground potential to a common conductor according to whether all of the outgoing trunks are busy or not. Such a conductor, 1308, (known as a busy-common conductor) is shown in association with relay 1306. This conductor is common to all of the outgoing repeaters in the same exchange. Obviously, when all of these repeaters are busy, all relays 1306 are operated, and ground potential is removed at all points from conductor 1308. This conductor may extend to a meter-controlling relay, or may be used in any other desired manner.

It may be pointed out here that there is no strap such as 1236 at the line switch LS3, as the line switch LS3 is associated with a restricted line. Therefore, if the subscriber at substation A2 should remove his receiver and dial the digit 0 in an attempt to set up a public-exchange connection, the seized first selector (first selector FS5, for example) would be unable to seize a trunk on the tenth level because of the resulting absence of ground potential on the incoming EC lead of the selector. It was pointed out previously that ground potential is required on this lead for the operation of the test winding of relay 1206. In this event, the selector continues to rotate until the overflow contacts 1212 and 1213 are operated, whereupon a busy tone signal is transmitted back to the calling line.

Local call in office 9

For the purpose of explaining the operations involved in the setting up of local calls in office 9, it will be assumed that the subscriber at substation A2 (No. 9225) desires to converse with the subscriber at substation A1 (No. 91225). That being the case, the subscriber at substation A2 removes his receiver and dials the desired number, 91225.

When the receiver is removed, the line switch LS3 operates in the manner explained in connection with the line switch LS2 to seize an idle secondary line switch (such as SLS) and the secondary line switch seizes an idle first selector, the first selector FS5, for example. Therefore, the line, release, and auxiliary release relays 1201, 1202, and 1203 in the first selector FS5 energize sequentially to prepare the selector for operation, and the calling subscriber at substation A2 receives a dial tone signal from the common dial-tone conductor 1215, by way of the lower winding of line relay 1201.

When the calling subscriber dials the first digit 9 of the desired number, line relay 1201 is momentarily deenergized nine times and thereby causes the vertical magnet 1207 to raise the wipers 1200 opposite the ninth level of bank contacts. At this time, the "9"-level shaft spring 1217 is operated, shifting therefore to its alternate position to open a point in the normally existing circuit for rotary magnet 1208 and to prepare a circuit for release

magnet 1209. This is for the purpose of causing the first digit to be absorbed when a local call is made within one office, and this has to do with the numbering system as hereinbefore explained.

Under this condition, when series relay 1204 (which is operated throughout the vertical movement) restores at the end of the vertical movement, it applies ground potential to the "9"-level spring 1217, as in its previously described operation. At this time, however, the spring 1217 is in its alternate position and the ground potential is extended by way of contacts of drop-back relay 1205, contacts of the energized relay 1203, and off-normal contacts 1211 to release magnet 1209. The release magnet 1209 actuates its contacts in addition to causing the selector FS5 to be restored to its normal position. At its outer contacts magnet 1209 maintains the circuit of rotary magnet 1208 open after the "9"-level spring 1217 has resumed its normal position in the releasing operation and until off-normal contacts 1210 have opened. At its inner contacts, the release magnet 1209 maintains a locking circuit of itself independent of spring 1217 until off-normal springs 1211 are opened.

When the normal position is reached, and off-normal contacts 1210 and 1211 are separated in the usual manner, release magnet 1209 is maintained operated momentarily in an extended locking circuit which includes the lower winding of the drop-back relay 1205, the lower contacts of this relay, contacts of auxiliary relay 1203, and the inner contacts of release magnet 1209, to ground by way of the contacts of the actuated line relay 1201 and contacts of relay 1206. Relay 1205 operates in this circuit and closes a locking circuit for its upper winding at its inner upper contacts. Relay 1205 also opens its operating circuit and the locking circuit of release magnet 1209 at its lower contacts, whereupon magnet 1209 restores. At its lower armature relay 1205 connects the alternate contact of spring 1217 to the normal contact thereof to permit rotation on the ninth level, while at its inner lower armature it opens the drop-back circuit through which release magnet 1209 was operated to cause the selector to drop back from the ninth level.

At its lower armature, relay 1205 substitutes direct ground potential for the common dial-tone conductor 1215, thereby terminating the application of dial tone to the calling line, following the first digit, in keeping with established practice.

When the calling subscriber dials the second digit (1) in the desired number (the first of office-indicating digit (9) having been absorbed), vertical magnet 1207 is again operated, this time bringing the wipers 1200 opposite the first level of bank contacts.

When series relay 1204 restores, the self-interrupting magnet 1205 drives the wipers 1200 across the first level of bank contacts in search of an idle second selector. Assuming that the second selector SES, Fig. 18, which is available to the first selector FS5 at terminals such as 1800, is the first one found to be idle, switching relay 1206 is operated over the associated C wiper and over the C lead extending from terminals 1800 to the second selector SES. An idle-indicating battery potential is normally applied to the incoming C conductor of the second selector SES by way of the upper winding of series relay 1504, off normal contacts 1812, and contacts of the make-busy key 1816. The encountering of this idle-indicating potential by the C wiper of the selector FS5 re-

sults in the operation of switching relay 1206 to extend the calling line to the second selector SES.

In the second selector SES, series relay 1804 operates over the incoming C lead and opens a point in the circuit of rotary magnet 1808.

Line relay 1801 operates over the calling line and closes a circuit for release relay 1802, which energizes and operates the auxiliary release relay 1803, in addition to applying a holding ground potential to the incoming C lead at the upper contacts of the release relay 1802.

When the calling subscriber dials the third digit (2) in the desired number line relay 1801 is momentarily restored twice. Each time it is restored, line relay 1801 closes a circuit through contacts of release relay 1802 for vertical magnet 1807. The vertical magnet therefore causes the wipers 1850 to be raised two steps until they come to rest opposite the second level of bank contacts (the level in which terminals 1851 are located). Relay 1804 is maintained energized by the impulses delivered to its lower winding in multiple with the circuit of vertical magnet 1807 after the initial circuit of the upper winding of the relay is opened at off-normal contacts 1812, upon the first vertical step of the switch.

Off normal contacts 1811 prepare a circuit for rotary magnet 1808, with the result that rotary magnet 1808 is operated in a buzzer-like manner through the contacts of relay 1804, when this relay energizes at the end of the series of impulses. Assuming that terminals 1851 are the first set of terminals found to be idle as the wipers 1850 are rotated over the second level of bank contacts, this set of terminals (associated with the local connector LOC1, Figs. 2 and 19), is the one seized. The C conductor associated with terminals 1851 and incoming to the local connector LOC1, Fig. 19, is normally supplied with an idle-indicating potential by way of the upper contacts of make-busy key 1926, off-normal contacts 1923, and the upper winding of vertical series relay 1906. As a result, the electro-polarized switching relay 1806 receives current from the C wiper which flows to the grounded C lead. Upon operating, relay 1806 terminates the hunting movement and switches the connection through to the local connector LOC1, Fig. 19. Relays 1801-1803 in the selector SES restore, but relay 1806 remains locked by means of its holding winding (the middle winding) to the grounded C lead to maintain the connection established and to maintain the release-magnet circuit open.

In the local connector LOC1, vertical-series relay 1906 is operated over the C lead through off-normal contacts 1923 to open a point in the circuit of rotary magnet 1920 and to prepare a circuit for its own lower winding and for that of vertical magnet 1919. Also, when the switching relay 1806 of the second selector SES operates to extend the calling line, line relay 1902 of the local connector LOC1 is operated over the calling line to close a circuit for release relay 1904. Release relay 1904 applies ground potential to the incoming C lead to afford a holding circuit for the preceding switches; it opens a point in the circuit of release magnet 1921; and it closes an operating circuit through contacts of the ring-cut-off relay 1911 for the lower winding of the auxiliary release relay 1905. Relay 1905 has an additional winding which is now included in a closed circuit through contacts of release relay 1904, thereby rendering the relay slow releasing. The purpose of this arrangement will appear subsequently.

With relays 1904, 1905, and 1906 operated, the

connector is prepared to respond to the tens digit (2) of the number. Relay 1902 is deenergized twice momentarily when the digit 2 is dialed. Each time it restores, relay 1902 closes a circuit through contacts of the operated relays 1905 and 1906 for vertical magnet 1919. Magnet 1919 therefore raises the wipers 1900 opposite the second level of bank contacts. The lower winding of vertical-series relay 1906 is maintained operated in circuit with vertical magnet 1919 after the initial circuit of the upper winding of relay 1906 is opened at off normal contacts 1923.

At the end of the vertical movement, the slow-acting vertical-series relay 1906 restores and transfers the operating circuit from vertical magnet 1919 to rotary magnet 1920.

When the units digit 5 is dialled, five impulses of current are delivered to rotary magnet 1920, with the result that the wipers 1900 are brought into engagement with the fifth set of bank contacts in the second level, which contacts are those through which the line of substation A1, Fig. 12, are reached. These contacts are shown in Fig. 12, associated with the line of substation A1, and they are marked to identify them, respectively, with the wipers 1900.

The slow-acting rotary-series relay 1914 operates in circuit with the rotary magnet 1920 and remains operated throughout the rotary movement. This relay shunts the lower contacts of busy-test relay 1913 to prevent a premature opening of the rotary-magnet circuit in the event that busy-test relay 1913 operates during the rotary movement because of the C wiper of the connector passing over contacts of busy lines. At its upper armature, rotary series relay 1914 closes a circuit for the auxiliary relay 1915. Relay 1915 disconnects the C wiper from the winding of idle-test relay 1917 and transfers it to the upper winding of busy-test relay 1913 so as to enable the usual busy test to be made by way of the C wiper. It may be mentioned that the class-test relay 1908 is not effective at this time because the class-recording relay 1907 has not been operated to connect the class-test relay 1908 to the EC wiper of the connector.

The called line is busy

Assuming now that the line of substation A1 is busy when called, busy-test relay 1913 is operated over wiper C of group 1900 when wipers 1900 come to rest on the terminals of the line of substation A1, Fig. 12. Under this condition, when relays 1914 and 1915 restore upon the cessation of rotary impulses, a locking circuit for the upper winding of busy-test relay 1913 is closed, by way of contact of class-test relay 1908, at the contacts of auxiliary relay 1915, which locking circuit includes contacts of busy test relay 1913, contacts of offering relay 1912, and the upper contacts of the auxiliary release relay 1905. With busy-test relay 1913 operated, idle-test relay 1917 is disconnected; the rotary-magnet circuit is open at the lower contacts of the busy-test relay; the offering relay 1912 is connected to the incoming C-lead for a purpose to be explained in detail subsequently; and busy-tone current is supplied from the common busy-tone lead 1943, through the upper contacts of busy-test relay 1913, and by way of the upper contacts of offering relay 1912, to the lower talking conductor, thereby transmitting the usual busy-tone signal back to the calling line to inform the calling subscriber that the called line is busy. Upon hearing this busy signal, the calling subscriber is ex-

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pected to replace his receiver and permit the operated switching apparatus to clear out.

The called line is idle

5 Assuming now that substation A1 is idle when called, busy-test relay 1913 is in a deenergized condition when the wipers 1900 come to rest on the terminals of the called line and relays 1914 and 1915 restore. In this event, the restoration
10 of relay 1915 results in the connection of the lower terminal of idle-test relay 1917 to the C wiper of the connector, the upper terminal of idle-test relay 1917 being connected through contacts of busy relay 1903 to ground at the upper contacts
15 of auxiliary release relay 1905. Therefore, relay 1917 energizes over the C wiper of the connector, the C terminal of the line of substation A1, Fig. 12, contacts of line relay 1231, and in series with the bridge-cut-off relay 1232 of the line switch
20 LS2. When the bridge-cut-off winding 1232 is energized alone, sufficient magnetic pull is developed to operate the bridge-cut-off armature 1235, but the pull-down armature 1234 is not operated. Bridge-cut-off armature 1235 actuates its associated contacts to clear the called line of the normal bridge connections.

In the connector LOCI, Fig. 19, idle-test relay 1917 operates after a slight interval has elapsed (because of the retarding action of the copper collar on the armature end thereof) to allow time
30 for the bridge-cut-off armature of the line switch to clear the line. Switching relay 1918 thereupon responds and disconnects rotary magnet 1920 and rotary series relay 1914; it disconnects
35 the EC wiper from the circuit which leads to class-test relay 1908 when class-recording relay 1907 is operated and transfers it to the upper winding of the marginal trap relay 1916; it closes a locking circuit for itself by way of the upper
40 contacts of relay 1905; it applies ground potential from the upper contacts of auxiliary release relay 1905 to the C wiper, thereby shunting idle-test relay 1917 and permits it to restore; and it connects up the negative and positive wipers
45 to the ringing circuit through contacts of ring-cut-off relay 1911. Ringing current from the ground-return generator lead 1941 (the generator being not shown but indicated by the dotted portion of the lead 1941 and the accompanying
50 symbols) now flows through contacts of ring-cut-off relay 1911 and through contacts of switching relay 1918 to the positive conductor of the line of substation A1, the return path to the negative pole of the exchange battery being
55 over the negative side of the line and through the upper winding of ring-cut-off relay 1911.

When the called subscriber responds, the usual closing of the direct-current bridge across the conductors of his line results in the well-known
60 operation of ring-cut-off relay 1911. Upon operating, relay 1911 closes a locking circuit for both windings in series by way of off-normal contacts 1925. Relay 1911 also opens the ringing circuit and completes the talking circuit, and it also opens the circuit of auxiliary release relay
65 1905, but relay 1905 remains operated momentarily because of the retarding effect of its upper winding, which is now included in a closed circuit by way of contacts of release relay 1904.

70 Back-bridge relay 1903 now operates over the called line in series with the differential transfer-control relay 1925. At its lower armature, relay 1903 closes a circuit for the reversing or supervisory relay 1901, which operates to reverse the
75 connection between the windings of line relay

1912 and the incoming talking conductors, thereby reversing the direction of current-flow in the calling line for supervisory purposes. This reversal however, is of no utility in the present (local) call.

5 As a further result of its operation, back-bridge relay 1903 closes a circuit for the lower winding of class-test relay 1908, which relay serves now as a holding relay. At its inner lower armature, relay 1908 prepares a locking circuit for
10 transfer relay 1910, while at its lower armature it shunts the corresponding contacts of ring-cut-off relay 1911, thereby reestablishing the circuit of auxiliary release relay 1905 before this relay has had time to restore.

15 The circuits remain in this condition throughout conversation.

Quick release of called line

In order to explain a special called-line-re-
20 leasing feature of the connector of Fig. 19, it will be assumed now that the called subscriber is the first to replace his receiver at the end of the conversation. When the receiver is replaced
25 on the called line, back-bridge relay 1903 restores and opens the circuit of supervisory relay 1901 at its lower armature, whereupon relay 1901 restores and reverses the connection back to normal between the incoming talking
30 conductors and line relay 1902. Back-bridge relay 1903 also opens the circuit of relay 1908 at its inner armature. Relay 1908 restores a moment later and opens the circuit of auxiliary relay 1905 at its lower armature. Auxiliary release relay 1905 restores shortly. Upon restoring,
35 relay 1905 removes ground potential from the C wiper at its upper armature, while at its inner upper armature it opens the locking circuit of switching relay 1918, whereupon switching relay 1918 restores and disconnects the negative, positive, and EC wipers. The line of substation A1 is thereby freed and the line switch
40 LS2 is again placed under the control of the line of substation A1, whereby the subscriber at substation A1 may either receive a call or initiate
45 a call while the connector LOCI of Fig. 19 is still held from the called line.

When the calling subscriber replaces his receiver, line relay 1902 restores and opens the circuit of release relay 1904. Release relay 1904
50 restores at the end of a slight interval and removes ground potential from the incoming C lead to permit the preceding switches to clear cut. Release relay 1904 also completes the circuit of release magnet 1921, whereupon the connector is
55 restored to normal position in the usual manner. The release magnet circuit is opened at off-normal contacts 922 when the normal position is reached, while the circuit of ring-cut-off relay 1911 is opened at off-normal contacts 1925. Idle-
60 indicating potential is now supplied to the incoming C lead by way of the upper winding of vertical series relay 1906 at off-normal contacts 1923.

At this point it may be explained how the
65 clearing out takes place when the calling subscriber is the first to replace his receiver. Under this condition, the restoration of line relay 1902 is followed by the restoration of release relay 1903, at which time the local circuit for the
70 upper winding of relay 1905 is opened to remove the slow releasing characteristic of this relay, with the result that relay 1905 is restored immediately responsive to the opening of its circuit by relay 1904. The called line is freed by
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the removal of ground potential from the C wiper at the upper contacts of relay 1905 and by the restoration of switching relay 1918 when its circuit is opened at the inner upper armature of relay 1905. The connector is restored to normal position as before described when release magnet 1921 operates responsive to the restoration of relay 1905.

Of the remaining switches operated under the control of the line of substation A2 to set up the previously described connection, the line switches LS3 and SLS, together with the first selector FS5, Fig. 12, clear out as before explained. The second selector SES, Fig. 18, is restored to normal position by release magnet 1899 when switching relay 1806 restores responsive to the circuit of its holding winding being opened upon the removal of ground potential from the C lead at the connector LOC1, Fig. 19.

20 *Incoming calls from the public exchange*

As pointed out before, calls incoming to the branch exchange from the public exchange are received by a branch-exchange operator and are then directed to the desired or appropriate line of the branch exchange. For the purpose of explanation, it will be assumed that a call is received from the public exchange over the incoming trunk IT, Figs. 2 and 4, and it will be explained how this call is directed to the line of substation A1, Fig. 12, substation A1 being a non-restricted substation and therefore entitled to receive calls incoming from the public exchange.

When the incoming trunk IT is seized in the public exchange, ringing current is projected thereover to operate the ring-up relay 401 Fig. 4, whose lower winding is bridged across the incoming talking conductors in series with the usual blocking condenser. Upon operating, ring-up relay 401 closes a locking circuit for itself at its inner contacts in series with the upper winding of start relay 402, while at its upper contacts it disconnects its lower winding from in bridge of the incoming talking conductor. When start relay 432 operates, it connects the C lead incoming from terminal group 400 to its own lower winding and the winding of cut-off relay 403, thereby marking the line circuit LC2 as calling in the bank of the finder F1, Fig. 7, and the other finders associated with the four positions of the link switchboard. Start relay 402 also closes a circuit through contacts of cut-off relay 403 for the group call lamp GC2 at position 1, and it places a ground potential through contacts of cut-off relay 403 on the associated start conductor 411.

At this point it may be mentioned that the group call lamp GC2 is common to the entire group of incoming trunks, of which the incoming trunk IC is one. The group call lamp GC1 at position 1 is similarly common to all of the circuits such as LC1, Fig. 3, while the group call lamps GC3 and GC4 are further group call lamps, each common to a group of trunks, and each representative of a different type of calling line. As is indicated by the symbols associated with the group call lamps above mentioned, the respective conductors leading thereto lead also to group call lamps at each of the other three positions. These group call lamps serve to identify groups in which unanswered calls are waiting.

The finder starting system

As above mentioned, the start conductor 411

associated with the line circuit LC2 has been grounded by start relay 402 to cause a finder to be set on the terminals of the line circuit LC2 to answer the call. The finder starting system will now be explained.

Upon referring to Fig. 20, which shows the common start lead and the finder distributor, it will be observed that there are nine start leads, indicated generally by the reference numeral 2000 and having the numbers 2 and 10 applied thereto. These latter numbers indicate the levels of the finders (Figs. 2 and 7) with which the start conductors 200 are respectively associated. Conductors 2 to 9 in group 2000, it will be observed, extend to the contacts in the bank of vertical wiper 712 of the finder F1 which are engaged by this wiper when the main wipers 700 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 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 in the bank of vertical wiper 712. It will be observed that the tenth contact in the bank of wiper 712 is permanently grounded so as to stop the finder invariably when the tenth and final level is reached. This provision accounts for the fact that the tenth one of the conductors 2000, Fig. 20, is not connected with the vertical banks of the finders.

Upon referring to Fig. 2, it will be noted that the first level of the finders leads to delayed-call selectors such as DCS, Figs. 2 and 9. Calls through the delayed call selectors are voluntarily extended by the operator, for which reason there is no conductor in the group 2000 associated with the first level of the finder bank.

All of the line circuits accessible to a given level of the finders all ground the corresponding one of the start leads 2000, Fig. 20, by way of the various start leads shown in Figs. 3 to 6, (311, 411, 511, and 611).

The common start relay 2001, Fig. 20, upon energizing responsive to a ground potential on one of the start conductors 200 lights the call pilot light in each of the positions, such as the pilot lamp 2004, associated with position 1. Start relay 2001 also closes a circuit through contacts of the distributor cut-off relay 2005 to the position-start conductor of whichever one of the four positions has been preselected by the distributor, or to the next one to be selected by the distributor if none has been preselected.

The preselection of a position by the distributor of Fig. 20 takes place in a manner which will now be pointed out. When she is not engaged in putting through or attending to a call, each of the operators is preferably instructed to operate the talking key of an idle finder-selector link in readiness for the arrival of a call. By means of the indicating lamps associated with her links, an operator is able to know which links are in use and which are not. The supervisory, busy, and hold lamps 741, 742, and 743, Fig. 7, inform the operator at position 1 of the condition of the link composed of the finder F1, Fig. 7, and the first selector FS1, Fig. 8.

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 busy lamp 742 indicates that the finder F1 and associated selector FS1 are

not in use, the operator throws her talking key K2, which may be in practice the right half of a double key of which the left half is the monitoring key K1. When the key K2 is actuated, a circuit is closed over the associated common test conductor 733 for the upper winding of connecting relay 703. Test conductor 733 is one of the common conductors contained in cable 3 (which is one of three multiplying cables which connects the equipment at position 1 with the group of finder selector links assigned to such position). Upon reference to Fig. 21, it will be observed that test conductor 733 is normally grounded at contacts of the normally restored talking relay 2104.

Upon operating, connecting relay 703 of the finder F1 locks itself to hold conductor 734, also contained in cable 3. Connecting relay 703, at its several contacts, completes the association between the finder-selector link and the position equipment, which association was partially effected by the operation of the talking key K2.

In the position equipment of Fig. 21, talking relay 2104 now operates over hold conductor 734 in the locking circuit of the connecting relay 703.

Upon operating, talking relay 2104 disconnects ground potential from the test conductor 733, thereby preventing the inadvertent operation of an additional connecting relay such as 703. The talking relay 2104 also disconnects the associated talking conductors from the windings of the repeating coil RC (used for monitoring purposes) and extends them to the operator's headset equipment. The talking relay 2104 also extends ground potential by way of contacts of pilot relays 2110 and 2111 to the winding of distributor-start relay 2112. Start relay 2112 prepares a circuit at its upper contacts for the signal relays 2105—2107; it grounds the distributor-start and marking conductors 2031 and 2032; and it connects the position start conductor 2033 to the start conductor 727, now extending by way of cable 1 to the preselected link.

Assuming the distributor to be in the normal position shown, the application of ground potential to the start conductor 2031 results in the consecutive operation of relays 2021, 2022, 2023, and 2024, in which operation the relays test for the position in which a link has been preselected in the manner just pointed out. The preselected position (position 1) is characterized by the ground potential now on the associated marking conductor 2032.

When distributor relay 2021 responds to the closure of its circuit from the grounded distributor-start conductor 2031 by way of contacts of relays 2024, 2023, and 2022, it connects the common start conductor to the position start conductor 2033 at its lower armature; it connects stop relay 2025 to the mark conductor 2032 of position 1 at its middle armature; and at its inner armature it closes a circuit for relay 2022 (associated with position 2) by way of contacts of stop relay 2025. In practice, relays 2021 to 2024, although of the usual quick acting type, have a relatively stiff adjustment, while the stop relay 2025 has a relatively weak adjustment. As a result, under the conditions now obtaining, relay 2025 operates over the grounded marking conductor 2032 through the contacts of relay 2031 to open the circuit of relay 2022 before the latter relay has had time to operate. Stop relay 2025 and distributor relay 2021 remain operated over conductors 2032 and 2031 until the next call has arrived and has been answered. At this point it may be mentioned that, in the event of a similar preselection at one

of the other positions when the distributor Fig. 20 is in normal position, the action is similar to that described except that the relays succeeding relay 2021 operate successively until the position in which there is a preselected finder has been located, at which time stop relay 2025 operates as above pointed out, leaving this position preselected.

Finding the calling line circuit

It will now be assumed that the finder F1, Fig. 7, has presented as described above, when the assumed call arrives over the incoming trunk IT, Fig. 4, at the line circuit LC2. Under this condition, the grounding of start conductor 411 above mentioned and the resulting actuation of the common start relay 2001 over the corresponding one of the level start leads 2000 results in the placing of a starting ground potential through the contacts of distributor relay 2021 on position start conductor 2033. The ground potential thus placed on conductor 2033 is extended through contacts of position start relay 2112 and over start conductor 727, in cable 1. From start conductor 727 the ground potential is extended through the lower contacts of the connecting relay 703 of the finder F1 and through off-normal contacts 715 to the lower winding of individual start relay 702, of the finder F1.

Start relay 702 operates through its lower winding and at its lower contacts locks its lower winding to the start lead 727 through the overflow contacts 714 independent of off-normal contacts 715, for the purpose of providing an automatic return and restart arrangement in the event that the finder overruns the calling line. At its inner upper contacts, start relay 702 prepares a locking circuit for its upper winding; it grounds conductor 717 at its upper armature to close a lighting circuit for the busy lamp 742; while at its lower armature it opens a point in the circuit of release magnet 711 and applies ground potential to conductor 718, thereby closing a circuit through the contacts of link-cut-through relay 708 for the hold lamp 743 and closing a circuit for the polarizing winding of the electro-polarized switching relay 701. As a further result of the application of ground potential to the conductor 718, an operating circuit is closed through contacts of relays 701, 720, and 719 for vertical magnet 709, so as to start the vertical movement of the finder in search of the level in which the calling line is located. When vertical magnet 709 operates, it closes a circuit for stepping relay 720, whereupon relay 720 operates and transfers the winding of vertical magnet 709 from conductor 718 to the vertical wiper 720, by way of the lower winding of change-over relay 719, thereby opening the circuit of vertical magnet 709. The vertical magnet thereupon restores and opens the circuit of stepping relay 720, whereupon the stepping relay restores also. The vertical magnet is then reoperated.

The above cycle of operations is repeated until wiper 720 comes into engagement with the previously grounded vertical contact, when the wipers 700 come opposite the level of bank contacts in which the calling line is located.

When the wipers of the finder reach the level containing the calling line, vertical wiper 712 encounters ground potential on the associated vertical test conductor. Then, when relay 720 reoperates following the operation of vertical magnet 709 which brought the wipers to the calling level, it closes a locking circuit for the vertical

magnet through the lower winding of change-over relay 719, vertical test wiper 712, the grounded level test conductor with which it is in engagement, and start conductor 411. Change-over relay 719 operates in the locking circuit of vertical magnet 709 and closes a locking circuit for its upper winding at its inner upper contacts; disconnects the L wiper of group 700 at its upper contacts; and at its lower armature it disconnects vertical magnet 709 and transfers the operating circuit to rotary magnet 710. When this occurs, vertical magnet 709 restores and permits stepping relay 720 to restore, whereupon rotary magnet 710 operates to advance the wipers 700 and 712 in a rotary direction over the selected level. The operation of rotary magnet 710 is accompanied by the operation of stepping relay 720, as in the case of vertical magnet 709. It may be pointed out that vertical wiper 712 is rotated out of engagement with the bank of vertical contacts on the first rotary step of the switch, whereby the rotary operation resulting from the interaction of rotary magnet 710 and stepping relay 720 is not interfered with.

The rotary movement continues until the wipers 700 come into engagement with the terminals of the calling line, in this case the terminals 400 associated with the line circuit LC2, Fig. 4. It will be recalled that the C lead at the line circuit LC2 has a potential placed thereon through the winding of relays 402 and 403 to mark the line as calling. Therefore, when the C terminal in group 200 is engaged by the C wiper of the finder F1, Fig. 7, a circuit is closed through the C lead of the line circuit LC2 for the upper or test winding of the electro-polarized test relay 701 of the finder, the other terminal of the test winding of relay 701 being connected to conductor 718, grounded at the lower contacts of start relay 702.

Upon operating, relay 701 at its inner upper armature closes an assisting or holding circuit for its middle winding, while at its lower armature it immediately opens the circuit of rotary magnet 710 to terminate the rotary movement with the wipers 700 in engagement with terminals 400. Switching relay 701 also completes the locking circuit of the upper winding of start relay 702 through resistor 716; it connects up the negative positive wipers of group 700; and it connects the grounded conductor 718 directly to the associated C wiper, thereby placing a direct guarding potential on the C lead of the line circuit LC2 in order to guard the line circuit effectively against seizure by subsequently operated finders and in order to afford a direct circuit for cut-off relay 403 of the line circuit LC2.

In the line circuit LC2, cut-off relay 403 operates over the associated C lead when the finder lands on the terminals 400. Upon operating, cut-off relay 403 closes a locking circuit for itself at its inner lower contacts independent of the contacts of start relay 402; it extinguishes the group call lamps GC2; it ungrounds the start conductor 411; it restores ring-up relay 402 by transferring its upper winding from the upper winding of start relay 402 to the associated EC lead; and it bridges the left-hand windings of repeating coil 430 across the conductors of the incoming trunk IT, thereby indicating in the public exchange by this direct-current bridge in the branch exchange that the call has been answered.

In the finder F1, Fig. 7, when the rotary-magnet circuit is opened at the lower contacts of switching relay 701, the locking circuit of change-

over relay 719 is opened, resulting in the restoration of relay 719. When it restores, relay 719 places ground potential on the L wiper from contacts of the connecting relay 703, thereby closing a circuit through the L terminal of group 400 for the identity lamp IL2 at position 1. This lamp becomes lighted to identify the group in which the line belongs with which the finder is now in connection. The lamp IL2 is common to all of the incoming trunks such as IT, being multiplied to the L leads of all the terminals such as 400 in the bank of finder F1 which terminate line circuits such as L2. The L lead extending to the L terminal of group 400, however, unlike the other leads extending from the line circuit LC2 to the terminals in group 400, is not multiplied into the banks of the finders associated with the other three operators' positions, as is indicated by the absence of a common connection symbol on the L lead adjacent the illustrated finder-bank terminal. The multiplying between the nine finders associated with the same positions is taken for granted, and is therefore not indicated. It will be understood, of course, that each of the other positions is provided with a lamp similar to the lamp IL2 to serve as an identity lamp when a finder at another position finds a line circuit such as LC2. The identity lamps IL1, IL3, and IL4 have a purpose similar to the purpose of the identity lamp IL2, each separate group of lines having its own separate identity lamp at each position which becomes lighted upon the finding of any line of the group.

It will be observed that the locking circuit for the upper winding of start relay 702, closed at contacts of switching relay 701, includes the resistor 716. This resistor is provided primarily to enable the start relay 702 to be shunted and thereby released under the control of the position equipment. For this purpose, the release-answer conductor 716 (cable 1) is now connected through contacts of connecting relay 703 to the junction of the upper winding of relay 702 and resistor 716. This conductor 726 extends to contacts of the release answer key, Fig. 21—part 3. Use is made of the release-answer conductor 726 to operate the answer-pilot relay 2110 as soon as the locking circuit for relay 702 is closed by the actuation of switching relay 701, the lower winding of answer-pilot relay 2110 being now connected in parallel with the resistor 716.

When answer-pilot relay 2110 operates, it opens the previously described circuit for position-start relay 2112 (closed as previously described upon the operation of talking relay 2104). The position-start relay 2112 is slow acting, as indicated, for which reason it remains operated for an interval after its circuit is opened. Answer-pilot relay 2110 also closes a circuit through contacts of the still operated start relay 2112 and over conductor 2124 to actuate the call-signal relay 2105 by way of contacts of signal-interrupter relay 2107.

When call-signal relay 2105 operates, it disconnects the operator's headset equipment from the tip and ring conductors 2141 and 2142 and extends them to the common call-tone conductors 2043 and 2044, coming from the secondary winding of the illustrated call-tone transformer. A distinctive tone current is therefore transmitted through contacts of the call signal relay 2105 and contacts of actuated talking relay 2104 to the operator's receiver, which receiver is associated with the secondary windings of the induc-

tion coil I in the usual anti-side-tone arrangement including the artificial line A. L.

Call-signal relay 2105 operates relay 2106. Relay 2106 interrupts the flow of call-tone current at its upper contacts, at the same time closing a circuit for relay 2107. Relay 2107 now operates and reapplies the call-tone current at its upper contacts, at the same time locking itself to conductor 2124 and opening the circuit of call-signal relay 2105. Call-signal relay 2105 restores after a slight interval and terminates the two short applications of call-tone current (commonly referred to as a zip-zip signal). Relay 2107 remains locked to conductor 2124 until the slow-acting position start relay 2112 restores, whereupon relay 2107 restores.

When start relay 2112 restores, it disconnects the position start conductor 2033 from start lead 727, but this is of no particular concern, as the upper winding of start relay 716 of the finder F1 is now included in the previously described locking circuit. Start relay 2112 also ungrounds the distributor-start and marking conductors 2031 and 2032, whereupon stop relay 2025 restores, and relay 2021 restores also unless the distributor-start conductor is grounded at another position, in which event it remains operated and the distributor proceeds to preselect 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 main-exchange subscriber over the tip and ring conductors 729' and 728', 729 and 728, contacts of the split answer relay 2115, tip answer and ring answer conductors 724 and 722; to the positive and negative (tip and ring) conductors of the finder G1 by way of contacts of the actuated connecting relay 703. At this point it may be conveniently mentioned that the finder F1 being the answering switch, and the conductor FS1 being the calling switch, conductors and other equipment having to do particularly with the finder are referred to as answer conductors, while conductors having to do particularly with the portion of the connection to be extended by way of the selector FS1 are referred to as calling conductors.

The branch-exchange operator at position 1 now converses over the incoming trunk IT, Fig. 4, with the main exchange subscriber. It may be conveniently assumed that the branch-exchange subscriber at substation A1, Fig. 12, is the one desired, whose telephone number is 91225.

Upon ascertaining the number (91225) of the desired line, the operator proceeds to set this number up on a selected register sender by operating her digit keys DK, Fig. 22.

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, SL1 and SL2, Fig. 22. These sender links have access by means of link finders LF1 and LF2 to each of the nine links at the No. 1 position, of which the finder F1, Fig. 7, and the selector FS1, Fig. 8, is one. These sender links also have access by means of the sender selectors SSL and SS2 to a group of sender selectors provided for the common use of all of the operators.

The sequence relays 2201 and 2202 operate

automatically to render the links SL1 and SL2 effective alternately.

Returning now to the point at which the answer-pilot relay 2110 operated responsive to the switching-through operation at the finder F1, relay 2110 extends ground potential by way of contacts of call-pilot relay 2111 to link start conductor 2141. Assuming sequence relays 2201 and 2202 to be both restored, when conductor 2141 is grounded a circuit is closed through contacts of relay 2101 for relay 2102. Relay 2102 thereupon operates and closes a locking circuit for itself at its inner lower contacts through contacts of the key 2103 and the lower winding of relay 2201. This locking circuit includes the hold conductor 2142, which is grounded at the contacts of the transmitter-supply relay 2101 as long as the operator has her transmitter and receiver plugged into the illustrated jacks provided for this purpose. Relay 2201, however, does not operate in this locking circuit for the time being, as its lower winding is shunted by the ground potential supplied to relay 2202 in its initial circuit.

With sequence relay 2202 operated and sequence relay 2201 not operated, start relay 2205 of sender link No. 1 is operated through contacts of start relay 2207 to start the link into operation, responsive to which the link finder LF1 finds the preselected link, and the secondary switch SS1 finds an idle register sender, as will now be explained.

When start relay 2205 energizes, it closes a circuit from ground at contacts of start relay 2207 through contacts of error relay 2206 for switching relay 2208 in series with operating magnet 2210. Moreover, it connects the junction of switching relay 2208 and operating magnet 2210, through contacts of relays 2208 and 2207, to test wiper 2212, whereby switching relay 2208 is shunted and operating magnet 2210 operates in a buzzer-like manner to advance the wipers 2211 (in the event that the register sender on which the wipers are standing is busy, and the test contact is therefore grounded) until an idle register sender is reached.

When an idle register sender is reached (register sender RS, Fig. 23, for example) switching relay 2208 operates, since it is no longer short circuited. Upon operating, relay 2208 disconnects test wiper 2212 from the test circuit and connects it to ground, thereby grounding the test conductor 2312 of the seized register sender to mark the register sender as engaged.

As a further result of its operation, start relay 2205 closes a circuit for the lower or polarizing winding of the electro-polarized switching relay 2204; applies ground potential to the test winding of relay 2204 to enable it to test for the preselected link; and it closes a circuit through contacts of switching relay 2204 for operating magnet 2209. Magnet 2209 now operates in a buzzer-like manner to advance the wipers of the link finder LF1. This stepping operation continues until the wipers arrive on the set of terminals associated with the link composed of the finder of Fig. 7 and the selector of Fig. 8, which link has been preselected by the operation of talking key K2. At this time, the C wiper of the link finder LF1 encounters the negative marking potential placed on the C conductor of the group extending to the preselected link of Figs. 7 and 8. This marking potential was placed on the above-mentioned C conductor by the

operation of the connecting relay 703, and is obtained through contacts of link cut-through relay 708, the C lead of the selector FS1, Fig. 3, and off-normal contacts 818 of the selector, through the upper winding of series relay 805. Series relay 805 of the selector energizes when the wipers of the link finder LF1 arrive on the link, but without any particular effect at this time.

In the sender link SL1, Fig. 22, switching relay 2204 energizes in series with the above-mentioned series relay of the selector over the C wiper and associated C lead. Upon energizing, relay 2204 opens the circuit of operating magnet 2209 to terminate the hunting operation, and it closes a circuit through contacts of switching relay 2208 to light the sender pilot lamp 2211, thereby indicating to the operator that she may now begin to set up the digits in the desired number. It will be understood, of course, that this operation is ordinarily completed before the operator can obtain the necessary number information from the calling subscriber.

Relay 2204 also closes the remaining three of the six leads associated with the operator's key, the first three having been connected up upon the operation of relay 2208. The conductors A, B, C, and D coming from the digit-keys DK are now extended through wipers 2216, 2215, 2214, and 2213, to the corresponding conductors leading to the register sender RS, Fig. 23.

This register sender is prepared for operation, by the release relay 2201 of the sender control circuit, which is operated over test conductor 2312 (grounded as previously explained when the sender is seized). It grounds the ground-in and digit-control conductors 2326 and 2324, leading in to the register sender RS. This register sender is similar to the register sender shown in Figs. 7 and 8 of the United States patent to Peterson, 1,914,383, June 20, 1933. The register sender RS, however, has five digit registers, whereas the register sender as illustrated in the Peterson patent is provided with only four. Since all of the registers in this register sender are duplicates, it is merely necessary to provide as many as may be required, the number being determined by the maximum number of digits contained in a number to be set up on a register sender.

Setting and starting the register sender

As the operator manipulates the keys DK, Fig. 22, to set up the number 91225, the digits are set up in the register sender in the usual manner, as explained in the above mentioned patent to Peterson. The hold relay 2304 of the sender control circuit illustrated in Fig. 23 operates when the hold conductor 2325 becomes grounded in the register sender, as it does when the first digit is stored. This relay remains operated until the stored number has been completely retransmitted, at which time it restores when conductor 2325 is ungrounded in the register sender RS.

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 stored by an operation of the error key ER. This results in an operation of the error relay 2306 in the sender link SL1. Error relay 2306 opens the circuit of switching relay 2208, whereupon relay 2208 restores and frees the register sender RS and permits it to clear out, by releasing relay 2301. When the error relay 2206 is permitted to restore, upon the release of the error key, the sender of Fig. 23 is seized again (unless it has been

seized in the meantime by another sender selector, in which case another sender is seized) and again prepared for operation.

When the operator has completed the setting up of the number, she depresses the start key ST, thereby closing a circuit for the sender-start relay 2207 in the link SL1. Relay 2207 operates and locks itself at its inner contacts to ground at the upper contacts of the link start relay 2205. Start relay 2207 also extends a ground potential by way of wiper 211 to the start conductor 2311, while at its middle armature it applies ground potential directly to testwiper 4212 independent of the contacts of switching relay 2208 and opens an additional point in the hunting circuit of the secondary switch. Start relay 2207 also applies ground potential directly to the C wiper of the link finder LF1 to place a guarding potential on the associated marking conductor, at the same time opening the circuit of link start relay 2205 and of switching relay 2208. Switching relay 2208 restores immediately, and link start relay 2205 restores after a very slight interval. Upon restoring, link start relay 2205, among other things, opens the circuit of the polarizing and holding windings of switching relay 2204, whereupon this relay restores.

With relays 2204 and 2208 restored, the conductors associated with the digit keys DK are disconnected from the link SL1 so that the operator may now use these leads in a subsequent call in connection with link SL2.

With the start relay 2207 energized, and the remaining relays of the link SL1 restored, the test wipers 3 and 2212 of the switches LF1 and SS1 are grounded, and the negative, positive, and CT (cut-through) wipers of the link finder LF1 are connected by way of contacts of the energized start relay 2207 and contacts of the restored switching relay 2208 to the corresponding wipers 2214—2216 of the sender selector SS1.

In the sender control circuit of Fig. 23, the starting impulse occasioned by the depression of the start key, as above explained, and the consequent operation of start relay 2207 is received over the start conductor 2311 by the upper winding of transfer relay 2302. Relay 2302 operates and closes a locking circuit for itself and a holding circuit for start relay 2207 through the winding of the associated start relay 2303 and contacts of the operated hold relay 2304. Start relay 2303, however, does not operate until the start key SK, Fig. 22, is restored, at which time the previously existing shunt is removed from around the winding of start relay 2303 and this relay becomes operated in series with the windings of relays 2302 and 2307. Upon operating, relay 2303 closes an additional holding circuit through the lower winding of relay 2302, which circuit also draws holding current through the winding of relay 2207 in multiple with the upper winding of relay 2302, thereby assisting in holding these relays operated.

At its upper armature, start relay 2303 extends ground potential through the contacts of hold relay 2304 to start conductor 2323 of the register sender RS, thereby starting the retransmission of the stored digits. The retransmission of the stored digits takes place over the negative and positive impulse conductors 2321 and 2322, through contacts of the energized transfer relay 2302, conductors C and B, wipers 2214 and 2215, contacts of relays 2208 and 2207, the negative and positive wipers of the link finder LF1, and the associated negative and positive link conduc-

tors extending to the selector FSI, Fig. 8. The line relay 802 of the selector SSI is energized over the associated incoming talking conductors and from the above-mentioned impulse circuit of the register sender RS as soon as transfer relay 2302 has operated as above described. Upon operating, line relay 802 closes a circuit for release relay 803, whereupon the release relay 803 and the auxiliary release relay 804 operate and the selector is prepared for operation. This preparation of the selector for operation, it will be understood, occurs responsive to the depression of the start key as before explained and before the start key is released to remove the shunt from around start relay 2303 and thereby start the actual generation of impulses.

Clearing out the position equipment

As soon as she has started the sending operation as described, the operator may restore her talking key and permit the position equipment to clear out. When the talking key K2 is restored, connecting relay 703 is permitted to restore because its circuit is opened by the restoration of the talking key. Relay 703 disconnects the talking conductors of the link from the common position equipment and rejoins the calling and answering link talking conductors together; it disconnects position conductors 725, 726, and 727; and it extinguishes the group-identifying lamp IL2, previously lighted through lamp lead L, as explained. Switching and start relays 701 and 702 remain operated, and the latter relay maintains ground potential on conductor 718, maintaining the holding lamp 743 lighted for the time being to indicate that the extension of the call has not yet been completed.

In the position equipment of Fig. 21, talking relay 2104 restores when the talking key is restored, while the answer-pilot relay 2110 restores responsive to the associated release-answer conductor 726 being disconnected upon the restoration of the connecting relay of the link. The position equipment of Fig. 21 is now in normal condition in readiness for the operator to accept a further call. Ground potential is removed from sender control conductor 2141 when relays 2104 and 2110 restore, whereby the initial circuit of the operated sequence relay 2202 is opened and the shunt is removed from around the lower winding of relay 2201. Relay 2201 now operates in the locking circuit of relay 2202 (over grounded conductor 2142) preparatory to the subsequent selection of sender link SL2.

At the link SL1, the sender-pilot lamp 2211, which was lighted as soon as the link switches LF1 and SSI completed their selecting operation, remains lighted through the lower contacts of start relay 2207 and the associated resistor until the register sender RS has completed its operation, but the lamp is now lighted dimly because of the inclusion of the resistor in its circuit, which indicates to the operator that impulses are being transmitted through this link.

Clearing out the register sender and the sender link

As soon as the last stored digit has been transmitted, the register sender RS clears out and removes ground from the hold conductor 2325. When this occurs, hold relay 2304 falls back and opens the circuit of start relay 2303 to permit the sender control circuit and the sender link SL1 to clear out. At the same time, hold relay 2304 closes a cut-through circuit over the associated

A-conductor by way of contacts of the still operated transfer relay 2302, still held by the slow-acting start relay 2303. This circuit extends through wipers 2316 and CT of the switches SSI and LF1, and by way of the lead CT to the link-cut-through relay 708. Relay 708 operates through the associated resistor 746. At its lower armature, relay 708 extinguishes the hold lamp 743, as the connection has now been extended and it closes a locking circuit for itself and opens its initial circuit. Link cut-through relay 708 also disconnects the C lead of the associated selector FSI from the branch thereof accessible to the link finder and connects it to ground locally; at its two uppermost contacts it closes through the talking circuit; and at its inner upper contacts it extends ground potential through contacts of relays 704, 705, and 707 to pick-up relay 751 of the time switch TS for a purpose to be discussed shortly.

The clearing out of the sender-control circuit of Fig. 3 and the sender link SL, Fig. 22, now takes place responsive to the restoration of the slow-acting start relay 2303, which opens the holding circuit of transfer relay 2302 and the branch holding circuit for start relay 2207 of the link SL1. Relays 2302 and 2207 thereupon restore, returning the associated circuits to normal condition.

When the sender link SL1 is cleared out by the restoration of start relay 2207, the wipers of the link sender LSI are disconnected, and the bridge across the negative and positive talking conductors of the link shown in Figs. 7 and 8 is opened. The established connection is maintained through contacts of the operated relay 708 and over the talking conductors of the finder FI, and through the right-hand windings of the repeating coil 430 of the line circuit LC2. The electro-polarized supervisory relay 704 has its lower winding in series with the negative talking conductor of the link, shunted by a by-pass condenser. Relay 704 does not operate until a reply is obtained because of the normal polarity of the current-flow through its lower winding; its polarizing winding is energized from conductor 717 through contacts of start relay 707.

Automatic timed recall

Provisions are made for automatically recalling the branch-exchange operator at the end of a predetermined time interval in the event that no response is obtained. The way in which this is accomplished will now be brought out. It was previously pointed out that a ground potential was extended at the inner upper armature of link-cut-through relay 708 and through contacts of relays 704, 705, and 707 to pick-up relay 751 upon the operation of cut-through relay 708, at the termination of the sending operation. Pick-up relay 751 is normally connected through its own contacts to the common pick-up lead 758 of the time-impulser TI. In the time-impulser TI, a negative potential is normally on pick-up conductor 758 when the impulser is quiescent. Under this condition, the left-hand winding of relay 751 is energized over conductor 758, whereupon relay 751 operates and closes a locking circuit for itself through its two windings in series, disconnecting itself from conductor 758. Relay 751 connects up the common stepping conductor 760 to operating magnet 753 by way of bank contacts and wiper 756, and it places a ground potential on start conductor 759, at the same time opening a point in the circuit of release relay 752.

When start conductor 759 is energized, a cir-

cuit is closed through contacts of relay 764 for the weighted-contact of relay 762. Relay 762 operates, but the contact associated with the armature thereof is so weighted and adjusted as to vibrate for a period of about two seconds before it comes to rest to permit relay 763 to be operated. At the end of the two-second interval, relay 763 operates and closes a circuit for relay 764, whereupon relay 764 operates and breaks the circuit of relay 762, permitting this relay to restore. Upon the restoration of relay 762, relays 763 and 764 restore successively, (each relay being retarded somewhat by its indicated copper collar). When relay 763 restores it closes a stepping circuit through contacts of the still-operated relay 764 for operating magnet 753. Magnet 753 operates and closes a shunt around the wiper 766 and associated bank contacts to prevent opening of its circuit while the wiper is being moved from one contact to the next. When relay 764 restores it opens the stepping circuit and reapplies potential to the pick-up lead to permit the pick-up of a relay such as 751 associated with any other link with which the time impulser TI is associated. It will now be seen that the wipers 755, 756, and 757 are advanced one step by magnet 753 each time the time impulser goes through its cycle of operations, which it does approximately every two seconds. Therefore, at the end of about eighteen seconds the wiper 757 will have made nine steps to reach its tenth contact. At this time wiper 756 engages a disconnected contact, so that no further stepping can take place. Wiper 757 extends the flash lead 751 to the previously extinguished hold lamp 753, causing this lamp to flash as an indication to the operator that the extended call has not been answered in the prescribed time, whereupon the operator may throw her talking key K2 and converse with the calling subscriber with a view of extending the call to some other branch-exchange line, it being well understood that in branch-exchange practice the public-exchange subscriber may be seeking information which may be given by any one of a number of branch-exchange subscribers. The way in which the extended connection is broken down and a new extension is built up from the calling public-exchange line will be covered by subsequent explanation. Ordinarily the call is answered in a reasonable time, in which event the time switch TS, Fig. 7, is not permitted to advance to recall position, before it is released by supervisory relay 704.

The setting up of the connection responsive to the transmission of the number 91225 by the register sender RS will now be described.

When the first digit 9 is delivered by the register sender RS of Fig. 23, line relay 802 of the first selector FS1, Fig. 8, is deenergized nine times momentarily, thereby delivering nine impulses of current to vertical magnet 808, as a result of which the wipers 800 are raised opposite the ninth level of bank contacts and the ninth-level spring 814 is shifted to its alternate position to cause the first digit to be absorbed, as explained in connection with the first selector FS5, Fig. 12. When the selector FS1 thus restores to normal, the drop-back relay 806 operates in series with release magnet 809 and locks itself at its upper contacts, thereby adapting the selector for operation as a regular selector without the drop-back feature.

When the second digit 1 is transmitted by the register sender, line relay 802 deenergizes once momentarily, bringing the wipers 800 opposite the

first level of bank contacts. The operation of rotary magnet 810 is initiated by the restoration of series relay 805, and the rotary movement continues until the C wiper of the selector encounters an idle-indicating potential on the C conductor of an idle second selector in the "91" group, the second selector SES, Fig. 18, for example. At this time, the electro-polarized switching relay 807 operates and switches the connection through to the seized second selector, permitting relays 802—804 and 806 of the selector FS1 to clear out.

Class recording in incoming calls

At this point, it is convenient to explain how class recording in incoming calls is effected. It is to be noted that the terminal of group 400 engaged by the discriminating wiper D of finder wipers 700 is connected to ground, while the corresponding terminals of groups 300, 500, and 600, associated with the other illustrated line circuits are left disconnected. By this arrangement, wiper D of the finder F1 encounters a group potential only in the event that the call being answered is a call incoming from the public exchange. By this arrangement, discriminating or class-recording relay 801 of the first selector FS1 is operated only in the event that the finder F1 is actuated to answer an incoming call, as in the call now being described. With relay 801 in operated condition, ground potential by way of the upper contacts of release relay 803 is applied to the EC wiper of the wipers 800 of selector FS1 when the switching relay 807 energizes as above pointed out. This application of ground potential to the EC wiper of the selector FS1 results in the closure of a circuit over the EC lead of the seized second selector SES for the class-recording relay 1805. Relay 1805 thereupon operates and locks itself through both windings in series to the incoming C lead, thereby recording that the call now being handled is a call incoming from the public exchange. It is to be particularly noted that the recording impulse transmitted by the selector FS1 is terminated after a short interval, upon the restoration of release relay 803 responsive to the operation of switching relay 807.

Responsive to the impulse series representing the third digit 2 in the desired number, the second selector SES is operated as hereinbefore described to raise its wipers to the second level and seize a local connector in group 912. It may be conveniently assumed, as in the example previously described, that the local connector LOC1, Fig. 19, is the one seized.

In the present example, the class-recording relay 1805 of the selector SES is in operated condition. Therefore, a ground potential is being maintained on the incoming EC lead of the selector SES by relays 1803 and 1805. Under this condition, the operation of switching relay 1806 results in the momentary application of ground potential through the EC wiper and the EC terminal in group 1851 to the incoming EC lead of the connector LOC1, Fig. 19. Under this condition, the class-recording relay 1907 of the connector is operated from the incoming EC lead through off-normal contacts 1924. Relay 1907 locks itself through contacts of the auxiliary release relay 1905, which relay is operated in the described manner upon the seizure of the connector.

The call impulse delivered over the EC lead by the second selector SES is terminated as soon as relay 1803 falls back, which it does shortly after the operation of switching relay 1806.

Responsive to the trains of impulses representing the two final digits 2 and 5, in the desired number, the local connector LOC1 operates as previously described to raise its wipers 1900 opposite the desired level and rotate them into engagement with the terminals of the desired line. With the class-recording relay 1907 operated, the EC wiper of the connector is connected to the lower winding of class-test relay 1908, as soon as rotary series relay 1914 restores at the end of the rotary movement. The class-test relay 1908 operates or not, depending upon whether the line being called is entitled to receive incoming calls or not. In the assumed example, the called line is the line of substation A1, Fig. 12. Since this line is a non-restricted line, the terminal now engaged by the EC wiper of the connector LOC1 is left disconnected instead of being connected to ground, as in the case of the corresponding terminal of a restricted line. Therefore, class-test relay 1908 is not operated and the connection is completed to the line and the called subscriber is signalled, all as hereinbefore described.

25 Preventing incoming connections to restricted lines

When the operator, in extending an incoming call, inadvertently sets up the number of a restricted line, the connection is prevented because the EC wiper of the connector (connector LOC1, Fig. 19, for example) encounters ground potential on the corresponding terminal of the called line. It is to be noted that the EC terminal of the group shown in association with the restricted line of substation A2, Fig. 12, is connected to ground. All other lines restricted as regards this class of service are similarly provided with a ground connection. Under this condition, when rotary series relay 1914 restores, and with class-recording relay 1907 operated as before pointed out, class-test relay 1908 operates and closes a circuit for the upper winding of busy-test relay 1913 by way of contacts of switching relay 1908 and the upper armature of relay 1905 to ground. The busy test relay 1913 causes a busy tone to be applied to the lower talking conductor as hereinbefore pointed out, while the connection is denied because busy relay 1913 maintains one terminal of the idle-test relay 1917 disconnected to prevent seizure of the line.

Recall of the operator by the public-exchange subscriber

In the event that the called line is busy and the busy tone is returned to the calling public exchange subscriber, or in the event that the operator has inadvertently set up the connection to a restricted line, in which case the busy tone is returned also, as above pointed out, the public exchange subscriber may immediately recall the branch exchange operator without waiting for the timed recall operation to take place. He does this by turning his calling device, by means of which impulses of sufficient potential are induced to cause the ring-up relay 401 to operate. Upon operating at this time, ring-up relay 401 closes a locking circuit for itself through contacts of the operated cut-off relay 403, over the associated EC lead, the EC wiper of the finder F1, contacts of relay 706, and through contacts of the talking key K2, to the supervisory lamp 741. Supervisory lamp 741 becomes lighted in the locking circuit of the above-mentioned ring-up relay 401 to serve as a recall signal to the operator. When the operator responds, the operation

of the talking key K2 opens the circuit of lamp 741 and the locking circuit of relay 401, permitting relay 401 to restore. The operator may then break down the busy connection and re-extend the incoming call to another line, in a manner to be subsequently pointed out.

Assuming now that the called line is idle, the ringing operation proceeds in the usual manner until the calling subscriber answers.

When the call is answered, the current-flow is reversed in the incoming conductors of the local connector LOC1, Fig. 19, by supervisory relay 1901, as pointed out in the previous description of the operation of this connector. When this reversal of current-flow takes place, the electro-polarized supervisory relay 708 in the finder F1 operates and closes a circuit for answering supervisory relay 705. Relay 705 operates and prepares a circuit for disconnect supervisory relay 706. It is to be noted that the circuit of pick-up relay 751 is opened upon the operation of relays 704 and 705, whereupon relay 751 restores and disassociates the time switch TS from the time-impulser TI. Release magnet 754 operates through contacts of relay 751 and the associated off-normal contacts 754 to restore the wipers 755-757 to normal position, whereupon the release magnet circuit is opened at off-normal contacts 754.

Local transfer service during an incoming call

For the purpose of explaining the previously mentioned transfer feature of the local connector LOC1, Fig. 19, it will be assumed that the called subscriber at substation A1 discovers during the conversation with the public exchange subscriber that he needs to secure additional information locally before continuing with the conversation. In this event the subscriber at substation A1 sets up a transfer connection between his line and another branch-exchange line, while the incoming main exchange connection is held.

To initiate the transfer connection, the subscriber at substation A1 momentarily depresses his grounding push-button, thereby unbalancing the current-flow in the windings of the differential transfer control relay 1926 of the connector LOC1. Relay 1906 is therefore momentarily operated to close a circuit through the upper winding of the two-step transfer relay 1910. The two-step transfer relay 1910 is operated through its first step when the circuit is closed for its upper winding, closing a locking circuit for both windings in series. This locking circuit becomes effective when transfer relay 1926 restores and removes the shunt from around the lower winding, whereupon relay 1910 operates fully and transfers the called line from the incoming conductors of the connector to the lineswitch LS4, Fig. 12. This lineswitch operates in the usual manner to take a first selector for use, whereupon ground potential is returned over the C lead thereof to provide a holding circuit for the upper winding of relay 1908. Back-bridge relay 1903 restores when the connection is transferred, but no harm results as relay 1903 is held operated over the C lead as above pointed out to maintain the auxiliary release relay 1905 operated, while transfer relay 1910 maintains the supervisory relay 1901 operated to avoid giving the branch exchange operator a disconnect signal.

After the subscriber at the called substation A1, Fig. 12, has established the transfer connection and has completed the conversation thereover, he again momentarily depresses the

push button at his substation, again momentarily operating the transfer control relay 1926. At this time, relay 1926 closes a circuit through contacts of the operated transfer relay 1910 for transfer-release relay 1909. Relay 1909 operates and opens the initial locking circuit for transfer relay 1910, closing a new locking circuit for it in parallel with relay 1909. Then, as soon as relay 1926 restores, the transfer relay 1910 restores, while slow-acting transfer-release relay 1909 restores a moment later. Back-bridge relay 1903 reoperates as soon as transfer relay 1910 restores and takes over the holding of relay 1908 and the holding of supervisory relay 1901, before the slow-acting transfer relay 1909 has restored.

The interrupted conversation with the calling main exchange subscriber may now be resumed.

20 *Passing an incoming call to a second line*

For the purpose of explaining an additional feature of the disclosure, it will be assumed, that the called subscriber discovers that another branch-exchange subscriber should take over the conversation with the main exchange subscriber. Under this condition, in order to recall the branch-exchange operator, the subscriber at substation A1 turns his calling device in accordance with a digit (the digit 5 for example), whereupon back-bridge relay 1903 is restored and reoperates a number of times. The combined class-test and back-release relay 1908 remains operated during impulsing, being a slow releasing relay because it is provided with a conducting sleeve as indicated. Supervisory relay 1901, however, restores and reoperates each time the circuit is opened and reclosed by back-bridge relay 1903. By this operation, a number of reversals in the current flow in the incoming conductors of the connector are produced.

In the operator's link, Fig. 7, momentary reversal in current-flow results in the restoration and reactuation of electro-polarized supervisory relay 704 of the operator's link. The first time it restores, relay 704 closes a circuit through contacts of the slow-acting answering-supervisory relay 705 for disconnect supervisory relay 706. Relay 706 thereupon operates and closes a locking circuit for itself at its inner lower armature. As soon as relay 706 operates, the supervisory lamp 341 is connected in multiple with the winding of relay 705, whereby lamp 741 flashes during the remaining impulsing operations of relay 704. When the impulses cease and relay 704 becomes operated steadily, supervisory lamp 741 becomes lighted steadily, as a recall signal.

Upon noting the recall signal, the operator again throws her talking key K2, whereupon lamp 741 is extinguished at the contacts of the key. At the same time, connecting relay 703 operates to associate this link with the operator's position equipment, being operated in the hereinbefore described manner over test lead 733 contained in cable 3. At the contacts of relay 730, ground potential is removed from the armature of supervisory relay 704 and from the locking armature of relay 706, whereupon relays 705 and 706 restore.

Identity lamp IL2, Fig. 4, is relighted over the L lead and through contacts of connecting relay 703 to remind the operator of the group identity of the calling trunk.

In the position equipment of Fig. 21, the answer pilot relay 2110 is operated over the release-answer conductor 726 and in parallel with

resistor 716 of the link, while the call pilot relay 2111 is energized over the release-call conductor 725 in parallel with the current-supply resistor 746 associated with link-cut-through relay 708. The energization of these two relays conditions the circuit arrangement in the position equipment in accordance with the condition now existing in the link circuit, which condition is that an incoming call has been answered and has been extended. Under this condition an invasion signal is applied to the connection by the operation of ticker relay 2103 through contacts of relays 2111, 2115, and 2116, as will be discussed subsequently.

Upon conversing with the called branch-exchange subscriber and learning to whom the incoming call should be passed, the operator throws the release-call key K9 to release the extended branch exchange connection. The release key K9 operates the split call relay 2116, thereby disconnecting the tip and ring calling conductors from the operator's headset and from the answering end of the connection, thereby isolating the disturbances occasioned by the release of the connection. Release-call key K9 also places a ground potential on the release-call conductor 725, thereby shunting the winding of link-cut-through relay 708 and causing this relay to restore. When relay 708 restores, it opens the previously established locking circuit for itself and recloses a circuit for the hold lamp 743, in addition to ungrounding the c lead of the selector PSI and opening the talking conductors to allow the extended connection to release.

When the operator restores her release call key K9, the split call relay 2116 restores, and the call pilot relay 2111 restores because link cut-through relay 708 has been unlocked and there is no longer current-flow through the resistor 746 to afford a potential drop for maintaining the call pilot relay 2111 operated. With relay 2111 restored, the previously mentioned invasion signal is no longer applied.

With the answering pilot relay 2110 operated and call pilot relay 2111 restored, the ground potential placed on the conductor 2123 by the operated talking relay 2104 is extended to the sender-control conductor 2141 to again bring about the selection of an idle sender. It has previously been mentioned that sequence relays 2101 and 2202 operate to render the links SL1 and SL2 effective alternately, and it has been explained in detail how relay 2202 operates to render the link SL1 effective when conductor 2141 becomes grounded at a time when both of the relays are restored. It was pointed out further how that relay 2201 is operated in series with relay 2202 in the locking circuit of the latter relay when ground potential is removed from sender-control conductor 2141 after relay 2202 has been operated. In the previous discussion of these relays, the relays were both operated in series over conductor 142 after the sender had been used. In order to complete the description of the operation of the sequence relays, it will be assumed that these relays are now both energized and are being held operated over conductor 2142 through contacts of key 2203 and the inner lower contacts of relay 2202. Under this condition, the grounding of the control conductor 2141 results in the closure of a holding circuit for relay 2201 through the inner upper armature of this relay, while the ground potential is extended through the middle upper armature of relay 2201 to the junction of relay 2202 and the associated resistor, 75

thereby shunting relay 2202 and bringing about its restoration and the opening of its previously existing locking circuit.

With relay 2201 in an operated condition and relay 2202 restored, the sender link SL2 is rendered effective through the lower contacts of these relays, whereupon the sender link SL2 operates in the manner described for the sender link SL1. More in particular, the sender selector SS2 selects an idle sender such as the one shown in Fig. 23, while the link finder LF2 finds the link of Fig. 7 (of which the talking key is operated). When these operations have been completed, the sender pilot lamp 2141 becomes lighted to indicate that the operator may now set up the digits of the desired number on the digit keys DK.

Following the setting up of the number the operator manipulates her start key SK to start the sending operation, which sending operation takes place as hereinbefore described. The new extension of the incoming connection to the alternative branch exchange line is thereby effected through the operation of the automatic switches.

When ground potential is next removed from sender-control conductor 2141, relay 2201 restores preparatory to the operation of sequence relay 2202 the next time the talking key of an idle link is thrown.

The invasion signal

As in the application of Thomas F. Crocker, 759,643, December 29, 1934, this system provides for the transmission of an invasion signal to the conversing subscribers in the event that the operator throws her talking key to listen in on an established connection. Since in the system herein disclosed an answering supervisory is not obtained on all calls, the application of the invasion signal is made dependent upon the link-cut-through relay 708 having operated. By this arrangement, in the event that the operator operates the talking key of the link after the link-cut-through relay has operated, or in the event that she fails to restore her talking key until after the link-cut-through relay has operated the invasion signal is applied; the link-cut-through relay does not operate until all of the digits of the desired number have been transmitted.

In order to explain this feature it will now be assumed that the operator desires to leave her talking key thrown after the number has been completely sent out by the register sender in order to determine whether or not the called line is busy. The operator will most likely do this in practice because the original call has been now passed to a new line, and she may be required to pass the call to a third line or back to the first called line in the event that the second called line is busy.

With the talking key K2 and the associated connecting relay 1103 still operated, when link-cut-through relay 708 operates, call pilot relay 2211 is operated over the release call conductor 725 in parallel with resistor 146. When call pilot relay 2211 operates, sender-control conductor 2141 is ungrounded, and a circuit is closed for ticker relay 2103 by way of contacts of the split relays 2115 and 2116. Ticker relay 2103 upon operating closes a short circuit around its winding, causing it to restore. This relay is provided with a conducting sleeve as well as a conducting collar, as indicated, rendering the action

rather slow, so as to give a low ticking signal which, although noticeable, does not preclude conversation. Each time it operates, relay 2103 closes a circuit through the tertiary winding of the induction coil I, through the left-hand winding of repeating coil RC, to battery by way of contacts of the monitoring relay 2102 and the current-limiting resistor 2161. The clicks (or ticks) produced by the closing and opening of this circuit are transmitted through the secondary windings of the induction coil IC to the talking circuit, being heard in the receiver of the operator as well as in the receiver of the calling public-exchange subscriber. As soon as the called branch exchange subscriber replies, he also may hear the ticking invasion signal and be notified thereby that the operator is in telephonic communication with the extended connection.

Since the invasion signal is intended solely for the purpose above pointed out of preventing eavesdropping, arrangements are placed at the disposal of the operator for accomplishing the instant desired result without causing this signal to be given. Since the operator is officially interested only in determining whether or not the call is extended to the desired line and is answered by the desired subscriber, she may operate the cut-off answer key K3 to disconnect the answering end of the link from her head set conductors and to split the link, in which case the invasion signal is not applied.

When the cut-off answer key K3 is thrown, the resistor R9 is bridged across the associated normally disconnected branches of the tip and ring answer conductors and a circuit is closed for the split answer relay 2115. Upon operating, split answer relay 2115 disconnects the tip and ring answer conductors from the tip and ring call conductors and from the conductors of the operator's head set and extends them to the resistor R9 by way of the contacts of the key K3, so as to maintain these conductors bridged, which operation is not required, however, in the instant call. Relay 2115 opens the circuit extending to ticker relay 2103, thereby terminating or preventing the operation of this relay.

If the called line is busy, the operator hears the busy-tone signal. In this event she may clear out the call in the manner before explained by operating the release call key K9, and then extending the call to another line.

Assuming that the called line is idle and that the call is answered, the operator may converse with the answering subscriber and ascertain whether or not he is the one for whom the call is intended.

The operator may restore the talking key K2 and the cut-off answer key K3, placing the link circuit of Fig. 7 in talking condition and clearing out the position equipment of Fig. 21.

Normal clear-out of an extended incoming call

The way in which an extended incoming call is normally cleared out will now be explained.

Assuming that a call has been extended through the link circuit of Figs. 7 and 8 as hereinbefore described, and that the called subscriber replaces his receiver at the end of the conversation. In this event, supervisory relay 704 restores and closes a circuit through contacts of slow-acting answering-supervisory relay 705 for disconnect-supervisory relay 706. Relay 706 thereupon operates and places a ground potential upon the second contact in the bank of

wiper 752 preparatory to clearing out the connection after the lapse of an interval of about two seconds. Since electro-polarized relay 704 does not reoperate to maintain relay 705 operated, supervisory lamp 741 is not lighted, and relay 705 restores after a slight interval and extends ground potential to pick-up relay 751, causing this relay to be operated over pick-up conductor 758 to start the time-interrupter TI and to place the time switch TS under the control of this interrupter.

About two seconds after pick-up relay 751 is operated, a stepping impulse is received over conductor 760 as explained hereinbefore, causing magnet 751 to step the wipers 755—757 one step. These wipers are normally standing on the first group of associated bank contacts, and the first step of the wipers brings wiper 735 into engagement with the second associated bank contact, which is now grounded through contacts of disconnect supervisory relay 706. Therefore, ground potential is applied through wiper 753 to the junction of the upper winding of start relay 702 and resistor 716. Relay 702 is thereby shunted and caused to restore to clear out the link.

It is to be noted particularly that the time interrupter TI is so arranged that the minimum time interval is always introduced thereby even though the time interrupter be operating in conjunction with another link circuit at the time ground potential is extended to pick-up conductors 751. During the operation of the time interrupter, the pick-up lead 758 is energized only while relays 763 and 764 are both restored, at which time the stepping conductor 760 is disconnected at contacts of relay 764. When relay 764 operates and opens the pick-up lead, it opens the stepping lead, following which relay 764 operates and opens a further point in the pick-up lead. Following this, relays 762 and 763 restore successively, and an impulse is delivered over stepping conductor 760, but the pick-up lead is still maintained open and is not reclosed until after the stepping impulse has been terminated. By this arrangement, after a pick-up impulse has been received to operate a pick-up relay such as 751, a stepping impulse is not received over conductor 760 until the full time interval of the timer has elapsed.

When start relay 702 restores as above pointed out, it opens the circuit of switching relay 701 at its lower armature and closes a circuit for release magnet 711 through off normal contacts 713. Relay 701 restores and disconnects the negative and positive wipers, while magnet 711 operates to restore the wipers to their normal position, whereupon the off-normal contacts 713 open the circuit of the release magnet. The removal of ground potential from the conductor 718 by start relay 702 results also in the restoration of the locked link-cut-through relay 708, and this relay restores also. Since the established branch exchange connection has been held by current flow over the talking circuit through the right-hand winding of the repeating coil 530, this connection is now cleared out. Switching relay 807 of the first selector FS 1 restores when the C lead becomes ungrounded, thereby closing a circuit through off-normal contacts 817 to cause release magnet 809 to restore the selector to normal position.

The busy lamp 742 becomes extinguished when conductor 717 is ungrounded by start relay 702,

whereby the operator is informed that the link is available for further use.

The hereinbefore described removal of ground potential from conductor 718 of the finder removes ground potential from the C wiper of the finder and consequently from the C lead of the link circuit LC2, whereupon the circuit of the lower winding of start relay 402 and the circuit of cut-off relay 403 are opened. Relay 402 restores immediately, but the slow-acting cut-off relay 403 does not restore until after the lapse of a substantial interval. When relay 402 restores it opens the loop across the incoming conductors at its inner upper armature, and it also disconnects ring-up relay 401 from in bridge of the incoming conductor to prevent a spurious operation of this relay which may otherwise be occasioned by the clearing out operation in the public exchange. After an interval, slow-acting cut-off relay 403 restores again preparing a locking circuit for ring-up relay 401, and again bridging the lower winding of ring-up relay 401 across the incoming conductors.

The opening of the bridge at the inner upper contacts of relay 402 gives disconnect supervision in the public exchange.

Calling to a distant branch exchange

The way in which calls are completed to one of the distant branch exchanges forming detached parts of the branch exchange system herein disclosed will now be described. These distant branch exchanges may be either manual or attended automatic branch exchanges of common construction. They are connected with the disclosed branch exchange by inter-branch-exchange trunk groups varying in size from one or two trunks to as many as ten.

As pointed out before, the lines leading to the distant branch exchange are accessible from a group of connectors reached by the dialling of the digits 9 and 9, of which the connector BC, Figs. 2 and 14, is one. As shown in Fig. 2, the line circuit LC 4 (and associated inter-branch-exchange line) is reached from the connectors by way of trunk 1451, which is indicated generally as accessible from any one of the first three levels of the connectors TC and BC, while on the fourth level the connector TC has access to toll lines which are not connected into the banks of the connector MC, as it is desired to have the operator set up toll connections.

For the purpose of explaining the operation of the branch exchange equipment in calling an inter-branch-exchange line, it will be assumed that the subscriber at substation A2, Fig. 21, desires to be connected with a subscriber in branch exchange 9931, in which case the subscriber at substation A2 removes his receiver and dials the number 9931.

When the receiver is removed, the calling line is extended automatically to a first selector, the illustrated first selector FS1, for example. This selector operates in the hereinbefore described manner in response to the first digit (9), being restored to normal position automatically at the end of this digit preparatory to responding to the second digit (9). When the second digit (9) is dialled, the selector does not again restore to normal position but rotates in a hereinbefore described manner to select an idle trunk, as the drop-back relay 1205 has operated and prepared the selector for normal rotation on the ninth level when the second digit (9) is dialled. Assuming that the branch-exchange connector

BC is the first to be found idle when the selector FS5 searches over the ninth level, this connector is seized by the selector of Fig. 12 at the terminals 1400, idle-indicating potential being normally applied to the C conductor of the connector BC by way of the upper winding of vertical series relay 4103, off normal contacts 1415, and make-busy key 1419. Relay 1403 operates. It is to be noted that the EC terminal in group 1400 is not used, as there is no need for an EC conductor in calls completed through this connector.

Line relay 1401 of the connector BC energizes over the incoming talking conductors and closes a circuit for release relay 1402, whereupon relay 1402 operates and prepares the connector for operation, at the same time placing a holding ground potential on the incoming C conductor.

When the tens digit (3) is next dialled, line relay 1401 restores three times momentarily, each time closing a circuit through contacts of the operated relays 1402 and 1403 for vertical magnet 1411. Vertical magnet 1411 raises the wipers 1450 opposite the third level of bank contacts. Vertical series relay 1403 is maintained operated throughout the vertical movement, at the end of which it restores and transfers the operating circuit to the rotary magnet 1412.

When the final digit (1) is dialled the single impulse delivered by relay 1401 passes through contacts of busy test relay 1405, rotary-series relay 4106, and contacts of switching relay 1410 to rotary magnet 1412. The rotary magnet is energized to bring the wipers 1450 into engagement with the first set of bank contacts in the third level, assumed to be the set of contacts from which the trunk line 1451 extends to the illustrated I. M. X. line by way of the line circuit LC4, Fig. 6.

Rotary series relay 1406 operates to bring about the operation of the auxiliary relay 1407. Relay 1407 connects the C wiper of the connector to best-test relay 1405, at the same time preparing a circuit for stepping relay 1408.

In the event that the first trunk line of the group is busy, busy relay 1405 is then in energized condition when the wipers come to rest. Under this condition, when rotary series relay 1406 falls back it connects the still-operated auxiliary relay 1407 in multiple with rotary magnet 1412, at the same time connecting stepping relay 1408 by way of the inner upper contacts of magnet 1412 and contacts of relays 1406 and 1405, to the S, or stepping, wiper. The contacts encountered by this wiper are strapped to the C lead of the associated trunk line, with the result that the ground potential on the C lead of the busy trunk line is encountered by the stepping wiper to operate the stepping relay 1408. Relay 1408 operates to close a locking circuit for itself at its upper contacts, while at its inner contacts it closes a circuit for rotary magnet 1412 to cause the wipers to be advanced another step, which circuit also extends now to auxiliary relay 1407 to maintain it operated and to thereby maintain the busy test relay 1405 connected to the C wiper. Stepping relay 1408 falls back when the rotary magnet 1412 operates, whereupon the rotary magnet circuit is opened.

The rotary movement continues by the interaction of relay 4108 and magnet 1412 until an idle line of the desired group is reached, or until the last line of the group is reached. As is common practice in grouped lines, the intercontact jumper is omitted at the last line of the group,

resulting in the cessation of the stepping movement when the last line is encountered, even though this line is busy. Under this condition, busy test relay 1405 remains operated, but auxiliary relay 1407 (which has been held operated in parallel with magnet 1412) restores. Upon restoring, auxiliary relay 1407 completes the locking circuit for busy relay 1405 by way of the upper contacts of release relay 1407. Busy relay 1405 is therefore locked locally and is disconnected from the C wiper of the connector. Busy relay 1405 maintains the rotary magnet circuit open at its lower contacts to guard against further operation in case the called subscriber again turns his calling device, while at its upper contacts common busy-tone conductor 1417 is connected to the associated talking conductor to return the well-known busy tone signal.

It may now be assumed that the line 1451 is idle when the number is dialled as above described, in which event busy relay 1405 is not operated. Under this condition, when relays 1406 and 1407 restore the latter relay connects idle-test relay 1409 between ground at the upper contacts of release relay 1402 and the C wiper, closing an operating circuit for idle-test relay 1409 over the associated C lead. Relay 1409 closes a circuit for switching relay 1410, whereupon relay 1410 energizes and connects up the negative and positive wipers. At this time, the negative wiper is connected to ground and then positive wiper is connected to the common ringing lead at the upper contacts of the slow-acting splash-ring relay 1404, initially energized on the seizure of the connector and by way of contacts of release relay 1402 and contacts of switching relay 1404. By this arrangement, an application of ringing current is made as soon as switching relay 1410 operates. This application of ringing current is terminated as soon as relay 1404 falls back responsive to being disconnected from the associated grounded conductor when switching relay 1410 operates. The blocking condenser 1418 permits ringing current to pass back to the calling line to serve as an indication of the application of ringing current. Relay 1410 also disconnects rotary magnet 1412, as well as preparing a circuit to be pointed out subsequently for use in recalling the distant branch-exchange operator.

In the line circuit LC4, Fig. 6, when the trunk 1415 is seized as above mentioned, cut-off relay 602 is operated over the incoming C lead through the inner upper armature of start relay 604. Upon operating, cut-off relay 602 disassociates start relay 604 and prepares operating and locking circuits for auxiliary relay 603.

When the above mentioned impulse of ringing current is received from the connector by way of trunk conductors 1451, the ringing current is repeated through the repeating coil 640 to the associated conductors outgoing to the manual exchange to operate the usual call apparatus thereat.

When the operator in the manual branch exchange replies, line relay 601 operates and closes a circuit for auxiliary relay 604, whereupon this relay operates and locks itself at its inner lower armature.

The conversation over the established connection may now take place with the distant branch exchange operator, who may extend the connection in the usual manner.

Recalling the distant branch-exchange operator

If the calling subscriber at substation A2 de-

sires to re-signal the distant branch exchange operator, he may do so by dialling a digit. By this operation, line relay 1401 of the branch-exchange connector restores momentarily one or more times. Each time it restores, it closes a circuit for the lower winding of vertical series relay 1403 by way of contacts of the operated release relay 1402 and the lower armature of the operated switching relay 1410. With vertical series relay 1403 operated, and with switching relay 1410 in operated condition, each time line relay 1401 re-operates at the termination of an impulse, it closes a circuit in parallel with release relay 1403 for temporarily reoperating the splash-ring relay 1404 to apply ringing current to the called inter-branch-exchange line for resignalling purposes. The resigalling arrangement above-mentioned has been arranged in the manner illustrated to depend upon the reoperation of line relay 1402 in order to prevent an inadvertent operation of the splash-ring relay 1404 when the receiver is replaced at the calling substation.

When the calling subscriber replaces his receiver at the end of the conversation, the line and release relays 1401 and 1402 of the connector BC restore, and relay 1402 removes ground potential from the incoming C lead to permit the preceding switches to clear out. Relay 1402 also unlocks the operating switching relay 1410 to free the line circuit LC4, Fig. 6. Release magnet 1413 operates through off-normal contacts 1414 to restore the switch to its normal position, whereupon the release-magnet circuit is opened at off-normal contacts 1414.

In the line circuit LC4, cut-off relay 602 restores when the connector is cleared out as above mentioned. The line relay 601 and the locked auxiliary relay 603, however, remain operated until the operator in the manual branch exchange takes down the connection. When cut-off relay 602 restores, start relay 604 operates through the lower contacts of relays 601 and 602 and places a guarding ground potential on the C lead of group 1451. The circuit is not placed in finder starting condition because relay 603 remains operated through its own inner lower contacts and those of line relay 601.

When the distant operator takes down the connection, relays 601-603 clear out.

Incoming calls from distant branch exchanges

The way in which calls incoming from distant branch exchanges are handled will now be pointed out. For this purpose, it will be assumed that the inter-branch-exchange line associated with the line circuit LC4, Fig. 6, is taken for use in a distant branch-exchange.

When the two-way, inter-branch-exchange line associated with the line circuit LC4 is taken for use in the distant branch-exchange, line relay 601 operates and closes a circuit through contacts of cut-off relay 602 for the start relay 604. Start relay 604 closes a circuit for the group-call lamp 334, position 1, and for the similar group call lamps at the other positions; it places a ground potential on start conductor 611 to bring about the starting of a finder; it connects the C lead associated with the finder terminals 600 with the winding of cut-off relay 602 so as to mark the line circuit LC4 as calling; and it disconnects the C lead of the local trunk 1451 from cut-off relay 602 and connects it to ground, thereby guarding the line from seizure by the connectors of the local branch exchange.

When the line circuit LC4 is found by a searching finder (by way of the terminals 600 or multiples thereof), cut-off relay 602 is operated over the C lead and through contacts of auxiliary relay 603 and of the energized start relay 604. Upon operating, the cut-off relay 602 locks itself directly to the C lead associated with the finders; it disconnects start relay 604 at its lower armature and closes an operating circuit for auxiliary relay 603. Start relay 604 now falls back and auxiliary relay 602 operates, whereby the finder-starting condition in the circuit is terminated and the group-call lamp GC4 becomes extinguished. The identity lamp IL4 at position 1 (assuming that the line circuit is found by a finder in position 1) is lighted over the associated L lead, which appears at position 1 only, similar leads being provided at the other positions for the identity lamps thereat.

After the connection has been extended, the switches of the local branch exchange are held through the loop including the right-hand windings of the repeating coil 630.

The extended connection is broken down automatically by the action of the supervisory relay (relay 704 of the link of Figs. 7 and 8) in the event that a response is obtained, while the connection is broken down under the control of the local operator, as hereinbefore pointed out in the event that the called line is busy or the called subscriber does not reply.

In the event that the inter-branch-exchange line is freed at the distant end before the extended connection is broken down, line relay 601 restores, but cut-off relay 602 remains operated and holds the auxiliary relay 603 operated. The inter-branch-exchange line is therefore held guarded locally and a reoperation of start relay 604 is prevented in the event that the line is again taken for use in the distant branch exchange.

In the event that the extended connection is broken down before the inter-branch-exchange line is freed at the distant branch exchange, cut-off relay 602 restores, but auxiliary relay 603 remains locked through its inner lower contacts and the inner lower contacts of line relay 601. Under this condition, the C lead associated with finder terminal 600 is disconnected at the upper contacts of cut-off relay 602 to avoid the marking of the line circuit LC4 as calling in the finder banks, but the removal of ground potential from the C lead of the conductors associated with finder terminals 600 and the consequent restoration of cut-off relay 602 removes the guarding potential from the C conductor in group 1451, whereby the inter-branch-exchange line is rendered available again to the local connectors. By this arrangement, the line may be seized before the connection is taken down at the switchboard of the distant branch exchange operator, which arrangement is calculated to speed up the service somewhat during heavy traffic.

When line relay 601 restores under the conditions assumed above (assuming that the trunk line is not seized locally in the meantime) auxiliary relay 603 restores, returning the line circuit to normal condition.

Offering calls to busy lines

Although it is a general rule that an existing conversation must not be disturbed in the event that either of the conversing subscribers is called, it is nevertheless desirable that provisions be made for extending urgent calls to busy lines. For this purpose, arrangements are provided

controlled from the operator's switchboard for permitting the operator to make a special connection to a desired busy line to offer a new call.

For the purpose of explaining the call-offering feature, it will be assumed that the subscriber at substation A2, Figs. 2 and 12, has dialed the number 91225 assigned to substation A1, Fig. 12, but has been unable to obtain the desired connection because of the busy condition of the line of substation A1. It will be assumed further that the call is urgent and that the subscriber wishes the call offered. Under this condition, the subscriber at substation A2 hearing the busy tone, replaces his receiver to clear out the previously operated switches, following which he removes his receiver and dials the operator number (97) and requests the operator who answers to set up the connection for him while he holds the line.

Assuming that the first selector FS5 is the one seized when the receiver is removed, this selector responds to the first digit 9 by dropping back in the manner explained, following which it raises its wipers to the seventh level in response to the second digit 7 in the operator number and then rotates the wipers over the contacts in the seventh level in search of an idle service trunk. It will be assumed that the service trunk (Fig. 3) comprising conductors 301, 302, and 303 extending from the banks of the first selectors to the line circuit LC1, Fig. 3, is the first one found to be idle and is therefore the one seized by the selector FS5. When the seizure occurs, line relay 304 energizes over the calling line through the wipers of the selectors FS5 and closes a circuit for the release relay 305. Release relay 305 operates start relay 306 and also places a holding potential on the incoming C lead to maintain the connection. Line relay 304 also makes connection between the incoming negative conductor through contacts of the cut-off relay, and common intermittent ringing lead by way of a small-capacity blocking condenser, thereby simulating the regular ringing operation which takes place in a call to a subscriber line. Start relay 306 grounds the associated start conductor 311 through the contacts of cut-off relay 308 in order to start a finder to searching for the line circuit LC1, and it closes a circuit by way of cut-off relay 308 for the group call lamp GC1 at position 1, as well as the corresponding lamps at the other positions, thereby indicating to the operators that a call is being received from a local branch-exchange subscriber. Auxiliary relay 306 also connects the C lead associated with the finder terminals 300 to the upper winding of cut-off relay 308, thereby preparing for the operation of cut-off relay 308 and marking the line circuit LC as a calling circuit in the finder banks.

Start relay 2001, Fig. 20, is energized over one of the leads 2000 and the vertical bank contact associated with the proper level is grounded in each of the finders such as F1, Fig. 7, when the start lead 311 is grounded as above pointed out. It may be conveniently assumed that the finder F1, Fig. 7, has been preselected by the operation of the talking key K2 and the resulting operation of connecting relay 703 in the link, of talking and start relays 2104 and 2112 in the position equipment, and the distributor of Fig. 20. Therefore, the operation of start relay 2001 results in the closure of the previously described circuit over the position start conductor 2033, through contacts of position start relay 2112, and by way of start conductor 727 in cable 1, contacts of connecting relay 703, and off-normal contacts

715, for start relay 702 of the finder F1. The finder F1 is thereupon operated in the manner hereinbefore described to first raise the wipers 700 opposite the calling level and to rotate them over such level in search of the calling line circuit. When the line circuit LC1 is found, switching relay 701 of the finder is operated over the associated C wiper in series with the upper winding of relay 308 of the line circuit LC1 to terminate the hunting operation of the finder and to seize the line circuit, which has been marked by the previously described operation of relay 306. Cut-off relay 308 closes a locking circuit for its lower winding through the inner lower contacts of release relay 305, at the same time opening the connection at its upper contacts through which ring-back tone was formerly transmitted. Cut-off relay 308 also disconnects the resistor associated with the C lead 303, incoming from the selectors; it extinguishes the group-call lamp GC1 and corresponding lamps in other positions; and it removes ground potential from start conductor 311 to permit common start relay 2001 to restore, unless another call has arrived in the meantime.

In the finder F1, the operation of switching relay 701 when the line circuit LC1 is found, results in the previously described closure of the locking circuit for the upper winding of start relay 702 by way of resistor 716. The potential drop across the resistor 716 is impressed as before described by way of contacts of connecting relay 703 and over the release-answer conductor 726 on the answer pilot relay 2110, resulting in the selection of an idle sender as before described; in the release of position start relay 2112; and in the operation of call-signal relay 2105 and the associated signal interrupter relays 2106 and 2107 to apply the "zip-zip" call tone to the headset of the operator at position 1.

As in the previously described operation of the finder F1, changeover relay 719 restores responsive to the operation of switching relay 701, applying ground potential by way of the contacts of link connect relay 703 to the associated call wiper and by way of the lamp lead L to the group identity lamp IL1 at position 1. This lamp becomes lighted to identify the call as from a local branch exchange line.

Upon conversing with the calling subscriber and being told of the desired number and of the urgency of the call, the operator manipulates the digit keys DK of Fig. 22 to cause the desired number to be set up and to be retransmitted. As the digits of the desired number, (91225) of the line of substation A1, Fig. 12, are sent out, the automatic switching apparatus operates as before described to extend the connection to the line of substation A1. More in particular, the first selector FS1, Fig. 8, responds to the first digit (9) to raise the wipers opposite the ninth level and then restore the wipers to normal thereby absorbing the first digit (9). The selector FS1 then responds to the second digit (1) by raising its wipers opposite the first level and selecting an idle second selector, the second selector SES, Fig. 18, for example. This selector responds to the third digit (2) in the number to select an idle connector by way of the second level, the local connector LOC1, Fig. 19, for example. The local connector LOC1 responds to the final digits 2 and 5 to bring the wipers 1900 on the terminals of the line of substation A1, indicated in Fig. 12.

Assuming that the line of substation A1 is still

busy, busy test relay 1913 is in an operated condition when the wipers 1900 come to rest on the terminal of the called line and it becomes locked when auxiliary relay 1915 restores. The busy tone lead 1943 is now connected through contacts of relays 1913 and 1912 to the talking circuit to transmit a busy signal to the operator and to the calling subscriber. Since she has been informed of the urgent nature of the call, the operator is still holding her talking key operated to permit her to listen in.

In order to make connection with the busy line, the operator throws the offering key K6, Fig. 21. The offering key K6 closes a circuit for the split answer relay 2115 in order to disconnect the calling line for the time being and in order to terminate the operation of the ticker relay 2103, which relay starts to operate as previously described, as soon as call pilot relay 2111 operates upon the transmission of the final digit and the resulting operation of link-cut-through relay 708 in the link circuit, Fig. 7. The offering key K6 also closes a circuit for the slow-operating offer relay 2113 and at the same time extends a potential by way of contacts of relay 2113 to the EC-call conductor 732. An impulse is therefore transmitted over conductor 732 for the interval of time required for relay 2113 to operate. This impulse passes from the EC-call conductor 732 through contacts of the talking key K2 to the EC lead incoming to the first selector FS1. The impulse is further transmitted through the EC lead through the EC wiper of the selector FS1 to the second selector SES and thence by way of the EC wiper to the EC lead incoming to the local connector LOC1. In the local connector LOC1, since busy relay 1913 is in an operated condition and the class-test relay 1908 has not been operated to indicate that this is a barred call, the incoming EC lead is extended to the offering relay 1912. Relay 1912 thereupon locks itself to the ground potential at the inner upper contacts of auxiliary relay 1905 and through contacts of the busy test relay 1913. Upon operating, relay 1912 completes a talking circuit through the negative and positive ones of the wipers 1900 to the called line, by way of the condensers 1928 and 1929 which block the flow of direct current and thereby prevent operation of the back-bridge relay 1903. Offering relay 1912 also makes a connection from the common tick-tone lead 1942 to the upper talking conductor, thereby imposing a mild, but distinctive tone on the connection to serve as a warning to the two subscribers engaged in conversation that the secrecy of their conversation has been invaded. The operator now converses with the subscriber at substation A and informs him of the urgency of the call. The desired subscriber may either agree to accept the new call, or he may decide that he does not wish to accept the new call.

If the desired subscriber does not wish to accept the call, the operator clears out the extension by depressing the release call key K9 to thereby shunt down the link-cut-through relay 708 and permit the operated selectors and connector to release. The operator may then restore the offering key and inform the calling subscriber of the refusal to accept the call.

Assuming now that the desired subscriber at substation A1, Fig. 12, agrees to accept the new call, the operator needs only to restore her talking key K2 and the offering key K6, Figs. 7 and 21, to again complete the talking circuit through the link of Fig. 7 and to clear out her position

equipment. The offering position is then completed to the busy line of substation A1, whereupon the subscriber at substation A2 may converse with the calling subscriber at substation A1 while the subscriber with whom the subscriber at substation A1 was formerly conversing is able to hear the conversation. This condition is indicated by the tick-tone signal from the lead 1942 which is being impressed on the connection as above pointed out. As previously mentioned, this tone signal is sufficiently mild that conversation may be carried on while it is being impressed on the talking circuit. Therefore, if the previous conversation has not been terminated and the new conversation will not require a great amount of time, the previous connection may be permitted to remain established in the event that the calling subscriber and the called subscriber have no objection to their conversation being overheard by the subscriber with whom the called subscriber was previously conversing. In this event, when the new conversation has been completed, the calling subscriber at substation A1 replaces his receiver and thereby causes the connection between his line and the line of the called subscriber to be broken and the connector of Fig. 19 to be restored to normal, when the line circuit LC1 clears out, permitting the previously existing conversation to now proceed as before.

Assuming now that the subscribers decide that the previously existing connection should be broken to permit a two-subscriber connection, the called subscriber at substation A1, Fig. 12, replaces his receiver, and thereby clears his line. When this occurs, busy test relay 1913 restores as its locking circuit was transferred to the C wiper of the connector upon the operation of offering relay 1912. The restoration of busy-test relay 1913 is retarded somewhat by virtue of the local circuit closed for the lower winding of the relay at the contacts of offering relay 1912. This gives sufficient time for the plunger of the line switch LS2, Fig. 12, to restore before busy relay 1913 is permitted to restore responsive to the removal of the holding ground potential from the C lead of the called line.

When relay 1913 restores, it opens an additional point in its previously existing local locking circuit; it breaks the circuit of offering relay 1912 to permit this relay to restore and open the previously established temporary talking circuit and the tick-tone connection; and it completes the usual test circuit through the C wiper for the idle-test relay 1917. Relay 1917 thereupon operates over the C lead of the line of substation A1 through the bridge cut-off winding 1232 of the called line and closes an energizing circuit for the associated switching relay 1918. Relay 1918 thereupon completes the connection to the called line and applies ringing current thereto in the usual manner. The subscriber at substation A1 then removes his receiver as in any ordinary call, whereupon the previously described relay operations take place in the connector LOC1, and the conversation may proceed.

Arrangements have been provided in the line circuit LC1 to permit a subscriber who has called the operator number and obtained a connection through the link switchboard to recall the operator at any time that he desires to do so. This arrangement is of utility, for example, in the event that the connection obtained is unsatisfactory or is broken down before he finishes his conversation. In any event, the calling subscriber may manipulate his calling device in accord-

ance with a digit to thereby cause line relay 304 to vibrate its armature and close a circuit through contacts of auxiliary relay 306 for the lower winding of recall relay 307. Relay 307 thereupon operates and closes a locking circuit for itself over the EC lead and through contacts of auxiliary relay 306. This locking circuit includes the upper contacts of disconnect supervisory relay 706 and contacts of talking key 741. The lamp 741 becomes lighted in this circuit to signal the operator, who extinguishes the lamp and restores the recall relay 307 when she operates her talking key.

When the conversation over the connection set up as described through the link switchboard and to the line of substation A1, Fig. 12, has been completed the calling subscribers replace their receivers. In the event that the called subscriber is the first to replace his receiver, the reversal of current-flow back to normal direction in the incoming leads of the connector (Fig. 19) brings about the restoration of electropolarized supervisory relay 704 to cause the operator link to clear out in about two seconds, as before described.

When the calling subscriber replaces his receiver, line relay 304 of the line circuit LC1 restores, permitting relays 305 and 306 to restore successively. The locking circuit for the lower winding of cut-off relay 308 is opened when relay 305 restores, but relay 308 remains locked operated over the associated C lead until the finder clears out. Incidentally recall relay 307 is operated momentarily and momentarily locked over the associated EC lead, but this circuit is opened by relay 306, and relay 307 restores after the supervisory lamp 741 has been lighted only momentarily. Relay 305 opens the bridge across the negative and positive conductors associated with the right-hand windings of the repeating coil 330 to permit the connector to restore. Relay 305 also connects these conductors to the two poles of the exchange battery for the length of time required for auxiliary relay 305 to restore. This latter operation, however, is of no purpose in a local call.

Responsive to the opening of the bridge across the talking conductors at the line circuit LC1, Fig. 3, the line relay 1902 of the local connector LOC1 falls back to permit the connector to clear out. The second selector SES, Fig. 18, and the first selector FS1, Fig. 8, are maintained operated for the time being by ground potential held on the C lead at the contacts of link-cut-through relay 708. In the event that the called subscriber has not replaced his receiver and thereby caused supervisory relay 704 to restore and initiate the clearing out of the link, relay 704 now restores for it is so adjusted that it will not remain operated when energized by the relatively weak polarizing winding alone. When the link clears out and link-cut-through relay 708 restores and removes ground potential from the C lead of the associated selector, selectors FS1 and SES, Figs. 8 and 18, release.

Cut-off relay 308 of the link circuit LC1 restores when the finder clears out. It reappplies idle-indicating potential to the incoming C lead to render the service trunk selectable again.

70 Barring through calls from the public exchange

It is to be noted particularly that the branch exchange operator cannot extend a connection from an incoming public exchange trunk (the incoming trunk IC, Fig. 4, for example) to a toll

line such as the one in Fig. 5 nor to an inter-branch-exchange line such as the one in Fig. 6, as the discriminating wiper, wiper D, of the finder encounters ground potential when the public exchange call is answered and operates the class-recording relay 801 as above pointed out. With the class-recording relay 801 operated, the raising of the wipers of the selector FS1 opposite the ninth level (in a call to connector group 99) and the resulting shifting of the ninth-level contacts 815 results in the opening of the test circuit of the electropolarized switching relay 807. Under this condition, relay 807 cannot operate and the selector continues to rotate until it passes entirely off the contact bank and thereby causes overflow contacts 811 and 812 to operate. The operation of overflow contacts 811 results in the returning of a busy tone signal, while the operation of overflow contact 812 results in the reoperation of series relay 805 to open the circuit of the rotary magnet.

Outgoing toll calls

The way in which calls to and from the toll lines, such as the toll line associated with the line circuit LC3, Figs. 2 and 5, are handled, will now be pointed out. It will be explained first how a connection is set up from a local line to a toll line, a toll line in group 9921, for example.

To obtain a toll connection, the calling branch exchange subscriber removes his receiver and dials the operator number 97, with the result that the connection is extended in the manner described hereinbefore to a service trunk, such as the one shown in Fig. 3. Assuming that this service trunk is the one seized, the relays of the line circuit LC1 operate as described to mark the link circuit LC1 as calling and to start a finder. Assuming that the finder F1, Fig. 7, of position 1 has been preselected by the operation of the key K2 and the connecting relay 703, this finder is the one which operates in search of and finds the line circuit LC1, Fig. 5, as before described. After the line circuit LC1 has been seized, relays 701—703 are actuated in the finder F1, while relays 2101, 2104, and 2110 are actuated in the position equipment.

The operator now sets up the desired number 9941 by manipulating her digit keys DK. Fig. 22, and she starts the operation of the sender by operating her start key, whereupon the stored digits 9, 9, 4, and 1, are retransmitted.

The selector of Fig. 8 responds to the first digit (9) by raising its wipers opposite the ninth level and then restoring them to normal, and it responds to the second digit (9) by raising its wipers opposite the ninth level and rotating them in search of an idle toll connector. With the wipers of the first selector FS1 opposite the ninth level, the ninth-level shaft contacts 813 are closed, applying ground to the associated (toll switching) TS lead, thereby operating the toll switching relay 707. Relay 707, in addition to preparing to cut through the EC lead at its upper contacts, makes an additional ground connection to conductor 717 at its inner upper contacts; opens the pick-up circuit of the timing switch TS at its inner lower contacts; and it prepares a special clear-out circuit at its lower contacts.

Assuming now that the toll connector TC, Fig. 15, is the first one of the group of toll connectors found to be idle when the selector FS1 rotates over the ninth level, this connector is seized at terminals 1500 by the wipers 800 of the first selector FS1, the toll connector TC being marked

idle by the negative potential applied to the incoming C lead from the upper winding of vertical-series relay 5103 through off-normal contacts 1515 and make-busy key 1516. Vertical-series relay 5103 operates when the connector is seized, preparing a circuit for vertical magnet 1511 and a holding circuit for itself.

As a further result of the seizure of the connector TC, line relay 1501 operates over the incoming talking conductors and brings about the operation of release relay 1502 to prepare the connector to operate in response to the final digits (4 and 1) in the desired number.

When the pre-final digit (4) is received, the four impulses generated by line relay 1501 are transmitted through contacts of the operated relays 1502 and 1503 to vertical magnet 1511.

At the end of the vertical movement, vertical-series relay 1503 restores and transfers the operating circuit to rotary magnet 1512, off normal springs 1515 having opened.

When the final digit 1 is received, rotary magnet 1512 operates to bring the wipers 1515 into engagement with the first set of contacts in the fourth level, assumed to be the contacts from which trunk conductors 1551 extend to the line circuit LC3, Fig. 5. Series relay 1506 is operated in the rotary magnet circuit and brings about the operation of auxiliary relay 1507, this operation being similar to that provided by relays 1406 and 1407 of the B. X connector BC, Fig. 14. It is to be noted that stepping relay 1508 is provided and that it is connected in circuit with the associated wiper S for the same purpose as described in connection with the corresponding relay 1408 and wiper S of the connector BC, which purpose is to provide for the automatic selection of trunk lines in a group. Assuming now that the first toll line of the group is idle, there is no ground potential on the C lead in group 1551. Under this condition, since no ground potential is encountered by the C wiper of the connector TC, busy test relay 1505 does not operate. The successive restoration of relays 1506 and 1507 results in the closure of a test circuit of the type previously described for idle-test relay 1509 through the C wiper of the connector and over the C-lead in group 1551 to the negative battery conductor by way of cut-off relay 503, which is connected to the associated C lead through contacts of relays 502 and 506. Idle-test relay 1509 closes a circuit for switching relay 1510, whereby relay 1510 operates and completes the connection to the toll line. It is to be noted that each of the incoming conductors of the connector TC is now switched through metallicity to the corresponding conductors in group 1551 and that line relay 1501 restores, for it is disconnected from the talking conductors at the contacts of the switching relay. Release relay 1502 is therefore restored, but the connection is maintained established because the C lead is maintained grounded during the sending operation at the sender link, Fig. 22, and thereafter at the contacts of link cut-through relay 708, Fig. 7. The circuit of release magnet 1513 is held open at the lower contacts of switching relay 1510.

In the line circuit LC3, Fig. 5, cut-off relay 503 operates over the C lead incoming from Fig. 15, thereby operating the associated auxiliary relay 504 to prepare for the subsequent operation of ring-off relay 505 and associated relays. While the number is being transmitted, the operator may throw the cut-off answer key K3, operating the split answer relay 2115 to disconnect the answering end of the connection. With relay 2115

operated, the described operation of ticker relay 2103 is prevented following the operation of call pilot relay 2111 when the link-cut-through relay 708 operates.

When she is informed by the extinguishing of the sender pilot lamp (2141 or 2142) that the connection has been set up to a toll line of the desired group, the operator throws her ring-call key K10 to project ringing current out over the established connection by way of contacts of split-call relay 2116, which relay is operated by the key K10. This ringing current passes through the selector of Fig. 8 and the operated connector of Fig. 15 and thence to the toll line of Fig. 5 by way of the repeating coil 530 and the normally closed contacts of ring-cut-off relay 505.

When the ringing current is transmitted, line relay 501 of the line circuit LC3 operates and closes a circuit for the lower winding of relay 502 over the EC lead, whereupon relay 502 operates and locks itself to the EC lead, which lead is now extended through the built up connection to the EC answer lead 731 and to the EC-call lead 732 of the position equipment, Fig. 21. The EC conductors 731 and 732 each has a negative potential applied thereto by way of a resistor, with the split relays 2115 and 2116 in operated position. Annoying audible chatter of the combined start and recall relay 502 of the line circuit is thus prevented. Relay 506 restores as soon as the negative potential is removed from the above-mentioned EC conductors when the operator's keys are restored.

When the distant operator responds to the application of ringing current, she may converse with the originating operator and complete the desired connection in the usual manner.

Having transmitted the desired number to the distant operator, the branch exchange operator may restore her keys and permit the distant toll operator to complete the connection.

Monitoring a connection

In the event that she wishes to monitor the established toll connection, the operator throws the monitoring key K1, thereby connecting the tip and ring talking conductors with the tip and ring monitor conductors 729 and 728 and grounding the switching lead 730. The ground potential on switching lead 730 operates the monitoring relay 2102 to place the operator's receiver across the secondary windings of the repeating coin RC instead of in its normal relationship to the secondary windings of the induction coil I, thereby providing the usual efficient monitoring connection. The monitoring relay 2112 also starts the ticker relay 2103 into operation to apply ground potential intermittently to the ticking circuit which includes the tertiary winding of the induction coil I and the secondary winding of the repeating coil RC. At this time the resistor 2162 is included in the circuit in series with the limiting resistor 2161 to adapt the current flow for the monitoring condition. As previously mentioned, the tick-tone produced is sufficiently mild that conversation may proceed uninterrupted and the operator is enabled to hear whether the subscribers are conversing satisfactorily. At the same time, the subscribers are enabled to hear the ticking signal to inform them that the operator is listening to their conversation.

Relay 2102 restores when the monitoring key is restored and the operation of this ticker 2103 ceases.

In the event that the toll operator rings back

over the toll line of Fig. 5, either as a recall signal or as a disconnect signal, line relay 501 responds and closes a circuit for relay 502 which extends through the lower winding of this relay, through contacts of the operated cut-off relay 5003, and over the EC lead of the established connection through the operated switches of Figs. 15 and 8, through the contacts of the operated toll relay 707, and through contacts of talking key K2 to the negative pole of the exchange battery, by way of the supervisory lamp 741. Lamp 741 becomes lighted in the locking circuit of relay 602 as a supervisory signal. The branch exchange operator answers the light 741 by throwing the talking key K2, thereby placing herself in telephonic communication with the toll line and disconnecting supervisory lamp 741. The lamp 741 thereupon becomes extinguished and the combined start and recall relay 502 restores. After answering an inquiry of the toll operator, the branch exchange operator may restore her talking key K2 and leave the connection established until the conversation has been terminated.

The local subscriber may also recall the branch exchange operator, which he does by dialling the digit 1, for example, causing the line relay 304 of the line circuit LC1 to restore momentarily and operate recall relay 307. Relay 307 locks itself over the associated EC lead and through the supervisory lamp 741. This lamp is extinguished and recall relay 307 is unlocked and restored when the operator responds.

When the conversation is terminated and the local subscriber replaces his receiver, line relay 304 restores and operates the recall relay 307 as in the above example, again lighting the supervisory lamp 741. This operation is more or less incidental at this time, as the connection is automatically cleared out in a manner which will now be pointed out.

Responsive to the restoration of line relay 304, the release and auxiliary relays 305 and 306 restore successively. When relay 305 restores it applies the potential of the exchange battery through the negative and positive talking leads extending to the finder terminals 300 for the interval required for the slow acting relay 306 to restore. Current flows therefore over the established connection by way of the switches of Figs. 7, 8, and 15 to the left-hand winding of the repeating coil 530 of the line circuit LC3. This current-flow is in the same direction as the current-flow that normally obtains before a local call through the link of Figs. 7 and 8 has been answered. However, the current-flow through the line winding of supervisory relay 704 is very much greater than the current flow normally through the relay when a call is being extended by the operator to a branch exchange line, on account of the relatively low resistance of the resistors at the line circuit LC1 through which the current is applied. Therefore, the line winding of relay 704 operates the relay in spite of the opposing effect of the locally energized polarizing winding. Then, when the supervisory impulse is terminated the polarizing winding reverses the flow of magnetism, causing the relay to restore.

The answering supervisory relay 705 is operated when relay 704 responds, preparing a circuit for the disconnect supervisory relay 706. This circuit is completed through contacts of slow releasing relay 705 when the supervisory relay 704 restores. Relay 706 thereupon locks itself energized. Since toll relay 707 is energized

(this being a toll call) relay 706 at its lower contacts applies a ground potential through the lower contacts of the energized toll relay 707 to the junction of resistor 716 and the holding winding of start relay 702. Relay 702 therefore restores in the usual way. Upon restoring, relay 702 opens the circuit of link-cut-through relay 708. Relay 706 restores responsive to the removal of ground potential from conductor 717 by start relay 702, and the finder F1 releases responsive to the restoration of start relay 702.

In the line circuit LC1, recall and cut-off relays 307 and 308 clear out responsive to the release of the finder. The supervisory lamp 741 is therefore extinguished before the operator has had time to respond to the lighting thereof.

Responsive to the restoration of the link-cut-through relay 708, the C lead of the connection established to the toll line becomes ungrounded to permit the operated switches of Figs. 8 and 15 to release and permit the line circuit LCs, Fig. 5, to clear out. When the first selector FSI of Fig. 8 releases the toll relay 707 is permitted to restore, thereby restoring the link of Figs. 7 and 8 completely to normal condition.

In the toll connector TC, Fig. 15, the above mentioned removal of ground potential from the C lead at the link-cut-through relay 708 results in the restoration of switching relay 1510 previously locked to the C lead. Relay 1510, in addition to disconnecting the wipers, closes a circuit through off-normal contacts 1514 for release magnet 1513, whereupon the connector is restored to normal condition in the usual manner.

In the toll line circuit LC3, Fig. 5, the removal of ground potential from the C lead results in the deenergization of cut-off relay 503. Relay 503 opens the circuit of the auxiliary relay 504 and closes a circuit through contacts of relay 504 for ring-cut-off relay 505. Ring-off relay 505 is therefore energized for a short interval to apply ringing current over the associated toll line to operate a disconnect signal in the distant exchange.

Timed, automatic toll-line guarding

It is a feature of the line circuit LC3 that this line circuit is again guarded against seizure by the toll connector, following the ring-off operation, for a substantial interval of time in order to permit the toll operator to respond to the ring-off signal and clear out the connection. This operation is performed as follows:

When ring-off relay 505 operates, it closes a circuit for guard relay 506. Relay 506 disconnects the associated C lead incoming from the connector banks from the cut-off relay 503 and connects it to ground, thereby guarding the toll line from seizure by way of the toll connectors. Relay 506 also extends ground potential through its inner lower contacts to conductor 533 associated with the timing device comprising relays 507-510. With conductor 533 grounded, a locking circuit now exists for relay 506 through contacts of counting relay 509 and lower contacts of relay 506. Over this locking circuit, relay 506 is maintained operated until the timing operation has been completed.

When conductor 533 is grounded, pendulum relay 507 is operated through contacts of relay 508. The armature of this relay preferably consists of a relatively heavy magnetic weight attached to the end of a spring, as is indicated diagrammatically. When this armature is attracted, a circuit is closed through the contacts associated

therewith for the holding relay 508. Relay 508 operates and closes a holding circuit for itself at its upper armature; it also disconnects conductor 533 from the winding of relay 907, whereupon relay 507 becomes deenergized and releases its armature, which swings back and forth for a period of several seconds. Relay 508 is slow releasing and therefore remains operated as long as the armature of relay 507 is vibrating with sufficient amplitude to touch either of the associated contacts.

When relay 508 transfers conductor 533 from relay 507 it closes a circuit through contacts of the relay 509 for relay 510 of the counting pair. Relay 510 operates and closes a locking circuit for itself in series with the lower winding of relay 509, but no current flows through this locking circuit for the time being because the initial circuit is still established.

When the amplitude of vibration of the pendulum relay 507 has decreased somewhat, holding relay 508 restores, thereby opening the initial circuit of counting relay 510. At this time, relay 509 is operated in series with relay 510. Relay 509 opens a point in the locking circuit of guard relay 506 at its lower armature, but the lower armature of relay 510 has closed a multiple point in the locking circuit so as to continue to hold relay 506 operated. Relay 509 also prepares a holding circuit for its upper winding and a restoring circuit for relay 510.

With relay 508 restored, relay 507 operates again, causing relay 508 to reoperate and again open the circuit of relay 507 which deenergizes and again permits its armature to swing back and forth. With relay 509 operated, relay 508 connects the grounded conductor 533 through the upper contacts of relay 509 to the junction of the winding of relay 510 and associated resistor, thereby shunting relay 510 to bring about its restoration. Relay 509 is held operated through its upper winding as long as relay 508 remains operated.

When the pendulum armature of relay 507 slows down the second time, relay 508 restores and finally disconnects conductor 533 from guard relay 506 at its lower armature, thereby opening the locking circuit of relay 506, relay 509 being operated and relay 510 restored. When relay 506 restores it disconnects ground potential from conductor 533, thereby preventing a further reoperation of pendulum relay 507. Relay 506 also disconnects the associated C lead from ground and reconnects it to cut-off relay 503, again marking the toll line idle in the connector banks after the lapse of the time interval introduced by the two described vibratory operations of the pendulum relay 507, controlled by the associated relays 508-510.

It is to be noted that the timing operation above described does not in any way interfere with the receipt of a call over the toll line and the starting of a finder in the event that the toll line is cleared out at the distant end and is used immediately for a call in the reverse direction.

Cutting in on a busy trunk line

The toll connector TC, Fig. 15, is provided with an offering relay 1504 associated with the incoming EC lead whereby the branch exchange operator, when requested to do so, may make connection with a busy inter-branch-exchange trunk line or with a toll line, Figs. 5 and 6, and request the conversing subscribers to replace their receivers and thereby free the trunk line for emergency

use. Offering relay 1504 operates as described for offering relay 1912 to make connection to the busy trunk line (the last one of the group); to substitute tick tone lead 1518 for busy-tone lead 1517; and to shift the locking circuit of busy-test relay 1905 to the C wiper, whereby this relay restores and permits regular seizing of the line when it becomes free.

Incoming toll calls

The way in which toll calls incoming to the branch exchange are disposed of will now be explained.

Assuming that the toll line of Fig. 5 is seized at the distant end and that ringing current is projected thereover to signal the branch exchange operator, line relay 501 responds and closes a circuit for start relay 502. Start relay 502 locks itself at its inner lower contacts; closes a circuit for the group-call lamp GC5 in position 1 and a circuit for the corresponding lamps in each of the other positions; it grounds the start conductor 511 to cause a finder to be started and to be guided to the correct level of bank contacts; it connects the C lead associated with the connector banks to ground; and it connects the C lead associated with the finders to the cut-off relay 503, thereby marking the line circuit LC3 calling in the finder banks.

When a searching finder arrived on the terminals of the line circuit LC3, the finder F1, Fig. 8, for example, cut-off relay 503 is operated over the C lead from the finder banks. Upon operating, cut-off relay 503 locks itself to the C lead of the finder; unlocks start relay 502 and extends its lower winding to the C lead for supervisory purposes; and brings about the operation of auxiliary relay 504. The group-call lamp GC3 now becomes extinguished and the start conductor 511 becomes ungrounded.

The branch-exchange operator may extend the incoming toll connection to the line of any branch exchange subscriber, to another toll line, or to any one of the lines outgoing to distant branch exchanges, such as the line of Fig. 6. In the event that the connection is extended to one of the local branch-exchange lines, the extended connection is released under the control of the time switch TS when the branch exchange subscriber replaces his receiver and permits the operator's supervisory relay 704 to restore, which releasing operation has been previously described. On the other hand, if the connection is extended to another toll line or to a line outgoing to a distant private branch exchange, the supervisory relay 704 does not operate to give answering and disconnect and therefore cannot control the release of the connection. In this event, however, toll relay 707 is operated through contacts 813 to open the pick-up circuit of the time switch TS and thereby prevent the undesired operation of the time switch TS. Toll relay 707 also joins the EC lead of the selector FS1 with the EC lead of the finder F1, both leads being connected through contacts of the restored talking key K2 (during conversation) to the supervisory lamp 741. This lamp may therefore become lighted from either end of the connection as a disconnect or recall signal. For example, if the calling toll operator rings off, the ringing current incoming over the toll line to the line circuit LC3, Fig. 5, causes line relay 502 to operate start relay 503 to operate and lock its lower winding over the associated EC lead in series with lamp 741. Relay 502 is restored when the operator throws her talk-

ing key K2, and the connection is cleared out when the operator throws her release-answer key to bring about the deenergization of start relay 702.

- 5 At the termination of the incoming call, the described ring-off signal is given, and line circuit LC3 is guarded against seizure by the branch exchange connector until the predetermined time interval has elapsed, the guarding being accomplished by relay 506 during the interval determined by relays 507—510. The guarding is initiated as before described by the operation of ring-off relay 505 responsive to the restoration of cut-off relay 503.

Calling toll lines from subscriber lines

- It may be pointed out that the branch-exchange connectors, such as the connector of Fig. 14, are suitable for connecting with the toll lines in the event that it becomes desirable to permit the branch-exchange subscribers to call the toll lines directly. For example, the negative, positive, and C leads of group 1551 may be connected to corresponding contacts in the same level bank of the connector of Fig. 14. It will be recalled that the connector of Fig. 14 sends forward a so-called splash ring by the operation of relay 1404 when it seizes a line. This connector is also arranged as previously described to reoperate the splash ring relay 1404 for recalling the operator in the event that the calling subscriber subsequently turns his dial for this purpose. Moreover, the connector of Fig. 14 has been particularly arranged so as not to project ringing current unnecessarily when the called branch exchange subscriber replaces his receiver, as the toll line circuits, exemplified by the line circuit LC3, Fig. 5, have the previously described provisions for giving a ring-off signal over the distant toll line.

Delayed calls

- As previously pointed out, provisions are made so that a branch exchange operator may set up a delayed-call connection. These facilities are particularly useful to permit a branch-exchange operator to make connection between a public-exchange line and a branch-exchange line after the branch exchange subscriber has attempted to establish a connection with the desired main-exchange line, but has been unable to secure the connection, usually because the main-exchange line is busy. In this event, the calling branch-exchange subscriber may dial the number 97 assigned to the link switchboard, obtaining connection with the switchboard by way of a line circuit such as LC1, Figs. 2 and 3, which operation has been described hereinbefore. It is to be noted particularly that the operator may not extend the received call in the regular manner, while the calling subscriber holds the line, as the first selectors linked with the finders do not have access to the public exchange trunks. The operator makes a note of the number of the branch-exchange subscriber and of the number of the desired main-exchange subscriber, following which she sets up a connection from her position to each of the lines.

- As before mentioned, delayed-call selectors are provided for the common use of the branch-exchange operators, and are accessible by way of the first level of the finders. The selector DCS, Figs. 2 and 9, is one of these delayed-call selectors.

- In order to prepare to take a delayed-call selector for use, the operator at position 1 throws the delayed-call key K7, Fig. 21. When this key

is thrown, ground potential from contacts of the release-answer key is applied to the upper winding of delayed-call relay 2114, operating relay 2116 in series with the upper winding of answering pilot relay 2110. Answering pilot relay 2110 operates to disconnect position start relay 2112. At its upper contacts, the delayed-call relay 2114 places ground potential on the associated marking conductor which is multiplied throughout the finders accessible to position 1, but which does not extend to the finders associated with the other positions, as each other position is provided with its own delayed-call marking conductor.

With the delayed-call key thrown, the operator throws the talking key of an idle link, the talking key K2 of Fig. 7, for example. This brings about the operation of connecting relay 703 in the link circuit and the operation of talking relay 2104 in the position equipment. The grounding of conductor 2123 by talking relay 2104 results in the closure of a circuit through contacts of the energized answer-pilot relay 2110 and over conductor 2141 to cause an idle register sender to be selected, but position-start relay 2112 is not operated at this time because of the operated condition of the answer-pilot relay 2110.

With the delayed call key K7 actuated and the delayed call relay 2116 actuated, ground potential is extended by way of contacts of this key and contacts of this relay to start conductor 727, and is further extended through contacts of connecting relay 703 to start relay 702 of the finder. 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, when vertical test wiper 712 encounters the first-level marking contact which has been grounded as above mentioned at the upper contacts of delayed call relay 2116. The wipers 700 of the finder F1 are therefore rotated over the first level of bank contacts in search of an idle one of the delayed-call selectors.

Assuming that the delayed-call selector DCS, Fig. 9, is the first one to be found idle, this selector is seized over its incoming leads. The selector DCS is normally marked idle by the potential applied to the C lead thereof through contacts of the included make-busy key and the winding of connecting relay 901. Connecting relay 901 is operated over the C lead to connect up the incoming negative, positive, and EC conductors and to prepare a locking circuit for cut-in relay 902. The ground identity lamp IL5 of position one becomes lighted over the associated L lead and the L wiper of the finder to inform the operator that the finder has found an idle delayed-call selector.

Line relay 903 of the delayed-call selector, is bridged across the incoming talking conductors through contacts of relays 908 and 902 when relay 901 operates. Line relay 903 therefore now operates through the negative and positive wipers of the finder F1, through contacts of relays 701 and 703, position conductors 721 and 724, contacts of split-answer relay 2115, and through the bridged retard coil 2118. Responsive to the operation of line relay 903, the release and auxiliary-release relays 904 and 905 prepare the selector for operation.

It has been found convenient to provide the operator with the calling device CD, Fig. 21, part 3, with which to set up connections through the delayed-call selectors, thereby permitting the register senders in the branch exchanges to be equipped with only sufficient digit registers (five)

to accommodate branch-exchange numbers, main-exchange numbers in general containing more digits, particularly since the digit "0" must be prefixed to all main-exchange numbers.

- 5 When she notes the previously mentioned lighted condition of lamp IL5, Fig. 9, the operator may now start to manipulate the calling device CD in accordance with the several digits in the number of the public-exchange line, preceded by the digit "0" which is required to give access to the public exchange. When the calling device CD is turned from its normal position in the dialling of the first digit, the off-normal contacts thereof (the lower set of contacts), extend ground potential to the winding of split-answer relay 2115. This relay now operates to bridge the impulse contacts of the calling device CD directly across the tip and ring answer conductors 724 and 722, by way of contacts of the delayed-call key K7. Therefore, as the calling device CD is returning to normal position ten momentary interruptions are produced in the circuit of the line relay of the delayed call selector DCS, Fig. 9.

- When the calling device reaches its normal position, the split-answer relay 2115 is restored, transferring conductors 722 and 724 back to the bridged retard coil 2118 and to the operator's headset conductors, permitting the operator to listen in between operations of the calling device CD to note the progress of the call.

- In the delayed call selector DCS, Fig. 9, the ten interruptions in its circuit causes the line relay 903 to restore ten times momentarily, thereby operating the vertical magnet 909 ten times to bring the wipers 900 opposite the tenth level of bank contacts. Series relay 906, whose upper winding was initially energized through off-normal contacts 915, upon the operation of connecting relay 901, restores at the end of the vertical movement and completes the circuit of rotary magnet 910. The wipers 900 are then rotated over the tenth level of bank contacts until they arrive on the terminals of an idle repeater associated with an outgoing trunk line, such as the repeater OR1, Fig. 13, associated with outgoing trunk line OT1. At this time switching relay 908 operates to seize the repeater OR1, while relays 903, 904, and 905 restore responsive to the operation of relay 908.

- In the repeater OR1, line and release relays 1301 and 1302 are operated as before described. Line relay 1301 closes a bridge at its lower contacts across the outgoing trunk conductors by way of the left-hand windings of repeating coin 1330. Responsive to the closure of this bridge, the public-exchange equipment is prepared for a response to the digits in the public exchange number of the desired subscriber, and the usual dial-tone signal is returned to indicate that the dialling may proceed.

- In the operator's position equipment of Fig. 21, split answer relay 2115 has restored following the return to normal position of the calling device CD, permitting the operator to hear the dial-tone signal transmitted back from the public exchange. Upon hearing this signal the operator proceeds to manipulate the calling device CD in accordance with the several digits in the desired number, causing the connection to be extended to the desired public-exchange line.

- Having dialled the number, the operator restores the delayed-call key K7, which opens the circuit of the slow acting relayed call relay 2114 and removes ground from start conductor 727, at the same time disconnecting the impulse con-

tacts of the calling device CD. Before the calling device is disconnected, the make-before-break contacts of the delayed call-key place a shunt across the impulse conductors through contacts of the delayed-call relay 2114 so as to hold the impulse conductors bridged until the split-answer relay 2115 restores (responsive to the return to normal of the calling device) and transfers the tip and ring answering conductors 724 and 722 back to the retard bridge 2118. It is to be noted that a locking circuit is maintained for the lower winding of delayed-call relay 2116 through contacts of split-answer relay 2115 to insure that relay 2115 restores before relay 2116 restores. It will be understood, of course, that ordinarily relay 2115 restores before the operator restores the delayed call key, as only a fraction of a second is required for relay 2115 to restore after the circuit is opened at the off normal contacts of the calling device CD.

It is to be noted that the answering pilot relay 2110 does not restore when the circuit of the delayed call is opened, as this relay is now maintained operated over the release-answer conductor 726, as before explained.

As a further result of the restoration of the delayed-call key K7, a ground potential is extended through the upper contacts of the key through contacts of the delayed-call relay 2116 to the EC-answer conductor 731 for the length of time required for the delayed-call relay 2116 to fall back after its circuit is opened by the delayed-call key. An impulse is therefore transmitted over EC-answer conductor 731, through contacts of the actuated talking key K2, upper armature and resting contact of disconnect-supervisory relay 106, the EC wiper of the finder F1, the EC lead incoming to the delayed-call selector DCS, Fig. 9, and contacts of connecting relay 901, to the two-step cut-in relay 902. The cut-in relay 902 is a two-step relay which operates only sufficiently to close its locking contacts when the upper winding is energized alone. The lower winding of the relay does not become effective as long as the initial circuit of the upper winding remains closed.

When the impulse has been terminated by the restoration of the delayed-call relay 2114, cut-in relay 902 operates fully and extends the incoming EC lead through contacts of the operated switching relay 908 to the EC wiper, so that this lead is extended to succeeding trunks provided such trunks contain an EC lead. The main function of cut-in relay 902 is to insert the repeating coil 930 in the talking circuit. With the cut-in relay operated, the incoming leads are extended to the left-hand windings of repeating coil 930, while the right-hand windings of repeating coil 930 are bridged across the outgoing leads through the negative and positive wipers and contacts of the operated switching relay 908.

Assuming now that the desired public-exchange subscriber answers, the branch-exchange operator informs him that she has a call for him and requests him to wait a moment while she completes the connection. The operator causes the connection to be completed to the local line by setting up the digits of the local branch exchange number on the digit keys DK as before described, and depressing the start key. This brings about the operation of the first selector FSI, Fig. 8, and the appropriate additional switching apparatus hereinbefore described to complete the connection to the local line. The operator may throw her cut-off answer key K3

and listen for the response of the local subscriber and informs him of the main exchange connection when he replies. The operator restores her key to finally establish the desired connection.

It is to be noted that the delayed-call selector DCS is provided with a pair of 0-level shaft contacts 918, which are now operated because the selector DCS has been raised opposite the tenth level in a call to the public exchange. With relay 918 operated, ground potential is applied through contacts of connecting relay 901 to the associated discriminating lead D, thereby extending a ground potential by way of the D wiper of the finder F1 and contacts of switching relay 701 to the class-recording relay 801 of the first selector FS1. As previously described, with this class-recording relay operated, the call can be extended through the first selector FS1 only to those lines which are entitled to public-exchange service.

The operation of supervisory relay 704 when the local subscriber responds results in the operation of answering supervisory relay 805 to prepare a circuit for disconnect supervisory relay 706, with the result that relay 706 responds, when the local subscriber replaces his receiver, and closes a locking circuit for itself, whereby the connection is released at the end of an interval of about two seconds by the previously explained action of the timing switch TS.

The restoration of the finder F1 results in the opening of the circuit for connecting relay 901 of the delayed call selector DCS. Relay 901 opens the locking circuit of cut-in relay 902, whereupon cut-in relay 902 restores. When the cut-in relay restores, the outgoing talking conductors are unbridged, permitting the line and release relays of the repeater OR1 to restore and the associated incoming C lead to become ungrounded. Switching relay 908 of the delayed call selector now restores and closes the release-magnet circuit through off-normal contacts 917. The selector is now restored to normal position in the usual manner.

It is to be noted that the C lead of the delayed-call selector is maintained grounded at the inner upper contacts of connecting relay 901 as long as this relay is operated, whereby the extended connection is held when it includes a circuit such as the toll line circuit LC3, Fig. 15, (reached by way of a toll connector) which does not supply a holding potential to the C lead.

Emergency provisions

Emergency provisions are made for by-passing the distributor of Fig. 20; for cutting either of the two sender links of Fig. 22 out of service in the event that it becomes temporarily defective; and for using the calling device CD, Fig. 21, part 3, in place of a register sender to set up local numbers in case both of the links of Fig. 22 fail.

In the event that the distributor of Fig. 20 (comprising relays 2021—2025) develops a fault, this distributor may be removed from service by an operation of key 2006, bringing about the operation of distributor-cut-off relay 2005. With the distributor cut-off relay operated the associated common start conductor controlled by start relay 2001 is connected to each of the four position start leads, such as lead 2033 of position 1, whereby the start lead at each position is grounded each time relay 2001 operates. Under this condition, a finder is started at each position at which the talking key of an idle link is thrown, and the first finder to arrive at the calling line

seizes the line and immediately guards it in the manner previously described, while the unsuccessful finder (or finders) may continue to rotate to the limit of permitted movement, at which point overflow contacts are operated to return the finder to its normal position. By this time the common start conductor will have become ungrounded unless another call has arrived in the meantime.

In the finder F1, Fig. 7, for example, when vertical test wiper 712 does not find a marked level conductor, the vertical operation is terminated at the permanently grounded tenth-level test contact. In this event the wipers are rotated over the tenth level. When the wipers are being rotated and a calling line is not found, the overflow contacts 714 are separated when the wipers rotate off the contact bank. Since off-normal contacts 715 are open, the separation of overflow contacts 714 opens the circuit of start relay 702 and permits the relay to restore. The finder now releases. The start relay 702 cannot reoperate until off normal contacts 715 are again closed.

In the event that sender link SL2 becomes defective the operator by observing the pilot lamp 2142 may note that the link is not operating properly. In this event she may actuate the key 2203 to open its lower contacts, thereby preventing relay 2201 from operating to select sender link SL2. Since no locking circuit now exists for relay 2202, this relay operates each time the sender-start conductor 2141 is grounded in the position equipment, thereby causing sender link SL1 to operate each time, instead of alternating with sender link SL2. Under this condition, during a busy period, the operator must refrain from operating the talking key of an idle link pursuant to the acceptance of a new call until the dimly lighted pilot lamp 2111 has become extinguished by the restoration of start relay 2201 to indicate that the previously recorded number has been completely sent out and that the sender link has cleared out.

In the event that it is the sender link SL1 instead of the sender link SL2 which has become defective, the operator may throw the key 2203 in the opposite direction, to close the upper contacts thereof. In this event, relay 2201 operates each time the start lead 2141 becomes grounded, while relay 2202 is shunted by the ground potential applied from the start lead 2121 through contacts of the actuated relay 2201 to the junction of relay 2202 and the associated resistor. With relay 2201 operating alone each time the start lead 2141 becomes grounded, the sender link SL2 is used for each call instead of alternating with the sender link SL1.

In the event that both sender links become defective, the operator does not employ the digit keys DK, but uses her emergency dial key K8. The operation of the key K8 closes a circuit for split-call relay 2116 and connects the calling device CD through contacts of the actuated split-call relay 2116 to tip and ring call conductors 723 and 721. The emergency-dial key K8 also applies ground potential by way of its upper contacts and through the upper winding of the emergency-dial relay 2117 to the cut-through conductor 735. Relay 2117 is operated over this conductor and locks itself through contacts of the actuated split-call relay 2116. In the illustrated link circuit, the cut-through lead 735 is extended through contacts of the talking key K2 to the link-cut-through relay 708 causing this

relay to operate when the emergency dial key is thrown. Relay 708 closes its upper contacts and thereby extends the prepared dialling circuit to the associated first selector FS1.

- 5 The calling device CD may be operated repeatedly to transmit the successive digits of the desired number.

When the emergency dial key K8 is restored, the calling device CD is disconnected, but a temporary holding bridge is closed across the associated dial conductors through the make-before-break contacts of the dial key and the lower contacts of the emergency-dial relay 2117 so as to hold the connection pending the restoration of split-call relay 2116 to reapply the retard bridge 2118 to conductors 721 and 723. Relay 2116 permits relay 2117 to restore.

Calls outgoing from office 9 to office 8

20 The way in which calls outgoing from office 9 to office 8 are handled will next be described. It has previously been explained in connection with Figs. 1 and 2 that calls originating in or arriving at office 9 and intended for a subscriber of office 8 or its associated sub-office 86 are forwarded by way of the eighth level of first selectors, such as the first selectors FS1—FS5, Fig. 2, to office 8 over one-way trunks such as T3, and over two-way trunks such as T2 when the one-way trunks are in use. The repeaters R2 and R1, Figs. 16 and 17, are accessible by way of terminals such as 1600 and 1700 to the first selectors in exchange 8. Each of these repeaters is provided with terminals associated with the inter-office trunk conductors 1613—1615 at the repeater R2 and 1713—1715 at repeater R1. The repeater R2, being associated with a one-way outgoing trunk, has the conductors of this trunk (T3) connected directly to terminals 1613 and 1614, and terminal 1615 is not used. In the repeater R1, the associated trunk T2 being a two-way trunk, transfer relay 1711 is connected to terminal 1715, while the associated trunk T2 is connected to contacts of the transfer relay 1711, as illustrated.

It is to be noted that the EC lead incoming to the repeater R1 from the terminals 1700 is extended through normally closed contacts of series relay 1703 to the upper right terminal of the repeating coil. This connection is made for the purpose of forwarding class-recording and call-offering impulses over the trunk T2.

When the repeater R1 is seized at the terminals such as 1600, responsive to the dialling of the office digit 8, line relay 1700 is operated through the left-hand windings of the associated repeating coil by way of contacts of supervision repeating relay 1706. Line relay 1701 operates release relay 1702, and relay 1702 applies ground potential to the incoming C lead to maintain the connection established. Relay 1702 also prepares a circuit for series relay 1703 and it completes a loop through the right-hand repeating coil windings and contacts of line relay 1701 as far as the terminals 1713 and 1714, which loop includes detector relay 1704 and the upper winding of the electropolarized supervisory relay 1705. Release relay 1702 also closes a circuit for the polarizing winding of supervisory relay 1705 and a circuit for the lower winding of the holding relay 1709. Relay 1709 operates and places an additional holding potential on the associated C lead through contacts of unlock relay 1710; it prepares to place the high-resistance unlock relay 1710 across the talking conductors, when release relay 1702 re-

stores; it prepares a locking circuit for the hold-repeat relay 1708; and at its lower contacts it closes a circuit for transfer relay 1711. Transfer relay 1711 operates to disconnect the negative and positive inter-office trunk conductors from the incoming selector IS2, Fig. 10, and to connect them to terminals 1713 and 1714 of the repeater R1. The above-described operations take place in rapid succession, whereby the connection through the repeater to the conductors of the trunk T2 is closed before the termination of a class-recording impulse over the incoming EC lead, in the event that a class-recording impulse is being received.

The two-way trunk T2 extends by way of contacts of transfer relay 2711, associated with the repeater R4 in office 8, to the incoming selector IS4 in office 8. The line relay 2602 of the incoming selector IS4, Fig. 26, is normally bridged across the conductors of the trunk T2 in series with the exchange battery. Therefore the closure of the bridge across the conductors of trunk T2 upon the operation of transfer relay 1711 of the repeater R1 results in the operation of line relay 2602 to prepare the selector for operation by operating the release relay 2603 and auxiliary release relay 2604. The placing of ground potential on the C lead of the selector grounds the C lead of the repeater R4 to mark the two-way trunk busy in office 8.

The differential recording-control relay 2602 is connected in series with the talking conductors incoming to the selector S4. Therefore, in case the call is incoming from the public exchange and a class-recording impulse is being received over the EC lead incoming to the repeater R1 when the repeater is seized, the resulting momentary grounded condition of the trunk T2 results in an unbalanced current flow through relay 2601. This relay thereupon operates and closes a circuit through contacts of switching relay 2606 for class-recording relay 2607. Relay 2607 thereupon operates and locks itself to the associated C conductor; opens its own initial circuit; and at its upper contacts it prepares to relay a class-recording impulse to the switch or trunk-line which the incoming selector is operated to seize.

In the repeater R1, Fig. 17, each time a digit is received the line relay 1701 responds and repeats the impulses thereof to the distant exchange at its upper contacts. Series relay 1703 is operated through the lower contacts of relays 1701 and 1702 during each series of impulses. At its lower contacts, series relay 1703 short circuits the lower left-hand repeating-coil winding to reduce the impedance in the circuit of line relay 1701 during the impulsing operation, while at its upper contacts it disconnects the incoming EC lead and by-passes the lower right-hand repeating-coil winding and the associated holding bridge through relays 1704 and 1705, thereby giving the upper contacts of line relay 1701 a more direct impulse control over the outgoing loop.

At the end of the series of impulses, series relay 1703 restores the associated bridges to their previously existing condition and again connects the incoming EC lead to the outgoing negative conductor.

In the incoming selector IS4, line relay 2602 responds to the first group of repeated impulses by operating vertical magnet 2603 to raise the wipers 2600 opposite the desired level of bank contacts. Series relay 2605, which is initially operated by auxiliary release relay 2604 through off-normal contacts 2613, restores at the end of the

vertical movement and closes a circuit through off-normal contacts 2612 for rotary magnet 2609. The rotary movement is thereby initiated and continues until the electropolarized switching relay 2606 is operated over the C wiper and the C lead of an idle trunk to switch the connection through to the said idle trunk. In the event that class-recording relay 2607 has been operated as above described, a class-recording impulse is transmitted over the EC wiper following the operation of switching relay 2606 until the auxiliary release relay 2604 restores.

In the event that the second digit of the number is one of the digits 2 to 4, a local connector such as the connector LOC3, Fig. 2, is taken for use. This local connector is similar to the local connector LOC1, Fig. 19, previously described. This connector therefore responds to the final digits of the number and completes the connection to the line or denies it, depending upon the class of the called line and upon the class of the calling line, as determined by the operated or unoperated condition of the class-test relay, (1908 in LOC1) and of the class-recording relay (1907 in connector LOC1).

In the event that the called line is busy and the call is being extended by way of the operator's switchboard and that the operator has been instructed to offer the call to the busy line, the receipt of the offering impulse at the incoming EC lead of the repeater R1, Fig. 17, results in the transmission of an impulse through contacts of relays 1703 and 1702 and over the negative conductor of the trunk T2, thereby momentarily unbalancing the circuit of the differential recording-control relay 1601. This relay operates and repeats the impulse over the EC wiper of the incoming selector IS4, thereby bringing about the operation of the offering relay of the connector in office 8, which offering relay is similar to the offering relay 1912 of the local connector LOC1, Fig. 19.

When the called subscriber responds and thereby brings about the usual reversal of current flow, the current flow is reversed in the back bridge of the repeater R1, Fig. 17, thereupon electropolarized supervisory relay 1705 responds and operates the supervision repeating relay 1706 to reverse the connection between the incoming talking conductors of the repeater and the windings of line relay 1701 to give answered supervision in the calling office.

Supervision-repeating relay 1706 also operates the associated back-release relay 1707 to prepare for the more efficient repeating of recall impulses in the event that the call is being extended through the link switchboard and the called subscriber desires to recall the branch-exchange operator by turning his dial. In this event, the operation of the called subscriber's dial causes the back-bridge relay of the connector to restore and reoperate one or more times to produce one or more momentary reversals in the direction of current-flow in the talking conductors. Supervisory relay 1705 is momentarily restored each time the current-flow is momentarily reversed back to normal direction. Each time it restores, supervisory relay 1705 opens the circuit of the supervision-repeating relay 1708 to bring about a momentary reversal to normal direction of the current-flow in the incoming talking conductors of the repeater. Supervisory relay 1705 also closes a circuit through contacts of the actuated back release relay 1707 for series relay 1703, whereby series relay 1703 is operated throughout the series

of recall impulses to shunt the lower left-hand winding of the repeating coil to reduce the impedance of the repeating coil. Series relay 1703 does not shunt out relay 1705 at this time as it does when the digits of the number are being forwarded to the distant office, as relay 1705 must remain in circuit to repeat the recall impulses. Because of the circuit change made at the upper armature of release relay 1707 the upper armature of relay 1703 now places the resistor 1712 in shunt of the winding of detector relay 1704 to reduce the back-bridge impedance.

At the end of the recall digit, supervisory relay 1705 comes to rest in an operated condition, as does supervision-repeating relay 1706, and the associated back release relay 1707 is held operated. Series relay 1703 now restores.

In the event that the called subscriber is the first to replace his receiver at the end of the conversation, relay 1705 restores, followed by the successive restoration of relays 1706 and 1707. Relay 1703 operates during the interval required for relay 1707 to restore, following which relay 1703 restores also. The repeater remains in this condition (with relays 1701, 1702, 1704, 1709, and 1711 operated) until the receiver is replaced at the calling substation.

When the repeater is replaced at the calling substation, line relay 1701 restores and opens the outgoing loop, at the same time incidentally operating series relay 1703. Release relay 1702 restores after an interval and opens the circuit of series relay 1703 to permit this relay to restore also. Relay 1702 also removes ground potential at one point from the incoming C lead, but the C lead is maintained grounded for the time being at contacts of the holding relay 1709. Release relay 1702 also opens the initial circuit of holding relay 1709, but this relay remains locked for the time being through its own inner upper contacts and contacts of unlock relay 1710, to ground through the upper contacts of the make-busy key 1716. Release relay 1702 also bridges the high resistance unlock relay 1710 across the outgoing conductors through contacts of holding relay 1709. The unlock relay therefore tests the conductors to determine whether or not a potential is still applied to them at the distant office, as is normally the case except when a call is to be deliberately held through an annoyance trap, as will be explained hereinafter. Under normal conditions, therefore, high resistance unlock relay 1710 energizes in series with a line relay in the distant exchange, but a normally adjusted line relay cannot operate through relay 1710 because of the high resistance of relay 1710. Relay 1710 ungrounds the C lead at its upper contacts and opens the locking circuit of the holding relay 1709 at its inner upper contacts. Relay 1709 therefore restores and opens a further point in its own locking circuit as well as a further point in the circuit through which ground potential was formerly applied to the C lead. At its upper contacts hold relay 1709 disconnects relay 1710 from in bridge of the talking conductors, whereupon relay 1710 restores also. Finally, transfer relay 1711 restores responsive to restoration of hold relay 1709 and transfers the conductors of the trunk T2 back to the incoming selector of Fig. 10.

From the foregoing description of its operation, it is seen that the repeater R1 is so arranged that, in addition to repeating the usual digit impulses in the forward direction and the usual supervisory and recall impulses in the backward direction, repeats impulses received over the EC

lead as an unbalanced line-conductor condition, whereby the recording control relay 2601 of the incoming selector IS4 can repeat the unbalanced line condition as a ground impulse on the EC lead in the distant office. By this arrangement, the application of ground potential to the incoming EC lead of the repeater R1, Fig. 17, results in an application of ground potential to the EC lead of the incoming selector IS4 under the control of relay 2601. The operation of the repeater in trapping annoyance calls will be pointed out subsequently.

Local calls in office 8

Referring now to Fig. 28, it will be explained how local calls are handled in office 8.

Calls from the non-restricted line of substation A3 (No. 8225) are made through the lineswitch LS1, similar to the lineswitch LS2, Fig. 12, through first selectors such as the first selector FS6. This selector is like the selector FS5, Fig. 12, except that it drops back from the eighth level instead of from the ninth level, the first digit of all numbers in office 8 being the digit 8. The first selector FS6 has access to local connectors such as the local connector LOC3, as has the incoming selectors such as the one shown in Figs. 25, 26, 31, and 32, while the local connectors have access to all of the local lines. The lineswitch LS8 is associated with the local connector LOC3 for transfer service as described in connection with the local connector of Fig. 19, while the lineswitch LS6 is shown associated with the outgoing repeater OR2 to provide transfer service on calls outgoing from office 8 to the public exchange. The outgoing repeater OR2 is like the outgoing repeater shown in Fig. 13.

Calls outgoing from office 8 to office 9

When a subscriber in office 8 desires to converse with a subscriber in office 9 or a subscriber reached by way of office 9, or to call the branch-exchange switchboard (No. 97) he dials the digit 9 as the first digit of the number to cause a first selector (the first selector FS6, Fig. 28) to seize a trunk line on the ninth level, such as the trunk line T1 associated with the repeater R3, Fig. 24, or the two-way trunk line T2 associated with the repeater R4, Fig. 27, in the event that all of the one-way trunk lines are in use. The repeaters R3 and R4, Figs. 24 and 27, are each similar to the repeater R1, Fig. 17, except that the repeater R3 is not provided with a transfer relay, while the repeater R4 is provided with a transfer relay 2711, corresponding to the transfer relay 1711 of the repeater R1.

Assuming now that the repeater R4 is seized in office 8 at the terminals 2700, transfer relay 2711 is caused to operate as explained in connection with transfer relay 1711, bridging the conductors of the trunk T2 across the loop terminals 2713 and 2714.

In office 9, the trunk T2 is normally connected through contacts of transfer relay 1711 (Fig. 17) to the incoming line conductors of the incoming selector IS2, Fig. 10. Therefore, upon the seizure of the trunk T2 in office 8, line relay 1001 of the incoming selector operates over the trunk T2 and brings about the operation of the associated release relay 1220, and release relay 1002 prepares a circuit for vertical magnet 1005 and operates series relay 1003 through off-normal contacts 1009. When release relay 1002 grounds the associated C conductor, a ground potential is extended to the incoming C conductor of the repeater

R1, Fig. 17, to which the incoming C lead of the selector of Fig. 10 is connected, thereby guarding the repeater R1 against seizure in office 9.

The selector of Fig. 10 operates in response to the next digit in the number as explained in connection with the previously described selectors, except that the incoming selector IS2 is a selector in substantially its simplest form whereas the selectors previously described have each had one or two additional relays. It suffices to say that the wipers 1000 are raised opposite the desired level of bank contacts by the action of vertical magnet 1005; that the operation of rotary magnet 1006 is initiated through off-normal contacts 1010 when series relay 1003 restores at the end of the vertical movement; and that the electropolarized switching relay 1004 operates over the associated C wiper and the C lead of an idle trunk to perform the usual switching-through operation.

The selector IS5 is subsequently restored to normal position by the action of the release magnet 1007 when switching relay 1004 restores when the connection is to be released.

Calls outgoing from office 8 to sub-office 86

The way in which calls originating in or being trunked through office 8 and intended for sub-office 86 are handled will now be explained. Upon reference to Fig. 2, part 3, it will be noted that the sixth level of the incoming selectors IS3 and IS4 and the local first selector FS6, in office 8, gives access by way of repeaters such as R5 and R6 to trunk lines such as T5 and T6 leading to sub-office 86, Fig. 2, part 4. The one-way trunk T6 leads to the incoming connector IC4 in sub-office 86, while the two-way trunk T5 (there are three such two-way trunks) leads to the incoming connector IC2, and is accessible also to the selector repeater SR. It will be seen therefore that, when the second digit 6 follows the first digit 8 (the first selector FS6 restores to normal when the first digit 8 is dialled), a trunk line outgoing to sub-office 86 is seized, whereby an incoming connector at sub-office 86 is taken for use to complete the call to the desired line in the sub-office.

The repeaters R5 and R6 associated with trunks T5 and T6 are shown in Figs. 33 and 34, while the incoming connectors IC1 and IC2 are shown in Figs. 36 and 35. In order to explain the operation best, it will be assumed that office 86 is called at a time when the one-way trunk T6, Fig. 34, is in use. It will be assumed that the two-way trunk T5 is idle and that the repeater R5 is seized at terminals such as 3300 by one of the selectors having access to it in office 8. Since the repeater R5 is like the repeater shown in Fig. 17, transfer relay 3311 is operated to transfer the conductors of a trunk T5 from the incoming selector IS6 to the loop terminals 3313 and 3314.

In the incoming connector IC2, Fig. 35, line relay 3303 is bridged across the incoming conductors through contacts of supervisory relay 3308 and in series with the differential recording-control relay 3307. Line relay 3503 therefore operates when the trunk T5 is seized in office 8, and it prepares the selector for operation by causing release and auxiliary release relays 3504 and 3505 to operate; vertical series relay 3506 operates through off normal contacts 3508. In addition, if a class-recording impulse is received at the time of seizure, recording control relay 3507 operates to close a circuit through off-nor-

mal contacts 3530 for class-recording relay 3520, and class-recording relay 3520 closes a locking circuit at its lower contacts through the lower contacts of auxiliary release relay 3505.

5 It may be well to point out at this time that the incoming connector IC2, Fig. 35, as well as the incoming connector IC1, Fig. 35, is similar to the local connector LOC1, Fig. 19 (whose operation has already been described) except for the
10 addition of the busy-common and cut-off relays 3501 and 3502, having to do with the two-way use of the trunk T5, and the addition of the differential recording-control relay 3507, corresponding to the recording control relay 2601 of
15 the incoming selector IS4, Fig. 26. For this reason, the operation of the incoming connector IC2 will be described rather briefly, reliance being had on the previously given description of the operation of the connector shown in Fig. 19.

20 When the tens digit of the number is dialled, line relay 3503 responds and secures the operation of vertical magnet 3524, whereby the wipers 3500 are raised opposite the desired level of bank contacts. At the end of the vertical movement,
25 vertical series relay 3506 restores and transfers the operating circuit to rotary magnet 3525, by way of contacts of busy-test relay 3517 and switching relay 3523.

When the final digit is dialled, rotary magnet
30 3521 responds and rotates the wiper 3500 into engagement with the terminals of the desired line, the line of substation A4 (No. 8665, for example). Rotary series relay 3519 and auxiliary relay 3518 are operated during the rotary move-
35 ment, and they cooperate with busy-test relay 3517 to permit the line to be tested by way of the C wiper of the connector and the C lead of the line as to its busy condition. Assuming that the line is idle, busy-test relay 3517 is not operated. Under this condition, idle-test relay
40 3522 operates over the C lead (when auxiliary relay 3518 restores) and in series with the bridge-cut-off winding (not shown) of the lineswitch LS10, associated with the called line.

45 Class-test relay 3515 is operated upon the restoration of rotary series relay 3529 in the event that class-recording relay 3520 has been operated and in the further event that the line being called is a restricted line, which is assumed not
50 to be the case.

In the assumed example, the operation of idle-test relay 3522 is followed by the operation of switching relay 3523 to seize the line and apply
55 ringing current thereto from the common ringing lead 3541, by way of contacts of ring-cut-off relay 3513.

When the called subscriber responds, ring-cut-off relay 3513 operates and closes a locking circuit for itself, in addition to completing the
60 talking circuit and placing the further holding of the called line under the control of the combined class-test and holding relay 3515, which relay now operates, responsive to the operation of back bridge relay 3509 over the called line,
65 and closes a circuit at its inner upper contacts for maintaining auxiliary relay 3505 operated after ring-cut-off relay 3503 has operated.

Back bridge relay 3509 also operates supervisory relay 3508 to give supervision by reversing the direction of current-flow in the incoming leads of the connector and therefore over
70 the trunk line T5.

In the event that the call is incoming from the public exchange, the subscriber at the called
75 substation A4, Fig. 10, may secure a transfer

service by depressing the grounding push button shown in association with his line, thereby controlling the transfer-control relay 3512, transfer relay 3511, and transfer-release relay 3510 to
5 give this service as described in connection with the local connector LOC1, Fig. 19, wherein the corresponding relays are 1926, 1910, and 1909.

Assuming that the called subscriber is the first to replace his receiver at the end of the conversation, back-bridge relay 3509 restores and
10 permits supervisory relay 3508 to restore and give disconnect supervision. Back-bridge relay 3509 opens the circuit of the combined class-test and holding relay 3515, whereupon relay 3515 restores and opens the circuit of auxiliary
15 relay 3505. Relay 3505, upon restoring, disconnects ground potential from the C wiper at its upper contacts, while at its lower contacts it opens the locking circuit of switching relay 3523 and permits this relay to restore, thereby
20 freeing the called line.

When the receiver is replaced at the calling substation, the repeater R5, Fig. 33, is cleared out and the loop across the conductors of the trunk T5 is opened to permit line and release
25 relays 3505 and 3504 to fall back. At this point the connector is restored to its normal position by the operation of release magnet 3526, through off-normal contacts 3527.

Handling calls originating in sub-office 86

The way in which calls originated in sub-office
86 are handled will now be explained. As is illustrated in Fig. 2, part 4, and in Fig. 37, the
35 selector repeaters (directly to the sub-exchange lineswitches) have access to two trunks outgoing to the public exchange; to one one-way trunk and three two-way trunks extending to the parent or main office (office 8); and to five local connectors, of which LOC4 is one. In controlling
40 the operation of the selector repeaters, it has been found convenient to provide three so-called busy-common conductors. One of these conductors is the public-exchange busy-common conductor 3908, associated with the two outgoing
45 repeaters, of which the outgoing repeater OR3, Fig. 9, is one. The second or main-office busy-common conductor 3538 is associated with the trunks extending to the main office (office 8). The third busy-common conductor is conductor
50 3858, associated with the local connector LOC4 and the other local connectors. Each of these busy-common conductors (3908, 3558, and 3858) is maintained grounded as long as there is an idle trunk in the associated group, but is un-
55 grounded automatically when all trunks in the associated group are busy. Upon referring again to the repeater OR1, Fig. 13 (the repeater OR3, Fig. 39, being similar to the repeater OR1) it will be noted that the busy-common conductor
60 1308 extends to ground through contacts of relay 1306, connected to the associated C lead incoming to the repeater. Therefore, when the repeater OR1 is seized, ground potential is removed at one point from conductor 1308, and
65 the conductor becomes ungrounded when all of the repeaters are in use. Busy-common conductor 3908 in sub-office 86 is controlled in the same way.

The C lead of the one-way trunk T4 extending from the sub-office 86 to the main office 8 terminates in a relay, as illustrated in Fig. 37, part 2, which removes ground potential at one point from the main-office busy-common conductor 3558 when the trunk T4 is in use. Simi-
75

larly, the busy-common relay 3501 of the incoming connector IC2 is connected to the C lead of the trunk T5 and the incoming connector IC2, whereby it is operated to remove the associated ground connection from the main-office busy-common conductor 3558 when the trunk T5 is in use. By a similar arrangement, local-conductor busy-common conductor 3858 is ungrounded at all points when all trunks leading to the local connector are in use. The busy-common conductors are each common to all of the selector repeaters, such as SR, as is indicated by their respective common-connection symbols.

15 *Call from sub-office 86 to the public exchange*

It will now be assumed that the subscriber at substation A4, Fig. 37, whose line terminates in sub-office 86, desires to converse with a subscriber of the public exchange. He therefore removes his receiver and dials the public-exchange number of the desired subscriber, preceded by the digit 0.

When the receiver is removed at substation A4, the line switch LS10 operates in the usual manner to select an idle trunk, which trunk may be assumed to be the illustrated one extending to the selector repeater SR, Fig. 37. The negative and positive conductors incoming to the selector repeater SR extend normally through contacts of switch-through relay 3701 and the left-hand windings of repeating coil 3733 to the windings of line relay 3702. Line relay 3702 therefore operates when the selector repeater is seized, causing release relay 3703 and auxiliary release relay 3704 to operate in succession. Release relay 3703 places a ground potential on the incoming C lead to maintain the lineswitch LS10 operated, while the auxiliary relay 3704 prepares a circuit through contacts of off-normal relay 3709 for the operating magnet 3718 of the marking switch MS, thereby preparing the marking switch for operation response to the dialling of the first digit.

It should be in mind that the connection is to be established to an incoming first selector in the parent office upon the removal of the receiver at the branch exchange in order to avoid the addition of a digit to the branch exchange numbers of subscribers in offices 8 and 9 when called from the sub-office, this arrangement being in accordance with well-established sub-office practice.

With the line and release relays 3702 and 3703 energized, the right-hand windings of repeating coil 3733 are bridged across conductors 3741 and 3742 by way of resting contacts of switch-through relay 3701, thereby closing a circuit for start relay 3736 associated with the mechanism of the selector repeater. The upper-winding of start relay 3736 is connected to conductor 3741, while ground potential is connected to conductor 3742 through the main-office busy-common conductor 3558 and through contacts of relays 3712 and 3713 (unless conductor 3558 is ungrounded because all of the trunks to the main office are busy). As a result, start relay 3716 is operated in the event that there is an idle trunk leading to the main office. Upon operating, relay 3716 connects the junction of the windings of switching relay 3715 and operating magnet 3717 through contacts of switching relay 3715 and contacts of relays 3713 and 3712 to test wiper C3, which is used to test the trunks leading to the main office. It is to be noted that all of the contacts in the banks of wiper C3 are connected

to ground except the four contacts which terminate the C leads of the main office trunks. Operating magnet 3717 is therefore operated in a buzzer-like manner in a circuit including test wiper C3 and the successively engaged contacts until the wipers 3700 arrive on the terminals of an idle main-office trunk. At this time, the wiper C3 is in engagement with an ungrounded contact and the stepping movement of magnet 3717 thereupon ceases. At this point, switching relay 3715, which has previously been short circuited by the ground connection through wiper C3 now operates in series with magnet 3717, through contacts of relays 3713 and 3712 to ground at the upper contacts of auxiliary release relay 3704. Upon operating, relay 3715 opens the test circuit and closes a holding circuit for the lower winding of start relay 3716 at its lower armature; extends the grounded incoming C lead to wiper C3, through contacts of start relay 3716, and it disconnects conductors 3714 and 3742 from the grounded conductor 3747 and the upper winding of start relay 3716 and extends them by way of contacts of start relay 3716 and the negative and positive wipers to the talking conductors of the selected main-office trunk, which trunk may conveniently be assumed to be the two-way trunk T5. Busy-common relay 3501 in the incoming connector IC2 is operated over the associated C lead when the trunk T5 is seized; cut-off relay 3502 is also operated over the C lead, through contacts of the make-busy key 3544, and through the upper armature and resting contact of release relay 3504. Cut-off relay 3502 disconnects the negative and positive conductors of the trunk T5 from the corresponding conductors of the incoming connector IC2.

The right-hand windings of repeating coil 3733 of the selector repeater SR are now bridged across the conductors of the trunk T5 by way of the negative and positive wipers of the wiper group 3700 of the selector repeater, whereby the line and release relays (not shown) of the incoming selector IS6, Fig. 32, in office 8 prepare the incoming selector for operation. The selectors incoming to office 8 from the sub-office are each similar to the first selector FS5, Fig. 12, in all respects except that the shaft springs therein corresponding to the ninth-level springs 1217 of Fig. 12 are set for the eighth level instead of for the ninth level, whereby the incoming selectors of Figs. 31 and 32 absorb the first digit 8 instead of the first digit 9.

A dial-tone signal applied through the windings of the line relay of the incoming selector of Fig. 32 is returned over the conductors of the trunk T5 to the selector repeater SR and thence by way of repeating coil 3733 to the line of substation A4, signifying that the calling subscriber may now proceed to dial the desired number, as the selector repeater SR is in readiness to respond to the first digit, as is the incoming selector IS6, Fig. 32.

It may be pointed out at this time that since the above described operation of start relay 3716 is dependent upon a ground potential obtained from the main-office busy-common conductor 3558, start relay 3716 does not operate responsive to the seizure of the selector repeater SR when all of the main-office trunks are busy. In this event, switching relay 3715 operates right away since no testing circuit is closed by the operation of relay 3716. Upon operating, relay 3715 disconnects start relay 3716 so as to prevent its

subsequent operation and extends conductors 3741 and 3742 to the two uppermost armatures of the unoperated start relay 3716. The upper armature of relay 3716 is now connected to the upper winding of this relay to form a return path for tone current, while the adjacent armature of the relay is connected through blocking condenser 3746 to the dial-tone conductor 3745, by way of contacts of relays 3713, 3712, and 3711. Thus, a dial-tone signal is given from the sub-exchange in this case to notify the subscriber to proceed to dial in spite of the fact that all of the main-office trunks are busy, whereas, if a main office trunk is idle, the local dial-tone lead is disconnected by relay 3716 for a dial-tone signal normally comes from the main office.

When the subscriber at substation A dials the prefix digit "0" in order to obtain connection with a trunk outgoing to the public exchange, line relay 3702 interrupts the bridge across the conductors 3741 and 3742 at its upper armature ten times. Since this bridge is now the holding bridge for the line relay of the incoming selector IS6, Fig. 32, the selector of Fig. 32 operates to raise its wipers opposite the tenth level of bank contacts. This operation is of no particular utility in this instance, as the tenth level of bank contacts is unused at the incoming selectors in office 8, as appears in Fig. 2, and as has been hereinbefore pointed out.

Line relay 3702 also delivers ten impulses through contacts of auxiliary relay 3704 to operating magnet 3718 of the marking switch MS. The first of these impulses passes through contacts of off-normal relay 3709, and the subsequent impulses pass through contacts of the slow-acting series relay 3707, which relay operates in multiple with magnet 3718 upon the delivery of the first impulse and places a shunt around the associated contacts of off-normal relay 3709, so as to maintain its own circuit and the circuit of operating magnet 3718 intact after off-normal relay 3709 has operated responsive to the closure of off-normal contacts 3721 of the marking switch MS. Off-normal relay 3709 also prepares a control circuit at its lower contacts, while at its upper contacts it prepares a circuit for release magnet 3719, which circuit is maintained open at contacts of the operated auxiliary release relay 3704.

Series relay 3707 also disconnects ground potential from wiper 3720 of the marking switch MS during the movement of the wiper and closes a circuit for the associated auxiliary series relay 3708, whereby relay 3708 also is energized throughout the series of impulses. 3708 disconnects the switch-through relay 3701, and it prepares to restore switching relay 3715, depending upon the value of the digit dialled as determined by the setting of the marking switch MS.

Since the digit dialled is the digit "0", the wiper 3720 is advanced to its final contact.

At the end of the series of impulses, series relay 3707 restores and opens the circuit of slow-acting auxiliary relay 3708 and applies ground potential to wiper 3720, thereby closing a circuit through contacts of relay 3711 for the lower winding of the number 0 relay 3713. Relay 3713 locks itself to the grounded conductor 3743; opens the circuit of switching relay 3715, since the auxiliary relay 3708 has not yet restored; prepares a circuit for switch-through relay 3701; disconnects main-office test wiper C3 and substitutes public-exchange test wiper C1; it closes a circuit for

discriminating relay 3714 at its lower contacts from the incoming EC lead (grounded by virtue of the jumper 3731 at the lineswitch LS10 to permit the discriminating relay to operate and prepare for extending the connection to the public exchange); and it disconnects start conductor 3747 from the main-office busy-common conductor 3550 and extends it through contacts of discriminating relay 3714 to the public-exchange busy-common conductor 3908.

Start relay 3736 whose locking circuit was opened at the lower armature of switching relay 3715 upon the restoration of the latter relay, remains operated through contacts of the restored relay 3715 and over the busy-common conductor 3908 by way of the contacts of the operated relays 3713 and 3714. Start relay 3716 maintains the junction of the winding of relay 3715 and operating magnet 3717 connected through contacts of the operated number 0 relay 3713 to the C1 test wiper. Therefore, the magnet 3717 is operated again to advance the wipers 3700 until an idle public-exchange trunk is reached, which trunk may be assumed to be the one extending to the outgoing repeater OR3, Fig. 39. When this trunk is reached, the C1 wiper no longer encounters ground potential and the operation of magnet 3717 ceases. Switching relay 3715 now operates again through operating magnet 3717 and through contacts of the now-restored series auxiliary relay 3708. With switching relay 3715 re-operated, start relay 3716 is again locked at the lower armature of the switching relay, and the connection is extended through the wipers 3700 to the outgoing repeater OR3. Ground potential from the grounded C lead 3743 is now extended through contacts of the operated switching and start relays 3715 and 3716 and by way of contacts of the operated number 0 relay 3713 and contacts of the restored series-auxiliary relay 3708 to the switch-through relay 3701. Relay 3701 thereupon operates to by-pass the windings of the repeating coil 3733 and to close a new holding circuit to the grounded C lead for switching relay 3715 independent of the upper contacts of auxiliary relay 3704. The line, release, and auxiliary-release relays 3702-3704 now restore, leaving relays 3701 and 3713-3716 operated in the selector repeater. The connection is now maintained by ground potential placed on the C lead of the outgoing repeater OR3, the incoming C lead of the selector repeater being extended through wiper C1 to the C lead of the repeater OR3. Release magnet 3719 of the marking switch MS operates through contacts of off-normal relay 3709 when relay 3704 restores. Switch MS thereupon restores to normal position, and relay 3709 falls away.

The calling subscriber may now operate his dial in accordance with the digits in the public-exchange number of the desired subscriber, which digits are repeated by the outgoing repeater OR3.

The calling subscriber may obtain transfer service through the outgoing repeater OR3 and lineswitch LS9, as explained in connection with the repeater OR1, Fig. 13, and the associated lineswitch LS1.

When the calling subscriber replaces his receiver upon the termination of the public-exchange conversation, the clearing out of the repeater OR3 results in the removal of ground potential from the associated C lead, whereupon the energized relays in the selector repeater SR restore and the lineswitch LS10 releases.

Calls outgoing from sub-office 86 to office 8

In order to further explain the operation of the equipment in sub-office 86, it will be assumed that the subscriber at substation A4 has removed his receiver with results as hereinbefore described, and that the first digit he dials is the digit 8 instead of the digit 0 and that he is calling a subscriber of office 8, in which event the second digit is some digit other than 6.

Since the first digit dialled is the digit 8, the wiper 3720 of the marking switch MS is advanced to the eighth associated contact. Under this condition when ground potential is reapplied to wiper 3720 upon the restoration of series relay 3707, a circuit is closed through contacts of stop relay 3710 for the number 8 relay 3711. Relay 3711 closes a locking circuit for itself at its inner lower contacts through stop relay 3710 to ground at the inner upper armature of auxiliary relay 3704. Relay 3710, however, does not operate in this locking circuit as long as ground potential is applied directly to the winding of relay 3711, as it now is by way of the wiper 3720. Relay 3711 also closes an additional temporary locking circuit for itself at its inner upper contacts through the lower contacts of off normal relay 3709 so as to prevent the operation of stop relay 3710 until the marking switch has been returned to its normal position.

Relay 3711 also closes a circuit through contacts of relay 3710 for release magnet 3719. Release magnet 3719 restores the wiper 3720 to normal position, whereupon off-normal contacts 3721 restore and open the circuit of relay 3709. Relay 3709 opens the temporary locking circuit of relay 3711 at its lower contacts to permit relay 3710 to operate, while at its inner lower contacts it reconnects operating magnet 3718 to permit it to respond again. Relay 3710 now operates in the locking circuit of relay 3711 to open the circuit of release magnet 3719 and to disconnect the junction of the windings of relays 3710 and 3711 to prevent further shunting of relay 3710 when the next digit is dialled.

When the next digit is dialled, operating magnet 3718 brings the wiper 3720 onto the corresponding bank contacts. Since it has been assumed that the call is for a line terminating in office 8, the next digit is some digit other than the digit 6, in which event no further switching operation takes place in the selector repeater after the wiper 3720 comes to rest. When series relay 3707 restores, it disconnects its own winding and that of the operating magnet 3718 from the operating conductor, with the result that the digits subsequently dialled have no effect on the marking switch MS, all of the digits dialled are repeated at the upper contacts of the line relay 3702, as pointed out previously, to the switching apparatus in the main office 8.

It is to be noted that the lower contacts of the No. 8 relay 3711 close a circuit for holding relay 3706, having to do with the holding of annoyance calls to be subsequently described. This relay operates and locks itself through contacts of relays 3705 and 3701 and through contacts of make-busy key 3732. Relay 3706 makes an additional ground connection to the C-conductor 3743 and an additional ground connection in multiple with that made at the upper windings of auxiliary relay 3704 so as to maintain switching relay 3718 operated independent of auxiliary relay 3704, while at its upper contacts, it prepares to bridge the high-resistance unlock relay 3705 across the conductors 3741 and 3742.

Calls through office 8 to office 9

At this point it may be mentioned that in the event that the calling subscriber is making a call to office 9 the only difference in the operation previously described is that relays 3710 and 3711 are operated in series at the end of the dialling of the first digit 9 when wiper 3720 is in engagement with the ninth associated bank contact instead of the eighth. Relay 3711 is rendered slightly slow operating, as indicated in the drawings, to permit relay 3710 to operate first and thereby prevent an undesired operation of release magnet 3719. No further operation of the marking switch MS takes place because the circuit of operating magnet 3718 is maintained open at the lower contacts of off normal relay 3709 after the series relay 3707 restores, as previously pointed out.

It is to be noted that no provision is made in the selector repeater SR for responding to a reversal of current when the called subscriber replies, as this operation is unnecessary in calls originating in the sub-office.

When the calling subscriber replaces his receiver upon the termination of an interoffice conversation, line relay 3702 falls back to open the bridge across the associated conductors and therefore across the conductors of the seized main-office trunk, thereby permitting the distant switching apparatus to be cleared out. Release relay 3703 and auxiliary release relay 3704 restore responsive to the restoration of line relay 3702. Auxiliary relay 3704 permits relays 3710 and 3711 to restore when it removes ground potential from wiper 3720 of the marking switch MS, but relays 3715 and 3716 are maintained operated temporarily because of the locked condition of hold relay 3706 above pointed out. Upon the restoration of release relay 3703, however, unlock relay 3705 is bridged across conductors 3741 and 3742 by way of contacts of hold relay 3706. The high-resistance unlock relay 3705 is thereupon operated over the conductors of the interoffice trunk line to open the circuit of hold relay 3706. Hold relay 3706 thereupon restores, permitting relays 3715 and 3716 in the selector repeater to restore and permitting the line switch LS10 to release. The connection is thereby cleared out.

Local call in sub-exchange 86

In the event that the subscriber at substation A2 is calling a local line in substation 86, the operations are as hereinbefore described in connection with a call through the main office 8 including the dialling of the first digit 8, responsive to which relay 3711 operates and brings about the restoration of the marking switch MS to normal position, whereupon stop relay 3710 is operated as described.

When the second digit 6 is dialled, the wiper 3720 is advanced into engagement with the sixth associated bank contact. Then, when series relay 3707 restores, operating magnet 3718 is disconnected so that it does not respond to further impulses, while the placing of ground potential on wiper 3720 results in the closure of a circuit through the lower winding of the number 86 relay, 3712. Relay 3712 locks itself to the C lead 3743. As is apparent upon an inspection of the drawings, relay 3712 performs switching operations similar to those described in connection with the operation of the number 0 relay 3713. As a result, switching relay 3715 is restored to permit a further hunting operation, while the local wiper

C2 is substituted for the main-office wiper C3. Moreover, the circuit of the upper winding of start relay 3716 is transferred to the local-conductor busy-common conductor 3858, whereby relay 3716 remains operated or not depending upon the busy or idle condition of the local connectors. If all the connectors are busy and start relay 3716 is therefore unable to remain operated, switching relay 3715 is subsequently operated alone, and a busy signal is given from the busy tone conductor 3744 through contacts of the operated relays 3709 and 3713. On the other hand, if one or more of the local connectors is idle (as is usually the case) start relay 3716 remains operated over busy common conductor 3858 and maintains the test circuit of operating magnet 3717 closed through contacts of the operated relay 3712 to the C2 wiper. The wipers 3700 are therefore rotated until an idle local connector is reached, which connector it will be assumed is the one shown in Fig. 38. When this connector is reached, the stepping operation ceases and switching relay 3715 reoperates through contacts of the now-restored series auxiliary relay 3708. Switch-through relay 3701 is now operated through contacts of number 86 relay 3812 and contacts of relays 3715 and 3716 to by-pass and disconnect the windings of the repeating coil 3733, and thereby extend the calling line directly to the local connector LOC4, Fig. 38. Relays 3702-3704, 3706, 3710, and 3711 restore and the switch MS releases, leaving relays 3701, 3710-3712, 3715, and 3716 operated in the selector repeater.

In the local connector LOC4, line relay 3802 operates upon the seizure of the connector and closes a circuit for release relay 3803, following which auxiliary release 3804 is operated through the lower contacts of relay 3803 by way of the lower contacts of ring-cut-off relay 3809. Release relay 3803 places ground potential through contacts of the associated make-busy key 3831 on the incoming C lead so as to maintain the connection intact through the selector repeater SR. Busy-common relay 3801 removes ground potential at one point from busy-common conductor 3858.

When the calling subscriber dials the tens digit in the desired number, vertical magnet 3815 is operated through contacts of the vertical-series relay 3805, which relay is initially operated through off-normal contacts 3819 and the lower contacts of release relay 3803. The wipers 3800 are thereby raised opposite the desired level of bank contacts.

At the end of the vertical movement, vertical series relay 3805 restores preparatory to the rotary operation.

When the units digit is dialled, rotary magnet 3816 responds and rotates the wipers 3800 into engagement with the terminals of the desired line. The busy test is applied by busy-test relay 3810, whose circuit by way of the associated C wiper is controlled by series auxiliary relay 3811, controlled in turn by rotary-series relay 3812. In the event that the called line is busy, a busy-tone signal from lead 3834 is returned, and busy-test-relay 3810 is locked energized upon the restoration of auxiliary relay 3811.

On the other hand, in the event that the called line is idle, idle-test relay 3813 is operated over the C lead upon the restoration of auxiliary relay 3811, to bring about the operation of switching relay 3814.

The ringing operation takes place when switching relay 3814 operates, ringing current being supplied by way of the common ringing lead 3820 through contacts of ring-cut-off relay 3809.

The ring-cut-off relay 3809 is operated when the called subscriber responds, following which back-bridge relay 3807 and back-release relay 3808 operate in succession. Back-release relay 3808 shunts the lower contacts of ring-cut-off relay 3809 to hold the auxiliary release relay 3804 operated following the operation of ring-cut-off relay 3809. The connector remains in this condition until the conversation is completed.

At the end of the conversation the two subscribers replace their receivers. In the event that the calling subscriber replaces his receiver first, line relay 3802 restores immediately, followed by the delayed restoration of the slow-acting release relay 3803, following which auxiliary relay 3804 restores immediately as its upper winding is open circuited upon the restoration of release relay 3803. Switching relay 3814 restores when its locking circuit is opened at the lower contacts of auxiliary relay 3804; back-bridge relay 3807 restores responsive to the restoration of switching relay 3814; back-release relay 3808 restores as a result; and the ring-cut-off relay 3809 restores when its circuit is opened at off-normal contacts 3820 upon the restoration of the connector by release magnet 3817, whose circuit is closed through off-normal contacts 3818 upon the restoration of auxiliary relay 3804.

On the other hand, in the event that the called subscriber is the first to replace his receiver the restoration of back bridge relay 3807 and the subsequent restoration of back release relay 3808 is followed by the restoration of auxiliary release relay 3804 to open the circuit of switching relay 3814 to disconnect the wipers 3800 and thereby free the called line. Under this condition, the connection is released responsive to the restoration of release relay 3803 when line relay 3802 restores upon the receiver being replaced at the calling substation.

In the selector repeater SR, responsive to the removal of ground potential from the C lead upon the restoration of release relay 3803 of the local connector LOC4, relays 3701, 3712, 3715, and 3716 restore, returning the selector repeater SR to normal condition.

Trapping annoyance calls

As has been mentioned hereinbefore, a feature of this invention is that new and improved arrangements have been provided for enabling a subscriber who is being annoyed by anonymous calls to trap or hold such a call at his discretion until the branch-exchange attendants have traced the call to its source to discover the line from which it has been made. For this purpose, special circuit arrangements have been made in the switching apparatus, and a number of special repeaters such as the call holding repeater shown in Fig. 40 have been installed in each of the branch offices for the temporary inclusion in the line of any branch exchange subscriber who may find himself being annoyed by anonymous calls.

The call holding repeater of Fig. 40 has been shown temporarily associated with the line of substation A1, Figs. 2 and 12, a non-restricted line of office 9. It will be understood, of course, that the conductors of a subscriber line are normally connected by means of a two-conductor jumper on the main frame to the connector-bank multiple of his line, and that the line switch as-

signed to this line is ordinarily connected to the negative, positive, and C conductors of the connector-bank multiple by means of a three-conductor jumper. The call holding repeater of Fig. 40 may be cable connected to the main frame, having one pair of terminals at the main frame to which a subscriber line may be attached by way of a two-conductor jumper such as 4023, while four terminals 4000 are provided corresponding to the conductors in the connector bank multiple to which the four conductor jumper 4021 may be connected to connect the call holding repeater with the connector bank contacts such as 1250, and the multiples thereof (not shown). The negative, positive, and C terminals in group 4000 are connected by means of a three-conductor jumper such as 4022 to the line switch.

Assuming the call holding repeater of Fig. 40 to have been inserted in the line of subscriber A1 by the temporary jumper connections as illustrated, the operations involved in making and receiving calls over the line will now be described.

Assume now that a connector (such as the local connector LOC1, Fig. 19) lands on the connector terminal 1250 of the line of substation A1 at a time when the line is idle, the C lead is extended by means of the C conductors in jumpers 4021 and 4022 to the lineswitch LS2, permitting the usual bridge-cut-off operation at the lineswitch LS2 and permitting the idle-test relay 1917 in the connector to operate and cause the line to be seized. When intermittent ringing current is applied by the connector, the ground-connected call relay 4001 is operated through the associated condenser and through contacts of release relay 4007. Relay 4001 operates by-pass relay 4002 to by-pass the windings of the repeating coil 4015 and thereby connect the line of substation A1 directly with the negative and positive terminals in group 1250 for the duration of the application of ringing current. Relay 4002 operates incoming recording relay 4003, which locks to the grounded C lead and prepares a circuit for trap-pulse relay 4010.

Each time a ringing period ends, call relay 4001 permits by-pass relay 4002 to restore and reintroduce the repeating coil 4015.

When the calling subscriber responds to the ringing operation by removing his receiver, the line relay 4006 operates over the called line in series with the retard coil 4005 and the differential detector relay 4004. Upon operating, line relay 4006 operates release relay 4007 to disconnect call relay 4001 and to prepare a circuit for series relay 4009. Line relay 4006 also bridges the right-hand windings of the repeating coil 4015 across the associated talking conductors, thereby operating the ring-cut-off relay in the connector and causing the back-bridge relay 1903 therein to operate and give answered supervision.

In the event that the call to the line of substation A1 is by way of the operator's switchboard and the subscriber at substation A1 desires to recall the operator, he may do this by turning his calling device, thereby causing line relay 4006 to deenergize one or more times. Each time it does so, line relay 4006 at its upper contacts opens the circuit of the back-bridge relay 1903 of the connector, the back-bridge relay 1903 is thereby restored momentarily one or more times to recall the branch exchange operator as hereinbefore described.

In the event that the call is one received from the public exchange and the subscriber at substation A1 desires to transfer the connection locally to the line of another subscriber as has been

hereinbefore pointed out, he momentarily operates the push-button at his substation, thereby unbalancing the current flow in the called line and causing the detector relay 4004 to operate. Detector repeating relay 4008 is thereby operated and it applies ground potential to the associated positive talking conductor, thereby unbalancing the current flow in the windings of the transfer-control relay 1926 of the connector. This causes the connector to be transferred as hereinbefore described. The transfer back to resume the main exchange conversation is accomplished when the subscriber at substation A1 again operates his push-button.

When the conversation is completed, the subscriber at substation A1 replaces his receiver, whereupon line relay 4006 restores and at its upper contacts opens the circuit of the back-bridge relay of the connector, causing the line to be freed in the manner hereinbefore described. Release relay 4007 restores and reconnects the call relay 4001.

When the subscriber at substation A1 removes his receiver to initiate a call, the line and release relays 4006 and 4007 operate as before and the operation of line relay 4006 closes a calling bridge at its upper contacts, causing the lineswitch LS2 to operate in the usual manner to initiate the extension of the connection. The dialling impulses are repeated at the upper contacts of line relay 4006.

The extended connection is cleared out when the subscriber replaces his receiver and permits the line and release relays 4006 and 4007 to restore.

From the foregoing description of operations involving the call-holding repeater it will be seen that the normal operation of the line of substation A1 is in no way interfered with by the temporary inclusion of the call-holding repeater.

Assuming now that the subscriber at substation A1, Fig. 40, responds to a call and discovers that the caller is someone who has been annoying him by calling him and refusing to identify himself. The subscriber at substation A1 may cause the annoyance call to be trapped by depressing his push-button and by operating his calling device at the same time. It will be recalled that the depression of the push-button alone is used to control transfer service, while an operation of the calling device during a call incoming to the line is used normally to recall the branch exchange operator. When both operations, however, are performed at the same time, the connection extended to the called line is trapped and held, as will now be pointed out.

When the push-button at substation A1 is depressed, detector relay 4004 responds and operates detector-repeating relay 4008. At the upper contacts, detector relay 4008 unbalances the back-bridge circuit of the connector (the connector of Fig. 19, for example). The detector-repeating relay 4008 also prepares a circuit for series relay 4009. Then, when the calling device at substation A1 is turned in accordance with a digit, the digit 1, for example, line relay 4006 is momentarily restored to close a circuit through contacts of relays 4007 and 4008 for series relay 4009. With series relay 4009 operated, upon the reoperation of line relay 4006, a circuit is closed through contacts of the incoming recording relay 4013 (which relay is operated on each incoming call and locked to the C lead) and through contacts of series relay 4009 for the upper winding of the trap pulse relay 4010. Trap pulse re-

lay 4010 operates and locks itself through contacts of the associated release key. This relay also lights the signal lamp 4016 and sounds the common alarm 4017. Trap pulse relay 4010 also connects the EC lead of the connector-bank multiple to the free positive terminal of a 90-volt booster battery, which battery has its negative terminal grounded and is therefore opposite in polarity to the exchange battery. This connection is made through the current-limiting resistor 4012. By this connection, a strong impulse of current passes over the EC lead and through the EC wiper of the connector. This impulse of current is terminated upon the operation of the slow-to-operate pulse-timer relay 4011.

When the push button at the calling substation is released, relays 4004 and 4008 restore. Series relay 4009 restores responsive to the cessation of impulse or impulses delivered by the calling device. Trap-pulse relay 4010, however, remains operated and locked so as to maintain the individual alarm lamp 4016 lighted and to maintain the circuit closed to the common alarm device 4017.

In the local connector LOC1, (assuming this connector to be the one through which the call was received) the lower winding of trap relay 1916 is connected through contacts of the operated switching relay 1918 to the EC wiper of the group 1900. Although this relay is marginally adjusted, so that it does not operate when the EC wiper encounters ground potential in a call to a restricted line, this relay now operates in response to the high potential trap pulse transmitted from the repeater of Fig. 40 as above pointed out. Upon operating, relay 1916 closes a locking circuit for itself through contacts of make-busy key 1926. Trap relay 1916 also opens the line-relay bridge by removing ground potential from the lower winding of line relay 1912, and it closes a holding circuit for release relay 1904 to maintain the release relay operated, whereby the connector is held operated and the preceding switches are maintained operated, since relay 1904 maintains ground potential on the incoming C conductor of the connector.

In the event that the now trapped call to the line of substation A1, Figs. 2, 12, and 40 (a line of office 9), is incoming from office 8, the removal of ground potential from the lower terminals of line relay 1902 of the local connector LOC1 relays the holding condition over the inter-office trunk to the repeater in office 8 to cause the local switches therein to be held, while if the call is being extended through office 8 from sub-office 86, the holding condition is relayed to switching selector repeater in use in sub-office 86, as will be pointed out subsequently.

The attendant in office 9 is expected to respond to the signal given by the common alarm device 4016. He is guided to the call-holding repeater in which the holding condition exists by the individual signal lamp 4016. The attendant is then expected to take the proper steps to trace the call back through the several switches and discover the line from which it was made, as the connection is held intact until this has been accomplished.

When the call has been traced, the attendant operates the release key associated with the lower winding of trap pulse relay 4010 of the call holding repeater, whereupon this relay restores and opens the associated signal circuits, at the same time opening the circuit of the associated pulse-timer

relay 4011, permitting this relay to restore also. The call holding condition is thereby terminated in the call-holding repeater.

After having traced the call to its source, the attendant may release the locked connector by momentarily operating the make-busy key 1926 of the connector shown in Fig. 19. The preceding local switches are permitted to release when the C lead is opened at the upper contacts of the make-busy key, while the locked trap relay 1916 restores when its locking circuit is opened at the lower contacts of the make-busy key. The circuit of release relay 1904 is opened when trap relay 1916 restores, whereupon the connector clears out and restores to normal position. The line of substation A1, Fig. 40, is thereby freed and relay 4013 restores.

In order to explain how interoffice annoyance calls are held, reference will be had to the repeater R1 shown in Fig. 17, which repeater is similar to the other repeaters excepting, of course, the selector repeater used in sub-office 86. It will be recalled that hold relay 1709 in the repeater R1 is operated each time release relay 1702 operates upon the seizure of the repeater and that this relay locks itself to ground at the contacts of make-busy key 1716, and closes a multiple ground connection to the incoming C lead to hold the local switches operated independent of the release relay 1402. It will be recalled, moreover, that unlock relay 1710 is bridged across the associated outgoing talking conductors when the receiver is replaced and that it normally operates to release the hold relay 1709 and permits the connection to clear out. However, in the event that an annoyance call is being made through the repeater and the call is trapped, the opening of the line relay bridge at the connector in the distant office (as explained in connection with the connector of Fig. 19) prevents the operation of the bridged unlock relay 1710, and the connection remains locked. Moreover, when the trapped condition is impressed on the connector and the line relay bridge is first opened, the detector relay 1704 in the repeater R1 restores and closes a circuit in multiple with the release relay 1702 and through contacts of the supervision repeating relay 1706 for the upper winding of the hold-repeat relay 1708. This relay operates and disconnects ground potential from the associated winding of line relay 1701, thereby repeating the holding condition over the preceding inter-office trunk, in the event that the repeater has been reached over an inter-office trunk. This latter feature is of no particular utility in the repeaters employed in office 9, but is useful in the repeaters employed in office 8, as calls pass through this office between offices 9 and 86.

It is to be noted that the repeater R1 clears out automatically as soon as the attendant has restored the locked connector as the line relay of the distant incoming selector is then again bridged across the line to permit unlock relay 1710 to operate and restore the hold relay 1709. Hold repeat relay 1708 restores when its locking circuit is opened by relay 1709. The line relay 1701 is thereby again bridged across the incoming conductors in series with the exchange battery.

The repeater R1 may be unlocked locally by a momentary operation of the make-busy key 1716 in the event that unlock relay 1710 fails to reoperate after an annoyance call has been traced, or in the event that the repeater fails to

clear out at any time, which may happen in the event of a faulty inter-office trunk or of an open condition of one of the conductors at the distant end.

Referring now to the selector repeater SR, Fig. 37, in sub-office 86, it will be recalled that hold relay 3706 is operated and locked through contacts of make-busy key 3732 upon the operation of relay 3711 when the first digit dialled is the digit 8 or the digit 9, including an inter-office branch-exchange call. When the call is repeated through the main office 8, the selector repeater SR acts as a repeater to repeat the impulses and remains in circuit throughout the call, in which event hold relay 3706 is not disconnected and unlocked by the switch-through relay 3701, as it is when the call is completed locally through a local connector.

When a call is made through the main office, therefore, high-resistance unlock relay 3705 must respond to open the circuit of hold relay 3706 when the calling subscriber replaces his receiver; otherwise the connection is trapped.

The trapped connection may be cleared out by a momentary operation of the make-busy key 3732 in the event that unlock relay 3705 fails to respond when the trapped condition is terminated in the distant office.

It will be observed that the local connector of Fig. 38 is provided with a marginal trap relay 3806, which responds to a trap pulse in the manner of the trap relay 1916 of the local connector shown in Fig. 19 to lock itself through the contacts of busy key 3831 and to close a holding circuit for release relay 3803, whereby the local connection is held, as ground potential is then held on the incoming C lead and the connector is prevented from releasing. The circuit of line relay 3802, however, is not passed through contacts of the trap relay 3806, as the connector of Fig. 38 is a local connector and is never used for interoffice calls.

The trap relay 3521 of the incoming connector IC2, Fig. 35, has the same contact arrangement as explained in the connector of Fig. 19 and for the same purpose. A trapped condition at the connector of Fig. 35 may be terminated upon the momentary operation of make-busy key 3544.

Trapping annoyance calls; restricted lines

As before pointed out, the call-holding repeater of Fig. 40 operates to trap an annoyance call responsive to two intentional acts on the part of the called subscriber: (1) operation of the grounding push-button, and (2) turning the calling device to generate impulses. It was also made clear that the reason for this combination of acts is that each of them is used singly to secure a different specific result. When the call-holding repeater of Fig. 40 is used in conjunction with a restricted line, there is no use for the grounding push-button at the substation (as a restricted line is barred from public-exchange calls). Therefore the turning of the calling device on a non-restricted line during an incoming call is considered to be sufficient to indicate that the call is to be held; a non-restricted substation, therefore, does not need to be provided with a grounding push-button. For this reason, the terminals 4041 are strapped when the call holding repeater of Fig. 40 is associated with a non-restricted line. With the terminals 4014 strapped together, the contacts of relay 4008 which bring about the operation of the series relay to cause

the call to be trapped through the consequent operation of trap-pulse relay 4010 are by-passed. In addition, the terminals 4013 are strapped together when the call holding repeater is used in conjunction with a restricted line, thereby placing a ground potential normally on the associated EC lead to prevent the completion of incoming public exchange calls to the line, while permitting the ground potential to be removed and the booster-battery connection to be substituted when relay 4010 operates pursuant to the trapping of a call.

Conference service

The way in which conference service is given in the branch exchange will now be explained in connection with the conference call unit of Fig. 41. This unit is provided with terminals as indicated so that it may be associated with a group of lines, and the lines may be changed from time to time as desired. The equipment immediately to the right of the dotted vertical line in Fig. 41 is associated with the connector bank contacts through which the conference call unit is reached when the conference number is dialed and is common to as many individual circuits as desired. One such individual circuit is shown to the left of the dotted line. It comprises relays 4101—4103 and associated connections. Each individual circuit is for association with a separate subscriber line which may be used normally as desired without any reference to the conference unit, as the circuit arrangement is such that the lines are placed together for conference service only when desired. The line of substation B is associated with the disclosed individual circuit of the conference-call unit through the jumper 4107. Connector terminals 4150, through which the line of substation B are reached, are connected by way of three-conductor jumper 4121 to the negative, positive, and C1 terminals in group 4109, while the lineswitch LS of the line of substation B is connected by means of the three-conductor jumper 4122 to the negative, positive, and C2 terminals in group 4109.

In order to explain the operation of the conference-call unit, it will be assumed that the conference number is called by a non-conference subscriber desiring to initiate and participate in a conference. When the wipers of the connector, (Fig. 19, for example) arrive on terminals 4100, cut-off relay 4105 is operated over the C lead and through the C wiper of the connector in series with the idle-test relay therein. Cut-off relay 4105 opens the circuit of normally-operated trip relay 4106 and closes a circuit for start relay 4104. The trip relay 4106 is sufficiently slow in releasing that it remains actuated until after the switching relay of the connector has operated and closed the ringing circuit and the ring-cut-off relay of the connector has had time to operate through contacts of the actuated relay. When trip relay 4106 restores, it extends the incoming talking conductors to the common talking circuit of the conference-call unit, across which the retard coil 4111 is bridged in order to maintain the back-bridge relay of the connector operated, which is necessary in order to hold the connection closed through the connector.

When start relay 4104 operates, it extends a ground potential to each of the individual line circuits. The extension of the ground potential to the individual line circuit shown results in the operation of transfer relay 4101. Relay 4101 dis-

connects the C1 lead from the C2 lead (the C lead of the lineswitch LS) and connects it to ground, thereby placing a guarding potential on the C terminal of group 450. The line of substation B is thereby marked busy in the connector banks. Transfer relay 4101 also transfers the line of substation B to the individual ringing circuit by way of contacts of ring-cut-off relay 4102. Ringing current from the associated common ringing lead 4112 now passes out over the line of substation B, a return circuit to the ungrounded pole of the exchange battery being provided through the upper winding of ring-cut-off relay 4102. Ring-cut-off relay 4102 is similar in construction and operation to the ring-cut-off relay ordinarily provided in a connector.

At the same time, the grounding of the other start leads associated with start relay 4104 causes the other individual line circuits to operate in the same manner, whereby all of the conference lines are now being signalled. It is to be noted that the switching over of the conference lines to the conference circuit interrupts any conversation that may be in progress over a conference line; which feature is provided intentionally as a conference is intended to be called only when a matter of considerable importance is to be discussed.

When the subscriber at substation B removes his receiver, ring-cut-off relay 4102 operates and locks itself to the associated start lead; places the slow acting transfer relay 4141 under the control of the associated line relay 4103; and it extends the line of substation B to the individual conductors associated with line relay 4103, which are connected to the common talking conductors. Line relay 4103 now operates and closes a holding circuit for transfer relay 4101 before this relay has had time to restore. Line relay 4103 also closes a multiple circuit for cut-off relay 4105 so as to maintain start relay 4103 operated and trip relay 4103 restored.

The subscriber at substation B may now converse with the subscriber who initiated the conference and with the other conference subscribers as they respond and are connected into the common circuit.

After having been called into the conference, the subscriber at substation B may retire before the conference is terminated in the event that he has other pressing duties and finds that he is no longer needed in the conference. He does this by replacing his receiver, whereupon line relay 4103 restores and opens the circuit of transfer relay 4101. Transfer relay 4103 now restores and transfers the line of substation B back to the associated lineswitch and to the connector bank multiple. Ring-cut-off relay 4102 remains operated over the associated individual start lead controlled by start relay 4104 and thereby maintains the circuit of transfer relay 4101 open.

It may be pointed out that the inner armature of transfer relay 4101 disconnects the C lead of the lineswitch LS when it applies ground potential to the C lead of the connector-bank multiple in order to permit a previously existing connection to clear out in case a conference is called when the line of substation B is engaged in a call outgoing therefrom.

The conference-call circuit is held as long as any one of the subscribers to the conference has his receiver off the hook, as the circuit of cut-off relay 4105 is held either from the C lead of the connector through which the conference was

initiated or from the inner upper contacts of the line relay of any conference line.

In the event that it is desired that no subscriber be permitted to engage in a conference call except over one of the conference lines, the two-conductor jumper 4108 is removed. With this jumper removed, the calling subscriber is unable to engage in the conference over the connection set up through the calling connector, as the talking conductors incoming from terminals 4100 do not extend through to the common conference conductors. With this arrangement, conferences are to be called and participated in only by one of the subscribers to the conference, the subscriber at substation B, for example.

When the subscriber at substation B calls a conference, he does so by removing his receiver and causing the lineswitch LS to operate, following which he dials the conference number. Then, when the cut-off and start relays 4105 and 4104 operate and cause the individual transfer relay 4101 to operate and switch the line of substation B over to the conference circuit, the connection set up to the conference terminals is released, and ring-cut-off relay 4102 operates immediately to complete the talking circuit to the conference unit. Line relay 4103 thereupon operates and closes a holding circuit for cut-off relay 4105 to maintain the start relay 4104 operated.

If it is decided definitely at the time the conference call unit is ordered for an installation that only the selected group of subscribers are to be permitted conference service, then trip relay 4106 and the retard coil 4111 may be omitted, as they are needed only in the event that a calling line outside of the conference group is permitted to be included in a conference connection.

What is claimed is:

1. In a telephone exchange system including a public exchange and a multi-office branch exchange, trunk lines interconnecting the offices of the branch exchange, means in one of the offices of the branch exchange including trunk lines incoming from the public exchange for receiving all calls incoming to the branch exchange from the public exchange and for directing their extension to a desired branch-exchange line in any one of the offices of the branch exchange, a separate group of outgoing trunks extending from each office of the branch exchange to the public exchange, and switching equipment in each office of the branch exchange for extending calls over the associated outgoing trunk group to the public exchange.

2. In a telephone exchange system, a first public exchange and associated branch exchange, a second branch exchange associated with a distant public exchange, switching mechanism in the first branch exchange for interconnecting local branch-exchange lines with each other for conversation and for interconnecting lines of both branch exchanges for inter-branch-exchange conversation, said switching mechanism also being effective for connecting lines of the first public exchange with lines of the associated branch exchange for conversation, and discriminating means included in the switching apparatus in the first branch exchange for preventing the operation of such apparatus to extend incoming public-exchange connections to the distant branch exchange.

3. In a switching system, line circuits divided into two classes, link circuits common to said line circuits, each link circuit having an answering switch for connecting such link circuit with a

calling one of said line circuits, a class conductor in each link circuit, and a corresponding class conductor in each line circuit of one class connected to a source of energizing potential, whereby upon connection being made with a calling line circuit by the answering switch of the link the class conductor of the link is energized or not depending upon the class of the line circuit with which the connection has been made.

4. In a switching system, line circuits divided into two classes, links common to said line circuits, a finder switch associated with each link for connecting the link with a calling line circuit, a class-recording relay in each link, circuit connections in each of the finders for extending an incomplete circuit for the class-recording relay to a line circuit when connection is made therewith, and a circuit connection in each of the links of a given class but missing in the links of another class for completing an energizing circuit for the class-recording relay of the link when connection is made to the calling line circuit, whereby the class recording relay operates or not depending upon the class in which the connected line circuit is contained.

5. In a switching system, a group of lines divided into classes, link circuits common to said lines, means for interconnecting any one of said links with any one of said lines pursuant to an extension of the connection from the connected line through the link, a class-recording relay in each link and means for operating it or not depending upon the class in which the connected line is located, other circuits through which connection from the connected line circuit may be further extended, switching apparatus for interconnecting a connected link with one of said other circuits, and means controlled in accordance with the operated or unoperated condition of the class-recording relay of a connected link for transmitting or not transmitting a class-indicating impulse to the said other circuit to which connection is extended.

6. In a switching system, lines divided into classes, primary and secondary links through which connections may be extended from said lines, each of said links having a class recording relay therein, means for extending a connection from a calling one of said lines to a primary link, means effective depending upon the class of the calling line for operating the class recording relay in the connected link, means for further extending a connection from the primary link to a secondary link, and means for operating the class recording relay in the secondary link depending upon the previous operation of the class-recording relay in the primary link.

7. In a switching system, a link circuit through which connections of different classes may be extended, a class-recording relay in the link circuit and means for operating it while a connection is being extended through the link and dependent upon the connection being of a predetermined class, trunk circuits each containing class-recording relay, switching apparatus operable to extend connection from said link to any one of said trunk circuits, and means effective upon the connection being made and depending upon the class-recording relay of the link being in operated condition for transmitting a momentary operating impulse to the class-recording relay of the trunk circuit to which the connection has been extended.

8. In a switching system wherein connections of different classes are set up by successive switching operations to link a plurality of trunk lines together in serial relationship, a class-recording relay in each of the trunk lines which may be included in an extended connection, means dependent upon the class of the connection being extended for operating the class-recording relay in the first trunk line, and means effective in the event that the class-recording relay of the first link is operated for transmitting a momentary operating impulse to the class-recording relay of the next succeeding trunk line each time a new trunk line is linked to the extended connection.

9. In a switching system wherein connections of a plurality of classes may be set up by the successive linking together of trunks in serial relationship, a control conductor included in the linked connection, a class-recording relay and a connection-offering relay included in one of the trunks of an extended connection, means effective when a connection of a given class is being extended for operating the class-recording relay over said control conductor upon the seizure of the trunk containing it, means effective upon the further extension of the connection for disconnecting said class-recording relay from the control-conductor and for connecting the control conductor to the offering relay, and means for subsequently operating the offering relay over said control conductor.

10. In an automatic telephone system, a connector switch for use in setting up connections of different classes, a control conductor incoming to said connector switch, means for taking said connector switch for use and for transmitting current thereto over said control conductor, means for operating said connector switch to extend connection to a desired line, a class-recording relay and an offering relay in said connector switch, and means for operating either of said relays responsive to the current transmitted to the connector over said control conductor, depending upon whether the current is received before or after the connector switch has been operated to extend connection to a line.

11. In an automatic telephone system, a connector operable to complete connections to called lines, conductors incoming to said connector including a control conductor, a class-recording relay in said connector normally associated with said control conductor, a busy-test relay in said connector operable to indicate that the called line is busy, and an offering relay in said connector operable to cause an offering connection to be made to a busy line, means effective upon the operation of the connector following its seizure for disconnecting the class-recording relay from said control conductor, and means effective upon the operation of the busy-test relay for connecting the offering relay to said control conductor, whereby said relays may be selectively operated over the same control conductor.

12. In a telephone system wherein the lines to be interconnected are of various classes, a link circuit through which connections may be extended from calling lines to called lines, a control lead in said link circuit included in any connection set up through the link toward a called line, means dependent upon the class in which the calling line is located and effective before the connection has been completely set up to a called line for delivering a class-recording impulse over the said control lead, means effective after the

connection has been extended in the event that the called line is busy for transmitting an offering impulse over the said control lead pursuant to the making of an offering connection to the busy line, and means effective when a connection has been set up to a line of a specific class for delivering supervisory information back over the said control lead from the circuit equipment of the called line to the link circuit.

13. In a telephone system, an operator's link circuit extending between an answering switch and a calling switch, incoming circuits accessible to said answering switch, means effective when there is a call to any one of said incoming circuits for operating said answering switch to find and connect with the calling circuit, groups of outgoing circuits accessible to said calling switch, means controlled by the switchboard operator for operating the calling switch to make connection with an idle circuit in any desired one of said outgoing groups to further extend a call received over one of the incoming circuits, a group of delayed-call selectors for use in setting up delayed-call connections, and means operative under the control of the switchboard operator for directing the answering switch of said link to search for and connect with an idle one of the delayed-call selectors whereby the operator may set up a connection by way of the delayed call selector to one line and may set up a connection by way of the calling switch of the link to the other line of a pair to be interconnected in a delayed call.

14. In a telephone system, an operator's link, a selecting switch terminating one end of said link and having access to groups of trunks, means controlled from the operator's switchboard for operating said switch to make connection with said idle trunk in any desired one of said groups, a class-recording relay in the operator's link circuit, and means controlled in accordance with the position taken up by said switch when it is operated for controlling the class-recording relay in the link to adapt the link for operation in accordance with the class of the trunk circuit to which connection has been extended.

15. In a telephone system, an operator's link, an answering switch terminating one end of the link and a calling switch terminating the other end, incoming circuits accessible to the answering switch, means for causing the answering switch to search for and connect with any calling one of said incoming circuits, means controlled by the operator for causing the calling switch to operate to further extend a connection toward a desired line, means under the control of the operator for clearing out the calling switch at will while leaving the connection through the answering switch intact, means also controlled at the will of the switchboard operator for clearing out the answering switch after a connection has been extended, and means automatically responsive to the clearing out of the answering switch for clearing out the calling switch.

16. In a telephone system, a group of links assigned to a position of an operator's switchboard, each link terminating at one end in an answering switch and at the other end in a calling switch, means for operating the answering switch of a link to connect the answering end of the link with a calling line and for operating the calling switch to further extend the calling line toward a desired called line, operator's position equipment common to all of said links, an answer-pilot relay and a call-pilot relay in said position equipment, means for associating the

position equipment with any one of said links, means effective when the answering switch of the link with which the position equipment has been associated has operated to find a calling line for operating the answer-pilot relay in the position equipment, means effective when the calling switch of the link has been operated to extend the call for operating the call-pilot relay in the position equipment, and circuit connections controlled by said relays for bringing about appropriate circuit connections in the position equipment depending upon the state of extension of a call being handled by the link circuit with which the position equipment is associated.

17. In a telephone system, an operator's link, means controlled by the switchboard operator for connecting said link with a calling line and for extending a connection through the link to a desired called line, a timing device and means for starting it into operation upon the extension of the connection, means for recalling the operator when the timing device has completed its operation, and means effective in the event that the called subscriber responds before the timing device has completed its operation for clearing out the timing device and thereby preventing the recalling of the operator.

18. In a telephone system, an operator's link, means operable under the control of the switchboard operator for extending a connection from a calling line by way of said link to a desired called line, a timing device in said link and means for starting it into operation upon the extension of the connection, means controlled by the timing device when it completes its operation for recalling the switchboard operator in the event that the extended connection has not been answered, and means in the link responsive to the answering of the extended connection for preventing the automatic recalling of the operator responsive to the operation of the timing device.

19. In a telephone system as claimed in claim 18, certain of the called lines being in a special class, and means in the link circuit responsive to the extension of a connection to a line of the special class for preventing the said recalling operation from taking place.

20. In a telephone system, an operator's link through which answered calls may be extended to desired called lines, a hold lamp in said switchboard and means for lighting it when a call has been answered, automatic switching apparatus operable to extend a connection from the link circuit to a desired called line responsive to impulses, means controlled by the switchboard operator for causing switch-operating impulses to be generated to thereby bring about the desired extension, and means automatically effective when the impulses have been transmitted and the extension has been completed to a desired line and independent of whether the called line is busy or idle for extinguishing said signal lamp.

21. In a switching system, a multi-position operator's switchboard, a separate group of finder-ended links at each switchboard, all links having common access to a group of lines, a start circuit common to all said lines for controlling the starting of the finders, means controlled by the operator at any position for selecting a finder allotted to her position, and 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.

22. In a switching system, a multi-position op-

erator's switchboard, a separate group of finders associated with each position of said switchboard, a start circuit common to all of said finders, means for enabling the operator at any position to select a finder at her position for operation, and means responsive thereto for rendering the common start circuit temporarily individual to the position at which a finder has been selected.

23. In a switching system, a multi-position operator's switchboard, a separate group of line finders allotted to each position of the switchboard, a common finder-starting circuit, a separate branch of said circuit assigned to each position of the switchboard, means at each switchboard for selecting a finder by connecting the associated branch of the common start circuit thereto, and means coincidentally effective for connecting the associated position branch of the start circuit to the common start circuit to the exclusion of the branches assigned to the other positions.

24. In a switching 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 by-passing the distributor and connecting all branches to the common start conductor simultaneously.

25. In a telephone system, an operator's switchboard, a group of links assigned to said switchboard, sending equipment, a talking key assigned to each link, position equipment common to all links, a talking relay in said position equipment and means for operating it responsive to the operation of the talking key of any link, a finder-start relay in said position equipment and a second-control conductor extending from said position equipment toward the sending equipment, means responsive to the operation of the said talking relay for operating said finder-start relay, an answer-pilot relay in said position equipment common to all links, and means for operating it from any link when the link has been connected with a calling line to answer a call, and circuit connections controlled by the answer-pilot relay for disconnecting the said start relay and for energizing the said sender-control conductor.

26. In a telephone system, an operator's switchboard, a group of links assigned to a position of said switchboard, 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 switchboard operator to extend connections from calling lines to desired called lines; a register sender for recording desired numbers and for transmitting switch-operating impulses pursuant to the setting up of desired connections, a talking key assigned to each of said links, means normally effective responsive to the closing of the talking key in the link for automatically associating the register sender with said link to enable the operator to bring about the desired extension of

a connection by way of the link, and means effective in the event that the operator closes the talking key of a link after a connection has been extended thereover for preventing the association of the register sender with the link.

27. In a telephone system, a group of links assigned to a switchboard position, automatic switching apparatus associated with said links to enable answered calls to be extended to desired called lines, a talking key assigned to each of said links, a register sender for use in operating the said automatic switching apparatus, means responsive to the closing of the talking key of a link pursuant to the answering of a call for associating the register sender with such link as soon as the call has been answered, said register sender being subsequently effective to register and send out digits of the desired number, and means effective when the desired number has been retransmitted for automatically disconnecting said register sender from the link.

28. In a telephone system, a group of links assigned to a switchboard position, automatic switching apparatus associated with said links to enable answered calls to be extended to desired called lines, a talking key assigned to each of said links, a register sender for use in operating the said automatic switching apparatus, means responsive to the closing of the talking key of a link pursuant to the answering of a call for associating the register sender with such link as soon as the call has been answered, said register sender being subsequently effective to register and send out digits of the desired number, and means for maintaining said register sender connected to the link independent of the continued maintenance of the talking key in closed position until the register sender has completed the retransmission of the registered number.

29. In a telephone system, a group of links assigned to a switchboard position, a talking key assigned to each of said links, position equipment common to all said links and including a talking relay automatically responsive to the actuation of the talking key of any link, a register sender common to all said links, means responsive to the actuation of the said common talking relay when the talking key of a link is actuated for causing the said register sender to become automatically connected with the link of which the talking key is actuated.

30. In a telephone system, a group of links assigned to a switchboard position, position equipment common to all said links, digit sending apparatus, a pair of link finders associated with the digit sending apparatus, means for causing calls to come in to said links successively, means in the position equipment operative when a call comes in to a link for causing one of said link finders to find the link and to associate sending equipment therewith, and control means associated with the link finders for causing them to operate sequentially in finding links which have received calls.

31. In a telephone system wherein a group of call-extending links are assigned to a switchboard position, a link terminating at one end in an answering switch and at the other end in a calling switch, said link being divided into two normally disconnected sections, a talking key associated with the answering section of the link to enable the position operator to answer calls received by way of said answering switch, digit sending equipment and means for bridging it across the disconnected calling end of the link

to bring about a desired extension of connection through the calling switch and for subsequently disconnecting the sending equipment, a link cut-through relay and means for operating it before the sending bridge is removed to join the two sections of the link together in order to close a holding bridge for maintaining the connection established.

32. In a telephone system wherein link circuits are provided at a switchboard position to enable connections to be extended therethrough from calling to called lines by way of automatic switching equipment, a link at said position and switching means associated therewith for enabling the operator to answer a call from a calling line, said link having a normally disconnected calling portion, means controlled by the switchboard operator for operating automatic switching apparatus for extending a connection from the normally disconnected calling portion of a link to a desired called line by way of the transmission of digit impulses, a switch-holding bridge associated with the calling line, and means effective after the connection has been extended for connecting the normally disconnected calling section of the link to the answering portion thereof to render effective the said holding bridge associated with the calling line.

33. In an automatic telephone system including an operator's switchboard through which calls may be extended when desired, service trunks incoming to said switchboard from the automatic switching apparatus for the completion of calls to the switchboard from calling automatic lines, links at said switchboard for enabling the switchboard operator to answer and extend incoming calls, a recall relay in each service trunk responsive to a further manipulation of the calling device on a calling line after a connection has been extended through one of the operator's links, means for locking said recall relay energized over a conductor of the connection between the incoming trunk and the link, and an operator's recall signal in the link circuit included in said locking circuit whereby the signal becomes energized when the recall relay is operated.

34. In an automatic telephone system including an operator's switchboard through which calls may be extended when desired, service trunks incoming to said switchboard from the automatic switching apparatus for the completion of calls to the switchboard from calling automatic lines, links at said switchboard for enabling the switchboard operator to answer and extend incoming calls, a recall relay in each service trunk, means for operating the recall relay of a service trunk responsive to a further manipulation of the calling device on a calling line after a connection has been extended through one of the operator's links, means for locking said recall relay energized over a conductor of the connection between the incoming trunk and the link, an operator's recall signal in the link circuit included in said locking circuit whereby the signal becomes energized when the recall relay is operated, and means under the control of the operator for opening the said locking circuit to deenergize the said signal and to restore the recall relay when she responds to the recall signal.

35. In a telephone system including an operator's switchboard, trunk lines associated with said switchboard, operators' links at said switchboard for making connection with said trunk line in order to enable inter-trunk calls to be set up through the switchboard, a supervisory signal in

each of the links, a trunk having a supervisory relay, means controlled over the associated trunk for operating said supervisory relay and for closing a locking circuit for it over a conductor of the connection and through the signal of the connected link, whereby the signal becomes energized when the locking circuit is closed, and operator-controlled means for opening the locking circuit to deenergize the signal and to restore the relay in the trunk.

36. In a telephone system, a trunk line extending from a first switchboard to a second switchboard, means for setting up an inter-switchboard connection including said trunk line, means for breaking down the connection at the first switchboard and for transmitting a disconnect supervisory signal over the trunk line to the second switchboard, and means at the first switchboard for placing a guarding condition on said trunk line at the first switchboard and for maintaining it for a predetermined interval in order to allow time for the connection to be broken at the second switchboard before the trunk line is again taken for use at the first switchboard.

37. In a telephone system, a trunk line extending between an automatic switchboard and a manual switchboard, means for setting up inter-switchboard connections over said trunk line, means for maintaining said trunk line guarded against seizure at the automatic switchboard while the connection is set up, means at the automatic switchboard for breaking down the connection to said trunk line thereat and for transmitting a disconnect supervisory signal over the trunk line to the manual switchboard, and means for maintaining the trunk line guarded at the automatic switchboard for a predetermined length of time after the connection has been broken down at the automatic switchboard in order to allow time for the connection to be taken down at the manual switchboard before seizure of the trunk line is again permitted at the automatic switchboard.

38. In a telephone system, a two-way trunk line extending between an automatic switchboard and a manual switchboard, switching equipment at the automatic switchboard for extending calls incoming over the trunk line and for extending outgoing calls over the trunk line to the manual switchboard, means effective when an inter-switchboard connection has been set up by way of said trunk line for breaking down the connection to the trunk line at the automatic switchboard, and means at the automatic switchboard thereupon effective for maintaining the trunk line guarded against calls outgoing thereover from the automatic switchboard until a sufficient interval of time has elapsed for the operator at the manual switchboard to take down the connection.

39. In a telephone system, an operator's link circuit, means under the control of the operator for directly extending a connection from each of the two ends of the link circuit to a desired line, and circuit connections making it necessary for the operator always to extend the connection first from the same end of the link circuit.

40. In a telephone system, switching apparatus for extending connection from subscriber lines to called lines of two classes, switching apparatus for extending connections to subscriber lines from calling lines of two classes, provisions at each subscriber line for separately making two discriminating connections thereto, means included in the switching apparatus which extends from the calling lines for permitting connections to

lines of one of the two said classes of called lines depending upon whether or not one of the two said discriminating connections to the calling line is made, and means in the switching apparatus

5 which extends connections to called lines for permitting a connection from a calling line of one of said classes to the called line depending upon whether or not the other of the two said discriminating connections is made to the line.

10 41. In a telephone system including a branch exchange and a public exchange, automatic switching apparatus used to interconnect branch-exchange lines with each other and also to interconnect branch-exchange lines with public-exchange lines, said switching apparatus being effective to interconnect any branch-exchange line with any other branch-exchange line, means for permitting the branch-exchange lines to be classified according to whether or not calls there-
20 over to public exchange lines are permitted and for causing the automatic switching apparatus to bar outgoing calls from restricted lines to public exchange lines, and other means included in the automatic switching apparatus for permitting lines to be classified according to whether they are permitted to receive public exchange calls or not without regard to the first-named classification, and means in the automatic switching apparatus for barring incoming public-exchange calls from the lines excluded therefrom
30 in the second of the said classifications.

42. In a telephone system, a multi-level selector for the common use of subscriber lines in extending calls therefrom by way of trunk lines
35 reached over its various levels, one level of said selector being set apart for calls of a special class, certain of said calling lines being entitled to originate calls of all classes, while others of the lines are entitled to originate calls except
40 those of the said special class, a discriminating conductor incoming to the selector and means for energizing it depending upon the line being a non-restricted line, an idle-test relay in said selector operative to stop the hunting movement
45 of the selector on an idle trunk, a test circuit for said relay normally locally completed within the selector, and means effective when the said special service level is called for transferring the said circuit of the said relay to said discriminating conductor, whereby the said circuit is completed or not in accordance with whether this
50 conductor is energized or not, whereby the selector is prevented from finding an idle trunk and rotates to its final position when a subscriber on a restricted service line attempts to originate a
55 call to which he is not entitled.

43. In a multi-level group selector, a switching relay operable to terminate the hunting movement responsive to the closure of the test circuit over the test conductor of an idle trunk when the selector is searching for a trunk after having been operated to a desired level, a test circuit for the test relay normally supplied locally with testing potential, an incoming conductor of the
60 selector accessible from preceding switching apparatus, and a switching device operated when the selector has been raised opposite a predetermined level for changing over the test circuit of the said relay so that it then includes the said incoming conductor.
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44. In a telephone system, a connector having access to called lines, a slow-releasing splash-ring relay in said connector switch and means for
75 operating it to prepare for a ringing operation,

means for operating the connector to make connection with a desired called line, means effective when the connection is made for applying ringing current to the connected line in a circuit whose closure depends upon the operated condition of the said splash-ring relay, means also effective upon the connection being made to the line for making a circuit alteration to bring about the restoration of the splash-ring relay after the slow releasing interval for which it is designed and
10 adjusted to thereby terminate the application of ringing current to the called line, and means operative thereafter at will for reoperating the splash-ring relay as desired to make further applications of ringing current to the called line.
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45. In a telephone system, a final connector having access to lines, means for operating said connector from a calling line to make connection with desired ones of said lines, means in said connector for testing the lines of a group successively and for coming to rest in engagement with the final line of the group in the event that all of them are in use, and means under the control of the telephonist on the calling line for causing the connector to complete a telephonic connection to the final line of the group when it is busy.
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46. In a telephone system, a final connector having access to lines, means for operating said connector from a calling line to make connection with desired ones of said lines, means in said connector for testing the lines of a group successively and for coming to rest in engagement with the final line of the group in the event that all of them are in use, means under the control of the telephonist on the calling line for causing the connector to complete a telephonic connection to the final line of the group when it is busy, and means in the connector for giving a distinctive signal to the subscriber conversing over the busy line with which connection has been made to inform them that the secrecy of their conversation has been invaded, whereby the telephonist on the calling line may not intrude upon an established connection without the subscribers to such connection being made aware of the intrusion.
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47. In a telephone system a group selector accessible to preceding switching apparatus and having access to groups of trunks, means for seizing said selector and for operating it to extend connection to an idle trunk in a desired group, means effective or not depending upon the condition under which the selector is seized for delivering an informative impulse to the selector which is unnecessary to the normal operation thereof, means in said selector for storing the informative impulse, and means effective when the informative impulse is stored in the selector for repeating the stored impulse to the succeeding trunk which it is operated to seize.
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48. In a switching system a selector accessible to preceding switching apparatus and having access to groups of trunks extending to succeeding switching apparatus, an impulse conductor incoming to the selector, a corresponding impulse conductor appearing in each of the said trunks accessible to the selector, means in the preceding switching apparatus for transmitting an informative impulse over the said incoming impulse conductor to the selector, means in the selector for recording the received impulse, and means effective when the selector is opened to seize a trunk line in a desired group and dependent upon an in-
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coming informative impulse having been recorded for transmitting a similar impulse over the impulse conductor of the seized trunk line.

49. In a telephone system wherein automatic switching apparatus is provided for setting up connections between lines responsive to the operation of calling devices on calling lines, an operator's switchboard and means thereat for controlling the operation of the automatic switching apparatus to set up connections to subscriber lines, link circuits provided at the switchboard through which connections may be set up, each link circuit having a supervisory lamp, and means effective when a connection is set up through one of the links at the switchboard for lighting the supervisory lamp of said link responsive to an operation of the calling device on the called line and for maintaining it operated after the operation of the calling device has ceased and until the operator at the switchboard responds to the signal.

50. In an automatic telephone system wherein the connector switches are arranged to reverse the direction of current flow in the incoming conductors thereof when the called subscriber responds and to again reverse the current flow back to normal direction when the called subscriber's loop is opened, an operator's switchboard and associated apparatus for enabling calls to be set up through the switchboard by way of the automatic switching apparatus to called automatic lines, links at said switchboard for enabling the operator to extend the said connections therethrough to the called automatic lines, each of said link circuits including a polarized supervisory relay included in the holding circuit of the automatic switching apparatus whereby the relay responds to reversals of current flow in the incoming conductors of the connector when a connection has been set up, a supervisory lamp associated with the polarized relay, and circuit connections controlled by the polarized relay for lighting the supervisory lamp as a recall signal when the called subscriber turns his calling device and for thereafter maintaining it lighted until the operator responds.

51. In an automatic telephone system, connector switches for completing calls to called lines, each of said connector switches having transfer leads outgoing therefrom, means effective after a connection has been set up through a connector to a called line and controlled at the will of the called subscriber for disconnecting the called line from the calling line and for transferring the called line to said transfer leads, said means being subsequently effective for transferring the called line back to the calling line, and automatic switching apparatus associated with the said transfer lead and effective while the called line is transferred thereto for enabling the subscriber on the called line to set up a temporary transfer connection through the automatic switching apparatus to another called local line while the original connection from the calling line to the connector remains established.

52. In a telephone system having provisions for setting up connections of two classes to called lines, the called lines being divided into two classes, a connector for use in completing calls to the called lines, said connector having a class-recording relay, means effective for operating the class-recording relay of the connector or not depending upon the class of the connection being extended, each of the called lines having an in-

dividual terminal which may be energized or left unenergized according to which class the line is assigned, said connector having a class-test wiper for cooperation with the said line terminals of the called lines, and means controlled through the class-test wiper and according to whether the said class-recording relay is actuated or not for permitting or denying attempted connections.

53. In a connector for use in an automatic telephone system wherein connections are classified and wherein the lines are classified and connections of a given class are barred to lines of one class, a class-recording relay associated with the incoming conductors of the connector to record the class of the connection being attempted, a class-test relay and means for operating it to test for the classification of any called line, and means controlled jointly by the said relays for permitting or barring the attempted connections.

54. In a connector for use in completing connections to called lines which are divided into classes, a class-test relay, means effective when the connector is set on the terminals of a called line for closing a test circuit to enable the class-test relay to test the called line for its classification, and means effective after the connector has extended connection to a called line and the called subscriber has responded and independent of the classification of the called line for operating said class-test relay under the control of current flow over the called line in order to maintain the connection established through the connector.

55. In an automatic connector for use in setting up connections from calling lines to called lines, a line relay operable over the calling line, a slow-acting release relay operated under the control of the relay, an auxiliary release relay operated under the control of the release relay, a ring-cut-off relay for opening the ringing circuit and completing the talking circuit after the connection has been set up to a called line and the called subscriber has replied, circuit connections in the connector for supplying current over the called line, and circuit arrangements controlled by the ring-cut-off relay when it operates for making the continued energization of the auxiliary release relay dependent upon the flow of current over the called line, and means effective in the event that the called subscriber first replaces his receiver for freeing the called line upon the consequent restoration of the said auxiliary release relay.

56. In an automatic telephone system, an automatic connector for completing calls to subscriber lines, said connector being responsive to control exercised over its incoming conductors to make connection with and supply ringing current to a desired line, and means in said connector responsive to the answering of the call for rendering the maintenance of the established connection dependent on the flow of current over the called line.

57. In an automatic telephone system, an automatic connector for completing calls to subscriber lines, said connector being responsive to control exercised over its incoming conductors to make connection with and supply ringing current to a desired line, means in said connector responsive to the answering of the call for placing the maintenance of the established connection under the control of the called line, and means effective thereafter in the event that the called subscriber replaces his receiver before the calling subscriber does for causing the connector to sever the con-

nection between the two lines and to free the called line for further use, while the connection established to the connector is maintained until the calling subscriber replaces his receiver.

58. In an automatic connector switch for use in an automatic telephone system to complete connections between lines, said connector having a front-bridge relay and a back-bridge relay through which current is supplied to the calling and called lines, respectively, front-release and back-release relays controlled by the said bridge relays respectively, and means effective after a connection has been established between two lines for severing the connection responsive to the restoration of either said release relays under the control of its associated bridge relay.

59. In a multi-office automatic telephone system wherein automatic switches are linked together in serial relationship to establish a connection from a calling line in one office by way of a two-conductor trunk line and additional automatic switching apparatus to a called line in a second office, an automatic connector switch in the second office for completing the connection to the desired called line, a trap relay in the said connector switch and means for operating it at the will of the subscriber on the called line, circuit connections controlled by said trap relay for applying a locking condition to the switching apparatus in the second office, other circuit arrangements associated with said trap relay for opening one of the line conductors incoming to the connector, a repeater in the first office associated with the outgoing two-conductor trunk, and circuit arrangements in the first office depending upon the said opening of the line conductors for maintaining the automatic switching apparatus operated in the first office after the called subscriber hangs up in order to enable the call to be traced and the identity of the calling line to be learned.

60. In a multi-office telephone system, an outgoing impulse repeater associated with a two conductor inter-office trunk, means effective when said repeater is seized for repeating switch operating impulses over the trunk to the distant call office, means in the repeater for locking the switches in the local office in energized condition subject to unlocking them under the control of the calling line and dependent upon the talking conductors over the inter-office trunk being continuous, means in the second office effective while a connection is established for opening one of the conductors of the inter-office trunk when it is desired to hold a connection after the calling subscriber has replaced his receiver, a detector relay in said repeater responsive to the opening of one of the talking conductors in the distant office, and means associated with said detector relay for repeating the open condition in the incoming talking conductors of the repeater, whereby the holding condition is relayed back to a preceding office in the event that the call is a tandem call and has been received from a preceding office.

61. In a telephone system wherein the connections are set up through successively operable automatic switches, means in the switch train for holding an established connection after the calling subscriber has replaced his receiver subject to a special control, a call holding repeater, terminal facilities for associating said call holding repeater with a line over which annoyance calls are being received, and means in the call-

holding repeater responsive to a specific control exercised over the called line by the called subscriber for exercising said special control over the switch train.

62. In a telephone system wherein the connections are set up through successively operable automatic switches, means in the switch train for holding an established connection after the calling subscriber has replaced his receiver subject to a special control, a call holding repeater, terminal facilities for associating said call holding repeater with a line over which annoyance calls are being received, means in the call-holding repeater responsive to a specific control exercised over the called line by the called subscriber for exercising said special control over the switch train, and means thereupon effective at the call holding repeater for signalling an attendant to trace the held connection.

63. In a telephone system wherein local calls are set up through automatic switches and incoming calls are set up through automatic switches under the control of a switchboard operator, circuit arrangements responsive to the manipulation of the calling device on the called line on an incoming call for recalling the switchboard operator, other circuit arrangements including a push button on the called line and responding apparatus for affording local transfer service during an inter-exchange call, and means effective in the event that a called automatic subscriber simultaneously operates his push button and turns his calling device for locking a local connection established, for holding the called line in the connection, and for signalling an attendant, whereby anonymous calls may be thus trapped and the identity of the anonymously calling line learned.

64. In a telephone system, a conference-call unit, means for taking said unit for use, a group of telephone lines associated with said unit and arranged for regular telephone service in addition to conference service, means responsive to the taking of said conference-call unit for use for connecting each of the conference lines to the conference-call unit and disconnecting them from the regular service conductors, there being a separate transfer relay for each line for this purpose, means for projecting ringing current over each of the conference lines to signal the conference subscribers, a separate line relay for each conference line, and means effective after a conference subscriber replies to the conference call for placing the continued actuation of his transfer relay under the control of his individual line relay, whereby a conference subscriber may replace his receiver during the conference and thereby retire from the conference by permitting his individual transfer relay to restore.

65. In combination, a selector repeater responsive to successive groups of digit impulses, three groups of trunks, means effective when the selector repeater is taken for use for selecting an idle trunk in the first group, means in the selector repeater for repeating subsequently received groups of digit impulses over the selected trunk, and digit-responsive switching effective depending upon the receipt of one group of digit impulses for freeing the seized trunk of the first group and for selecting an idle trunk in the second group and depending upon an alternative group of digit impulses for freeing the seized trunk of the first group and for seizing a trunk of the third group.

66. In combination, a switching selector repeater, three groups of trunks accessible thereto, a separate busy-common conductor assigned to each trunk group, means for applying potential to said conductors depending upon the availability of trunks in the respective associated groups, means for causing said selector repeater to seize an idle trunk in a specific group when taken for use and to maintain the trunk seized or to subse-

quently free the seized trunk and seize an idle one in either of the other two groups, and means controlled jointly according to groups of received impulses and the application of potential to said conductors for directing the said action of said switching selector repeater. 5

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