Dec. 26, 1944. P. BAKKER 2,365,996

PRIVATE BRANCH EXCHANGE AUTOMATIC TELEPHONE SYSTEM

Filed Aug. 12, 1942 14 Sheets-Sheet 1

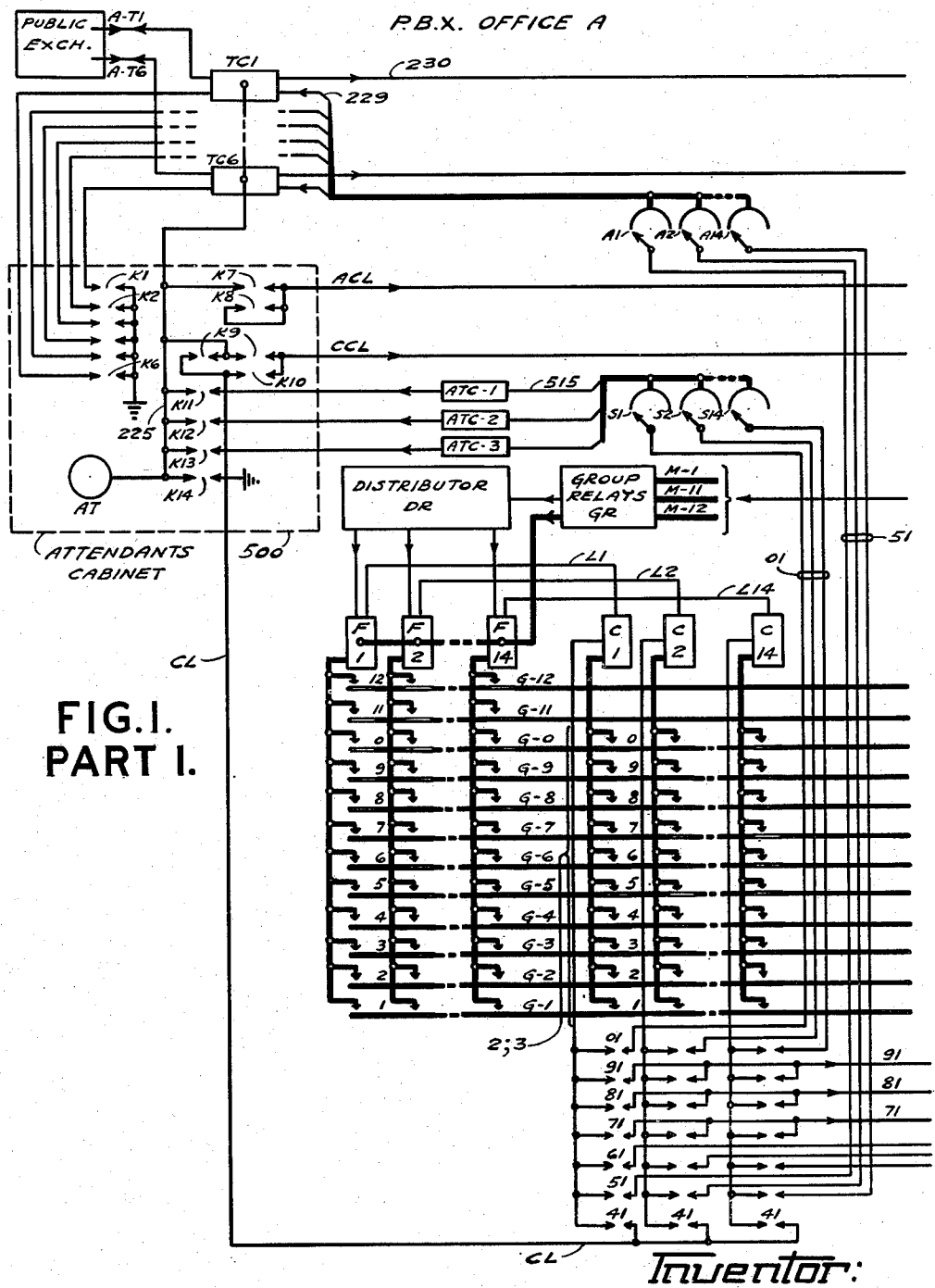


FIG. 1. PART I.

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Dec. 26, 1944. P. BAKKER 2,365,996

PRIVATE BRANCH EXCHANGE AUTOMATIC TELEPHONE SYSTEM

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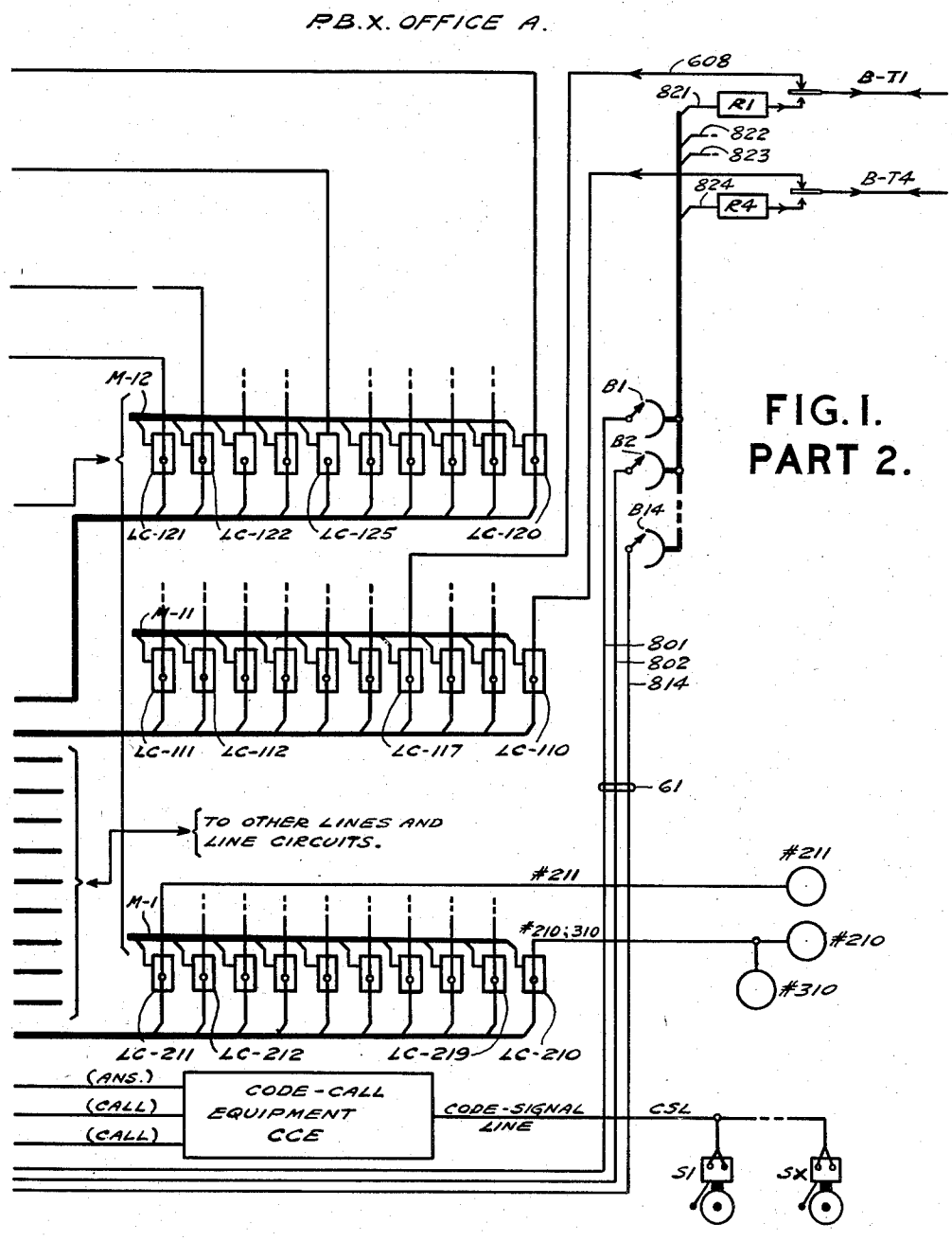


FIG. 1. PART 2.

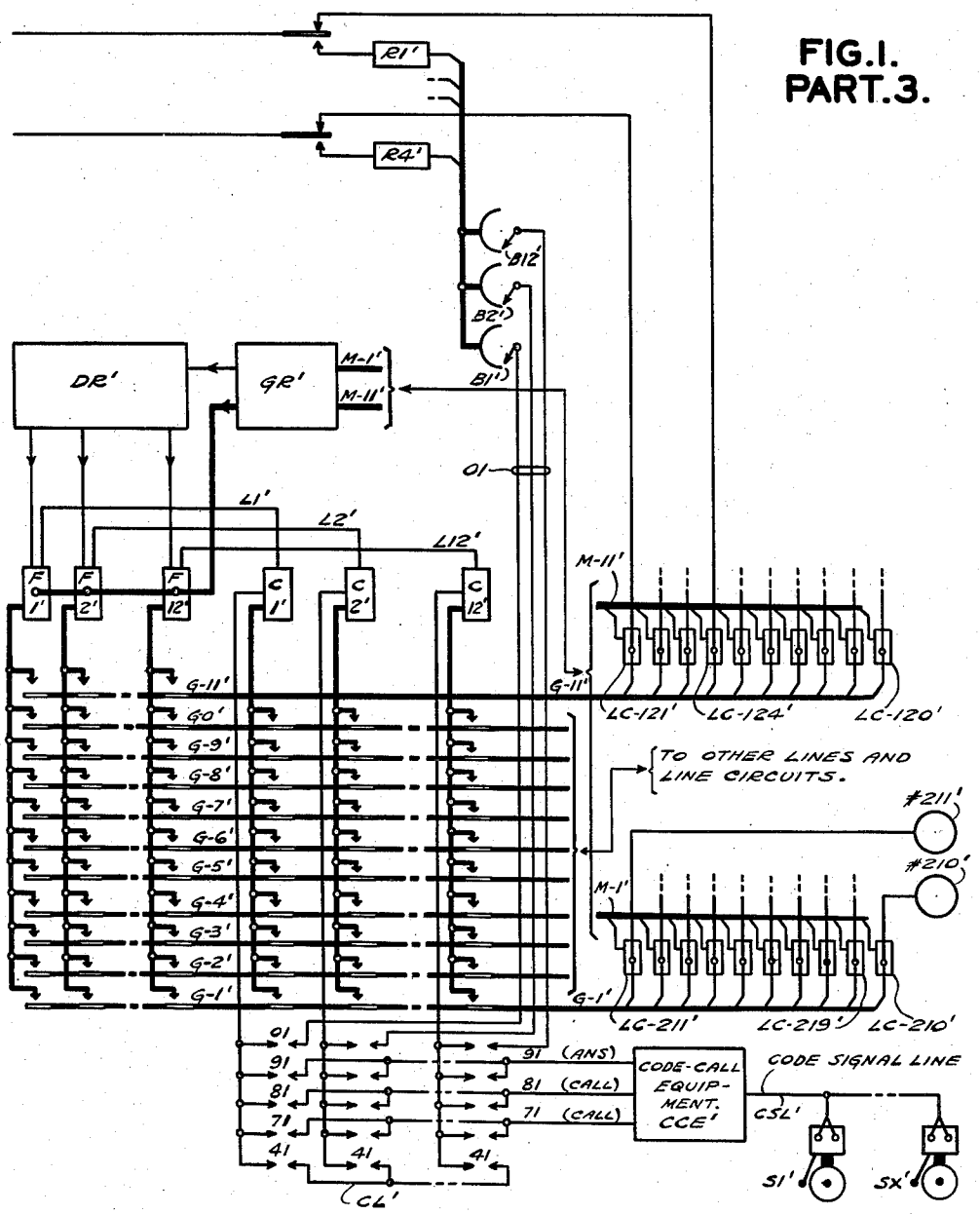
Inventor:
Pier Bakker
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Dec. 26, 1944. P. BAKKER 2,365,996

PRIVATE BRANCH EXCHANGE AUTOMATIC TELEPHONE SYSTEM

Filed Aug. 12, 1942 14 Sheets-Sheet 3

FIG.1.
PART.3.



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PRIVATE BRANCH EXCHANGE AUTOMATIC TELEPHONE SYSTEM

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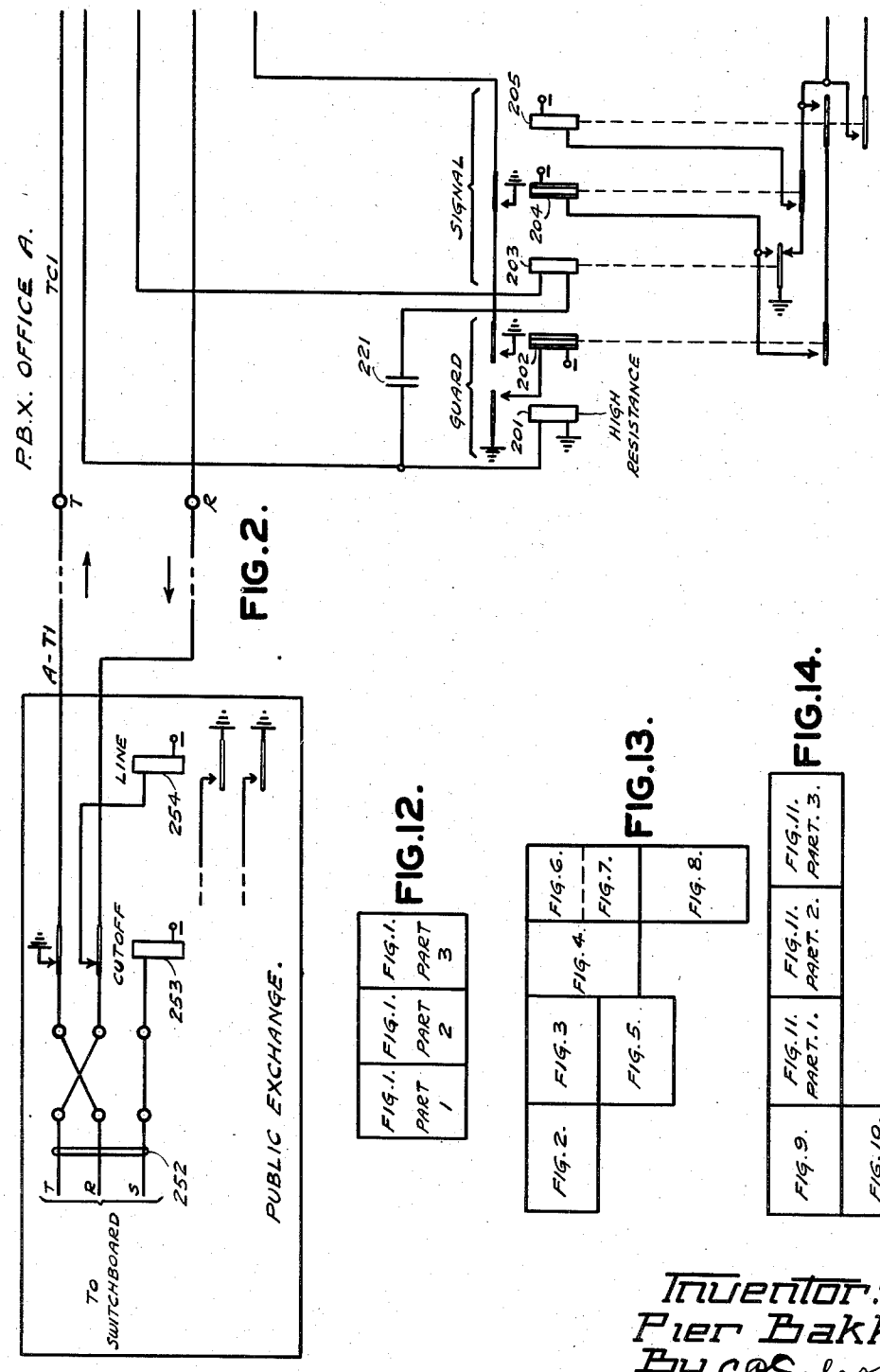


FIG.2.

FIG.12.

FIG.1. PART 1	FIG.1. PART 2	FIG.1. PART 3

FIG.13.

FIG.2.	FIG.3	FIG.4.
	FIG.5.	FIG.6.
		FIG.7.
		FIG.8.

FIG.14.

FIG.9.	FIG.11. PART 1.	FIG.11. PART 2.
FIG.10.		FIG.11. PART 3.

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Dec. 26, 1944. P. BAKKER 2,365,996

PRIVATE BRANCH EXCHANGE AUTOMATIC TELEPHONE SYSTEM

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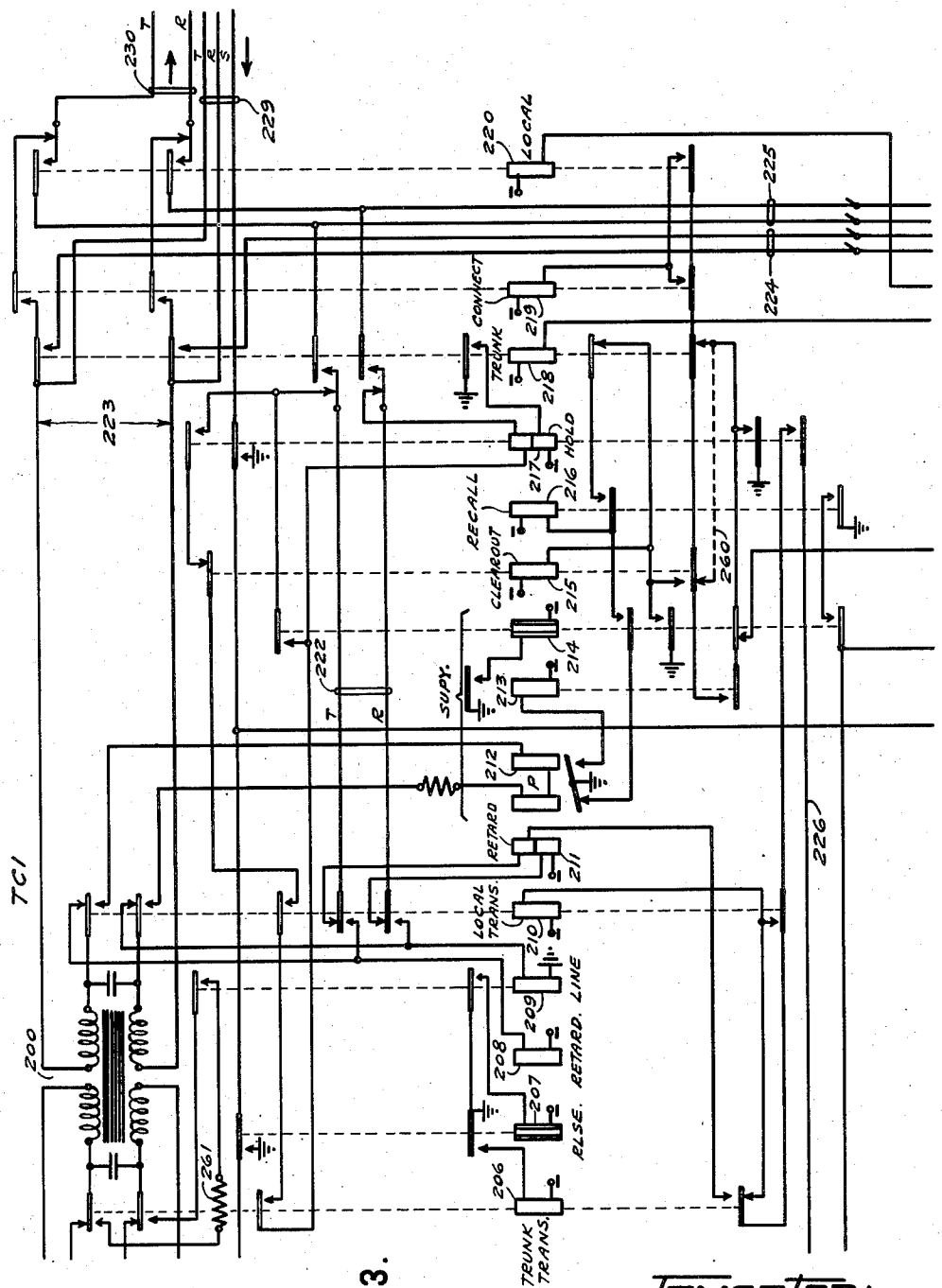


FIG. 3.

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Dec. 26, 1944. P. BAKKER 2,365,996

PRIVATE BRANCH EXCHANGE AUTOMATIC TELEPHONE SYSTEM

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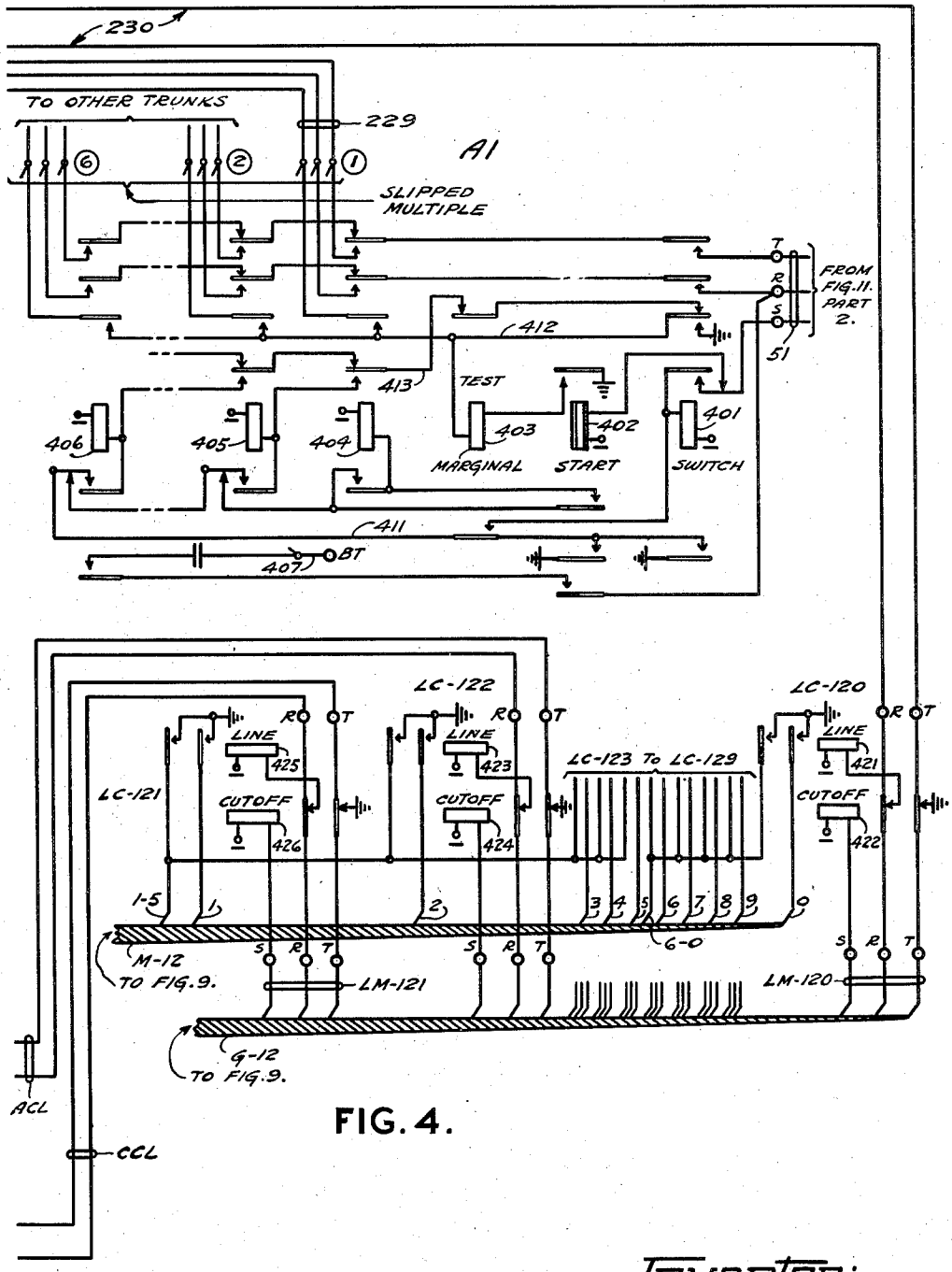


FIG. 4.

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Dec. 26, 1944. P. BAKKER 2,365,996

PRIVATE BRANCH EXCHANGE AUTOMATIC TELEPHONE SYSTEM

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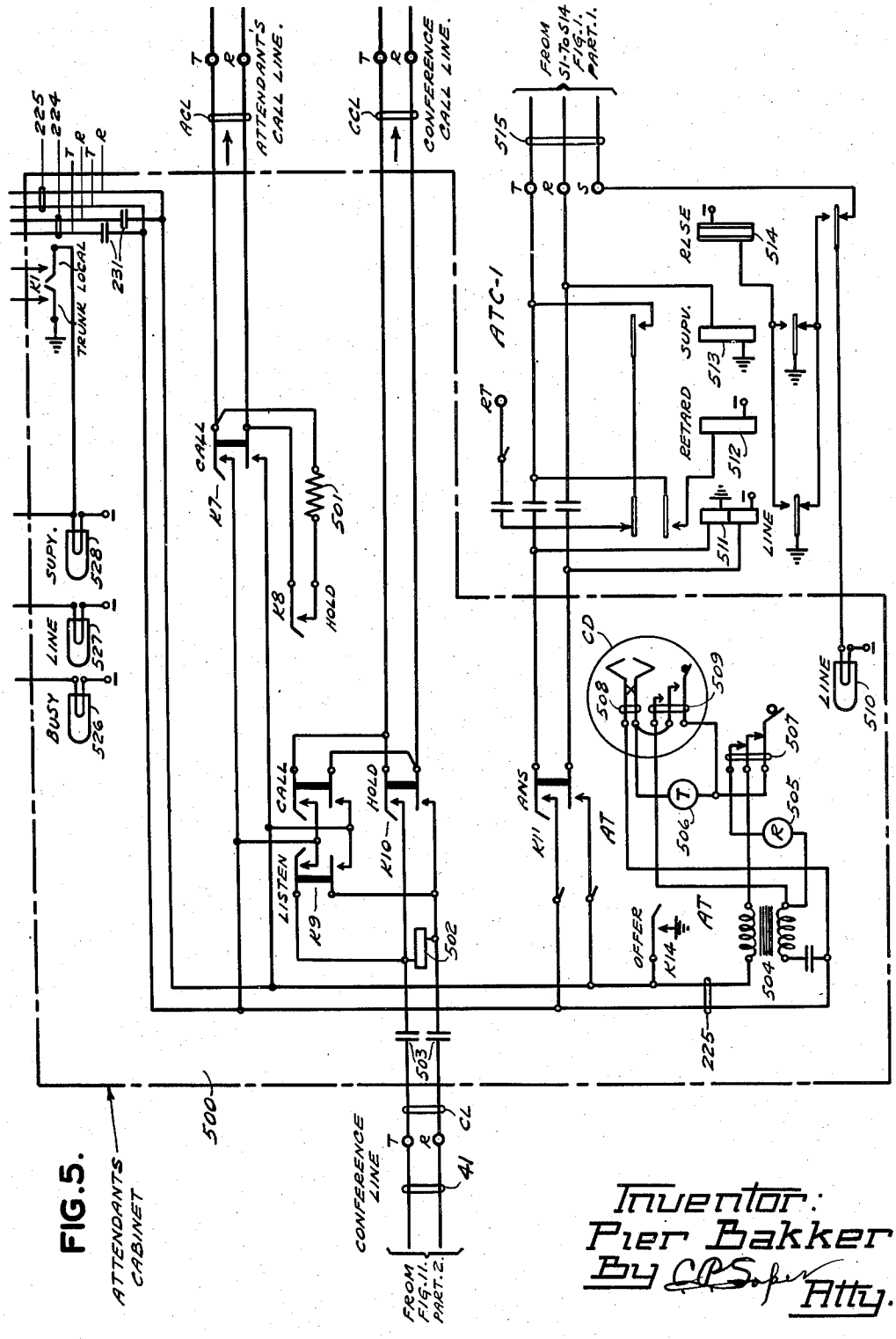


FIG. 5.

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Dec. 26, 1944. P. BAKKER 2,365,996

PRIVATE BRANCH EXCHANGE AUTOMATIC TELEPHONE SYSTEM

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FIG.6.

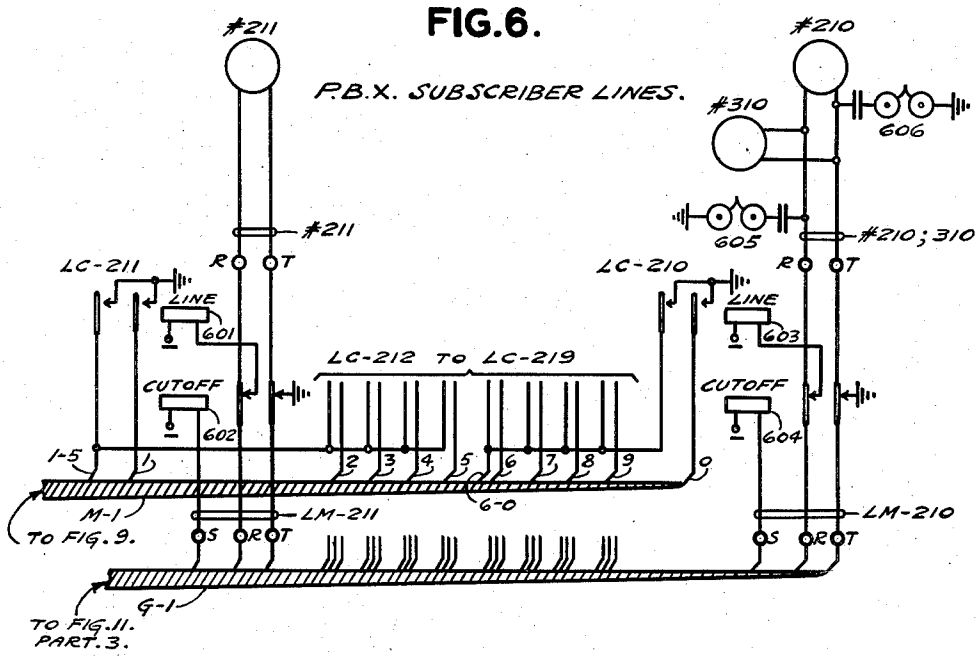
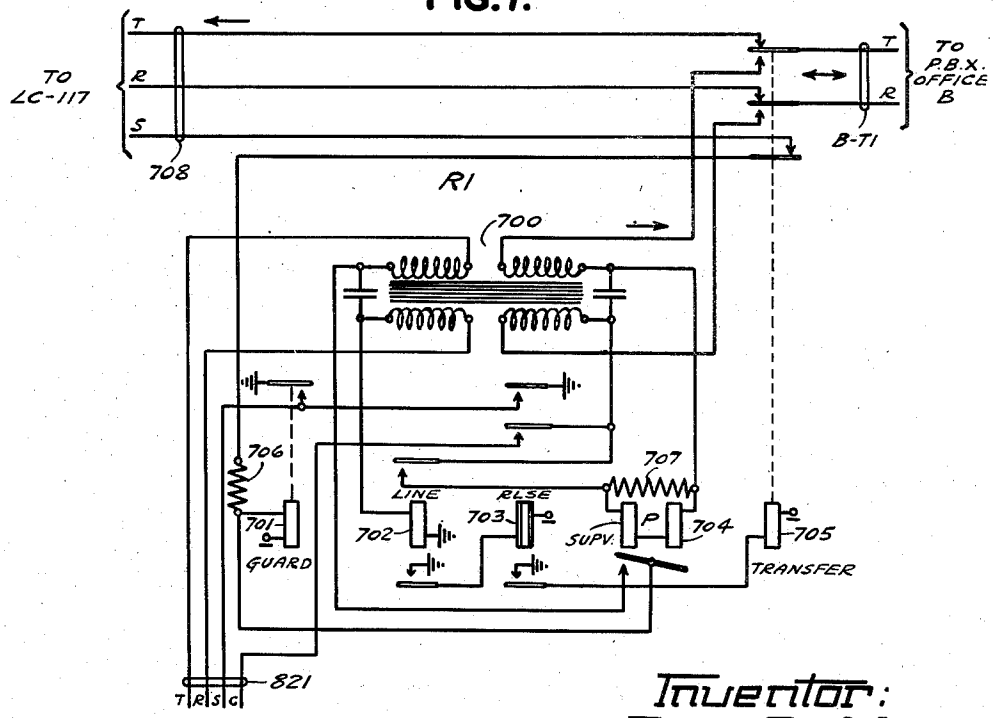


FIG.7.



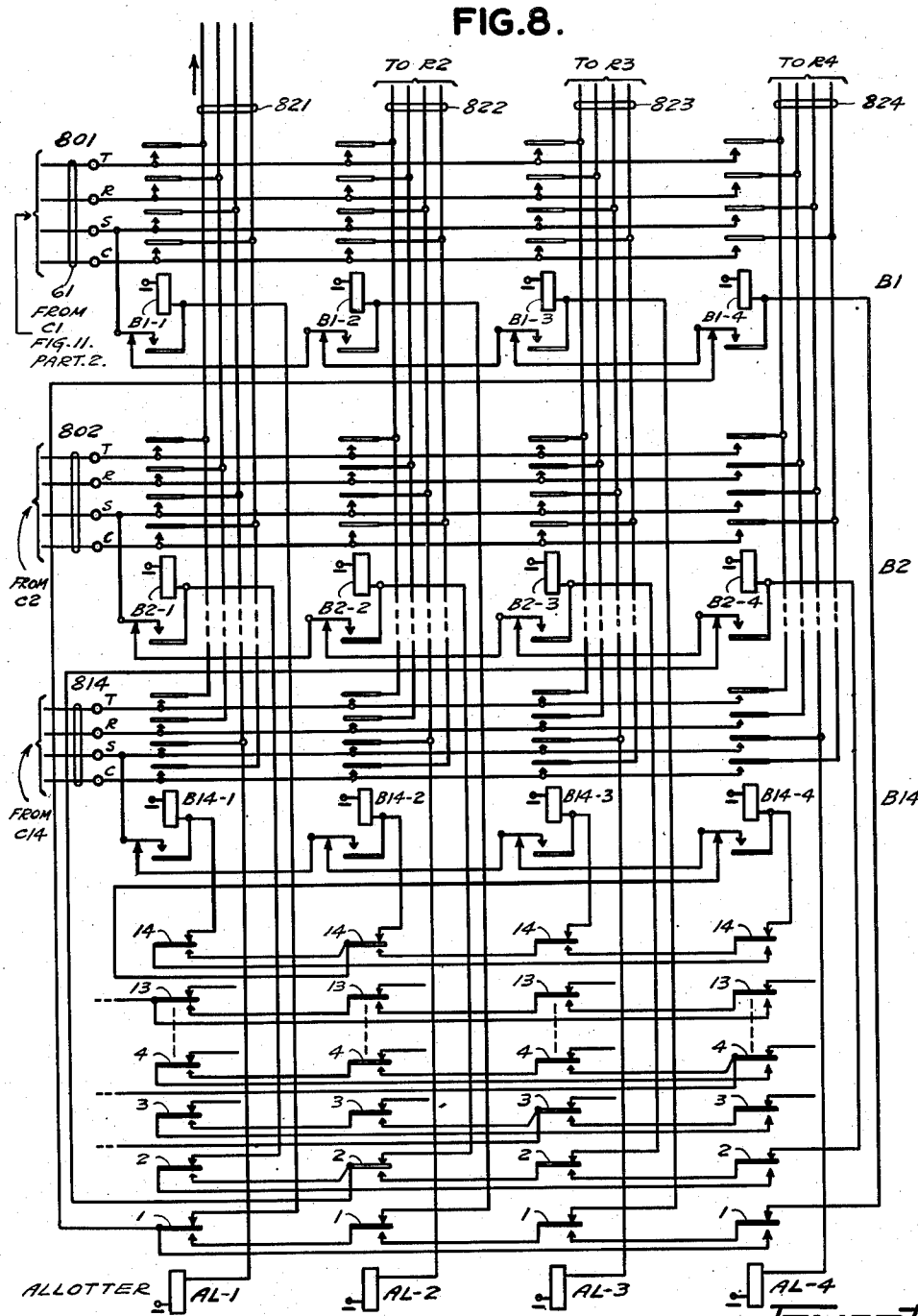
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Dec. 26, 1944. P. BAKKER 2,365,996

PRIVATE BRANCH EXCHANGE AUTOMATIC TELEPHONE SYSTEM

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FIG.8.



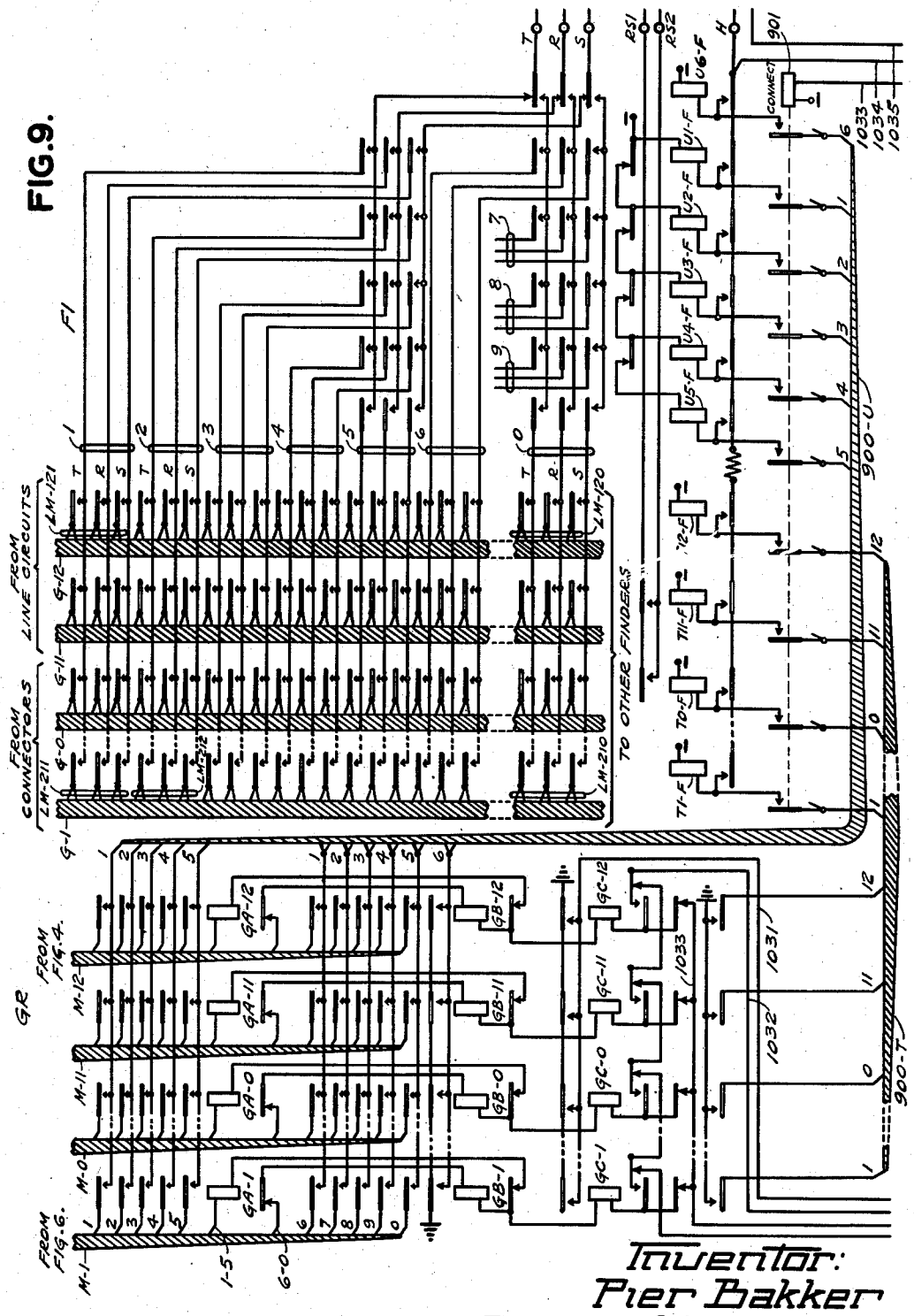
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Dec. 26, 1944. P. BAKKER 2,365,996

PRIVATE BRANCH EXCHANGE AUTOMATIC TELEPHONE SYSTEM

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FIG.9.



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PRIVATE BRANCH EXCHANGE AUTOMATIC TELEPHONE SYSTEM

Filed Aug. 12, 1942 14 Sheets-Sheet 11

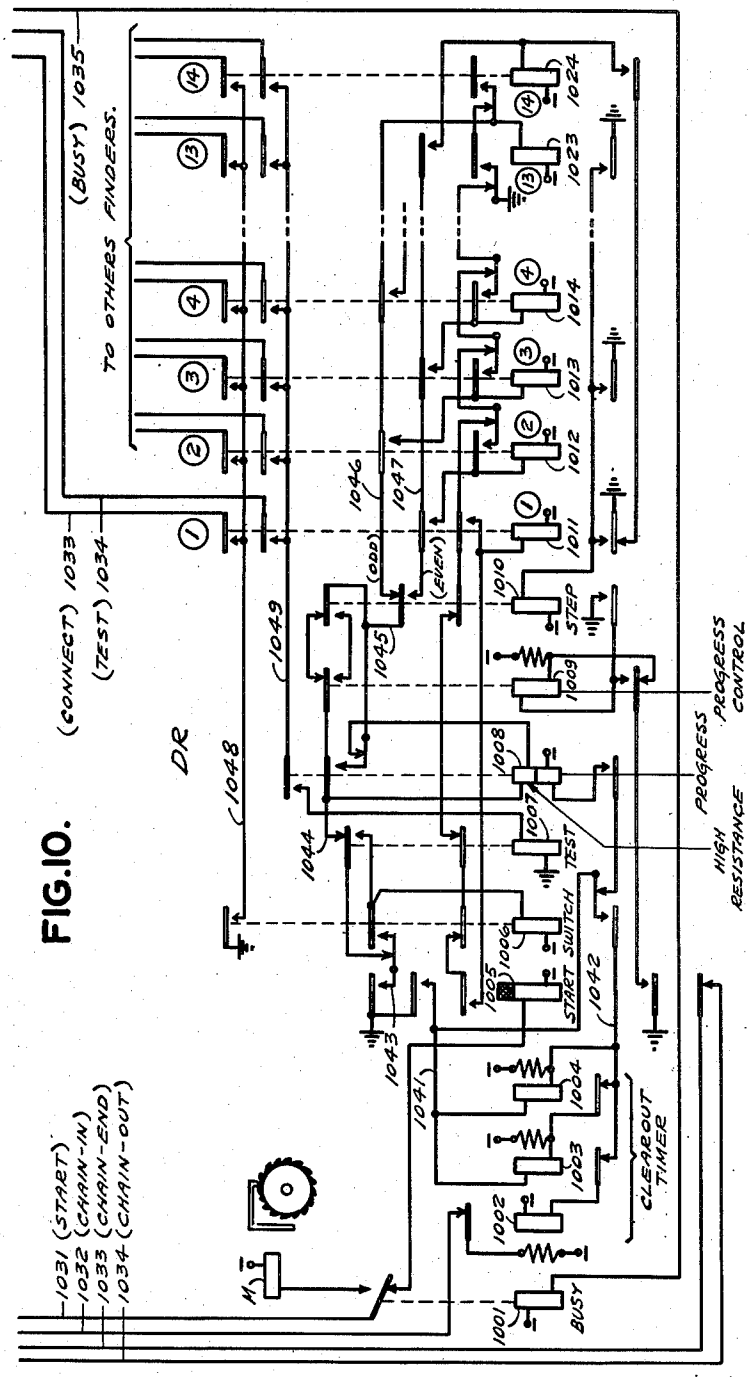


FIG. 10.

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Dec. 26, 1944. P. BAKKER 2,365,996

PRIVATE BRANCH EXCHANGE AUTOMATIC TELEPHONE SYSTEM

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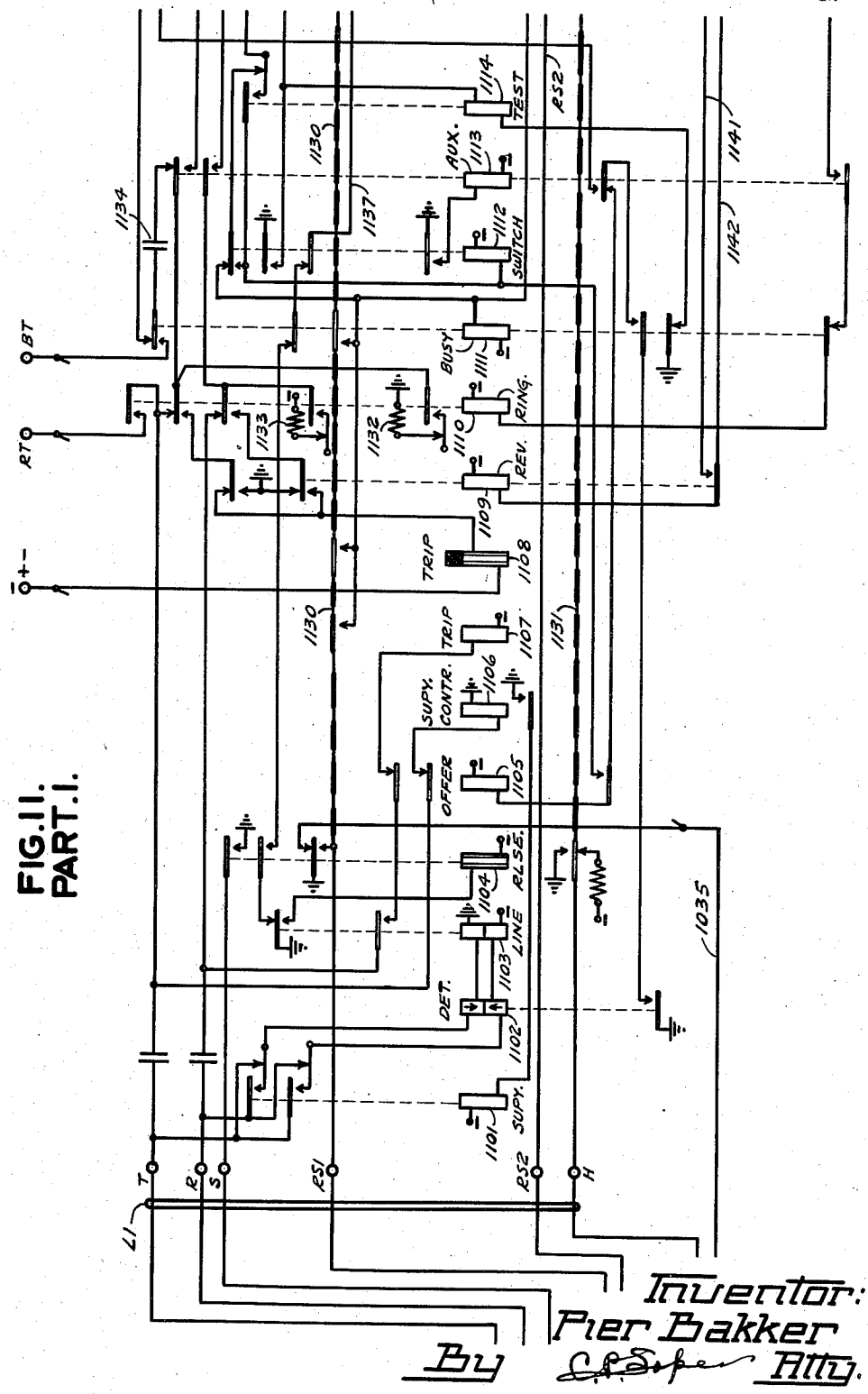


FIG. 11. PART I.

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PRIVATE BRANCH EXCHANGE AUTOMATIC TELEPHONE SYSTEM

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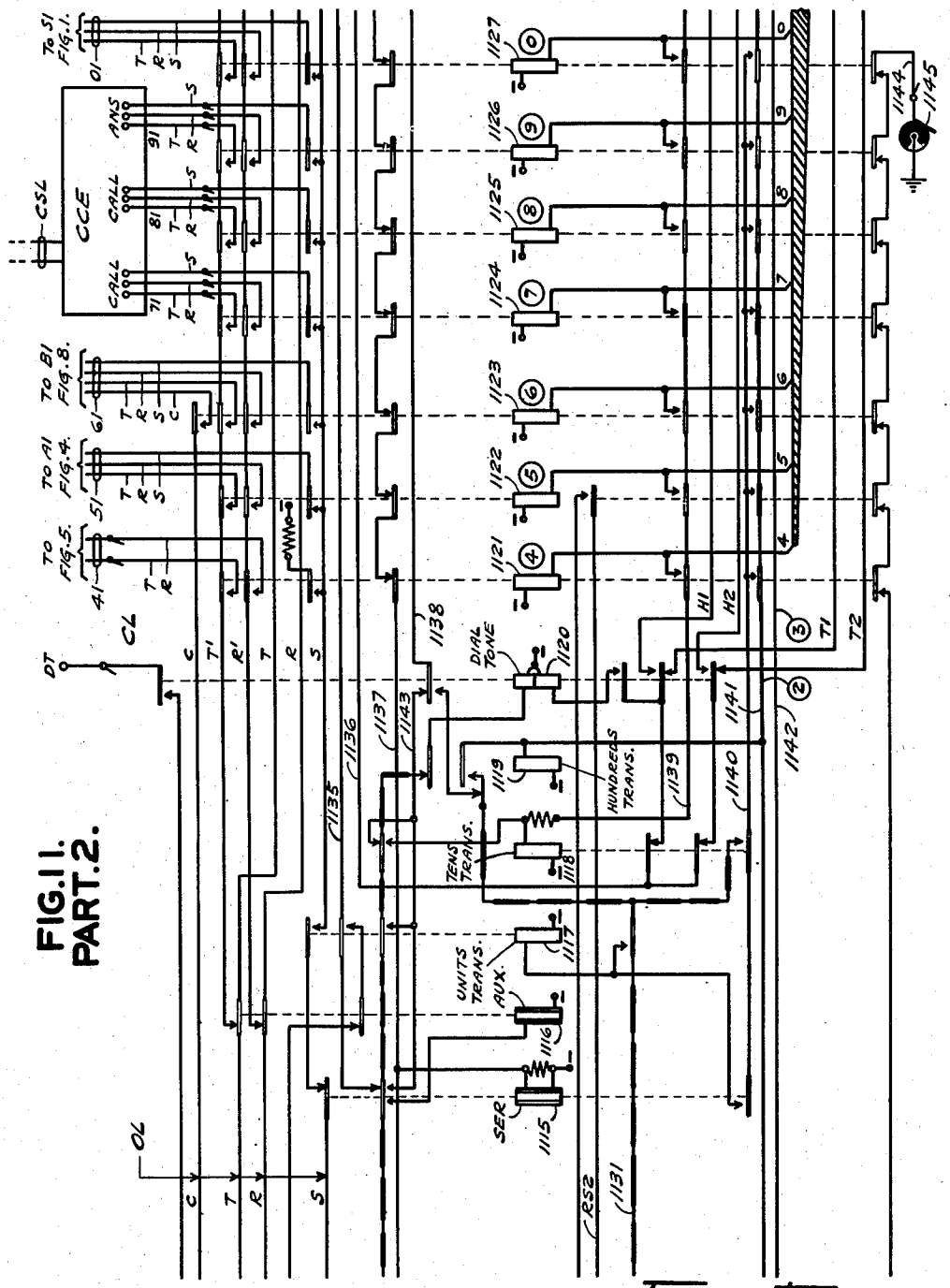


FIG. 11. PART. 2.

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PRIVATE BRANCH EXCHANGE AUTOMATIC TELEPHONE SYSTEM

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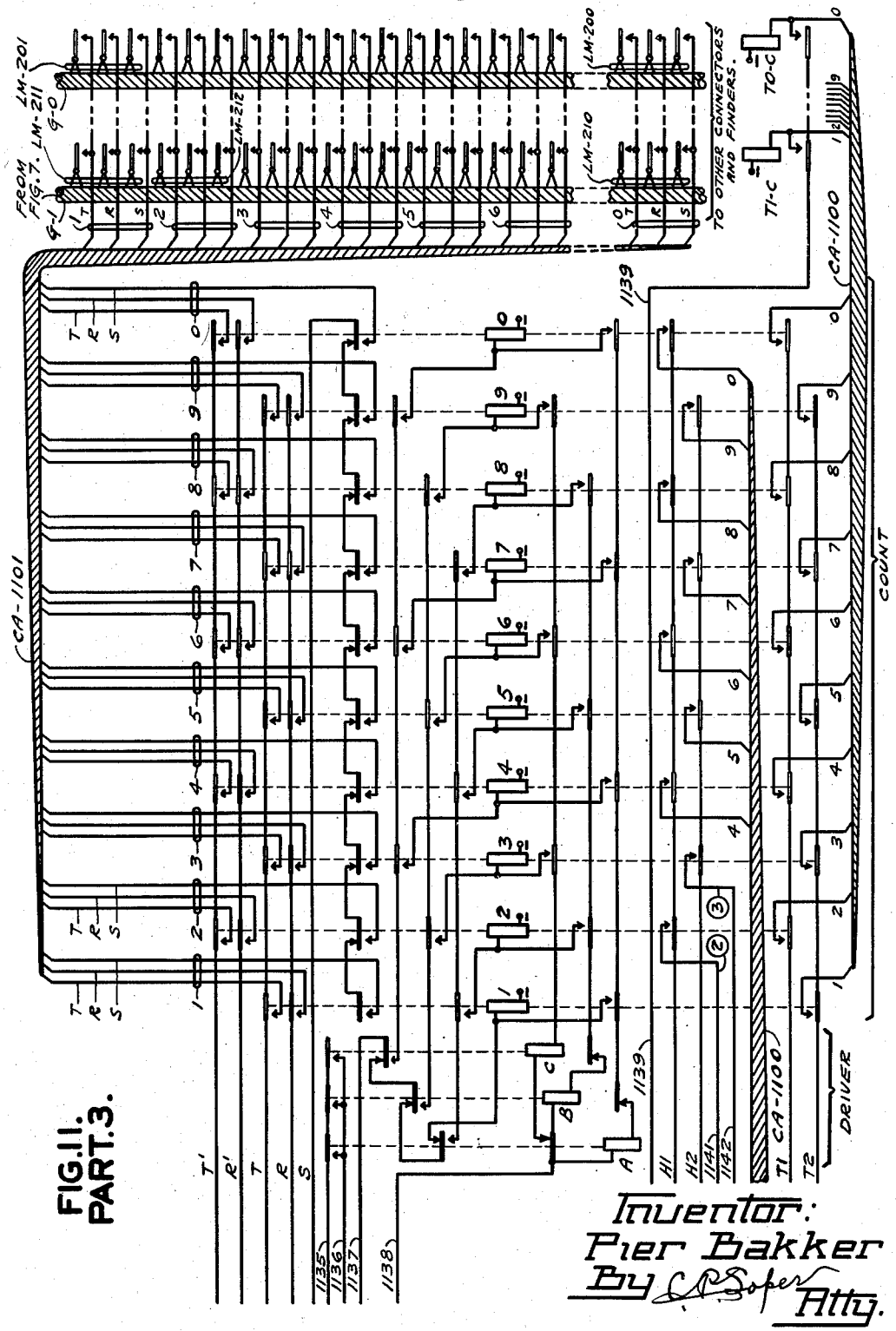


FIG. 11. PART 3.

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Patented Dec. 26, 1944 2,365,996

UNITED STATES PATENT OFFICE

2,365,996

PRIVATE BRANCH EXCHANGE AUTOMATIC TELEPHONE SYSTEM

Pier Bakker, Chicago, Ill., assignor to Kellogg Switchboard and Supply Company, Chicago, Ill., a corporation of Illinois

Application August 12, 1942, Serial No. 454,624

19 Claims. (Cl. 179—27)

This invention relates to private branch exchange automatic telephone systems. The principal object of the invention is the provision of new and improved circuit arrangements for use in a private branch exchange to enable the several desired features of service to be given more efficiently and satisfactorily.

An additional object is the provision of suitable circuit arrangements for use in multi-office private branch exchanges.

General Description

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 interconnected with each other by trunk lines, and wherein one of the offices is interconnected with the public exchange.

Referring now to the accompanying drawings comprising Figs. 1 to 14,

Fig. 1 is a schematic diagram of the arrangement in the private branch exchange and the trunk-line interconnection with the public exchange;

Figs. 2 to 11 are circuit diagrams; and

Figs. 12 to 14 show the way in which the sheets on which Figs. 1 to 11 are drawn are intended to be arranged.

The system arrangement

Referring now to Fig. 1, comprising parts 1 to 3, the private branch exchange (P. B. X) comprises offices A and B, interconnected by four two-way trunk offices A and B, interconnected by four two-way trunk lines, of which trunk lines B–T1 and B–T4 are shown. Office A of the P. B. X is interconnected with the public exchange by way of six two-way trunk lines (or P. B. X lines) of which lines A–T1 and A–T6 are shown. An attendant's cabinet **500** is located in office A and is provided with key equipment enabling the operator or attendant thereat to answer and extend calls incoming from the public exchange; answer calls from subscribers of the P. B. X; originate calls to P. B. X lines; and to set up tail-to-tail connections between public-exchange lines and P. B. X lines.

Office A

The connections in Office A of the P. B. X are set up through finder-connector links shown in Fig. 1, part 1. In the specific installation depicted, fourteen of these links are provided, of which links L1, L2, and L14 are shown. The fourteen finders are presented by finders F1, F2, and F14, while the fourteen connectors are represented by C1, C2, and C14.

Each of the connectors C1 to C14 has ten levels (groups) of bank contacts (levels 1 to 0), each level serving a separate ten-line group. These levels are served respectively by the group cables G–1 to G–0, each such group cable carrying the tip, ring, and sleeve conductors for a separate ten-line group. The group-one cable G–1 serves the ten illustrated line circuits LC–211 to LC–210 and attached P. B. X subscriber lines. Each of the other group cables, G–2 to G–0, similarly serves a separate group of ten line circuits and attached P. B. X lines.

The cables G–1 to G–0 serving the one hundred P. B. X lines and line circuits are multipled to the corresponding levels 1 to 0 of the finders F1 to F14. The finders have two additional levels served respectively by group cables G–11 and G–12. Group cable G–11 contains ten line multiples extending respectively to line circuits LC–111 to LC–110, while the line multiples contained in cable G–12 extend respectively to line circuits LC–121 to LC–120.

As many of the line circuits LC–111 to LC–110 and LC–121 to LC–120 as are needed are used to terminate the incoming branches of the public-exchange trunk lines and the incoming branches of the interoffice P. B. X trunk lines. Specifically the trunk-line branches incoming from office B are terminated respectively at line circuits LC–117 to LC–110, and the incoming branches of the public-exchange trunk lines are terminated at line circuits LC–125 to LC–120. Additionally, line circuits LC–121 and LC–122 terminate call lines ACL and CCL extending thereto from the attendant's cabinet **500**.

Each group of ten line circuits is provided with a mark cable containing conductors controlled by the line relays to control the starting and setting of the finders F1 to F4. The cables for the three groups of line circuits illustrated in Fig. 1 for office A are M–1, M–11, and M–12.

The twelve mark cables M–1 to M–12 extend separately to the group relays indicated at GR. These group relays cooperate with the distributor indicated at DR to cause idle ones of the finders F1 to F14 to be set successively on the successive calling lines.

In addition to giving access to any one of the full number of one hundred P. B. X subscriber lines, the connectors C1 to C14 must be arranged to provide additional services. These additional services comprise making connection with the

conference line CL when the conference number 41 is dialed; making an outgoing connection over an idle public-exchange trunk line when the public-exchange call number 51 is dialed; making an outgoing connection with an idle one of the P. B. X interoffice trunk lines when the Office-B number 61 is dialed; making calling connection with the code-call equipment CCE when either of the code-call numbers 71 and 81 is dialed; making answering connection with the code-call equipment CCE when the code-answer number 91 is dialed; and making connection with an idle one of the trunk lines extending to the attendant's cabinet 500 when the attendant's number 01 is dialed.

For this purpose, each of the connectors C1 to C14 is provided with one additional set of contacts for each of the called numbers 41 to 01. These contact sets are indicated below the levels 1 to 0 of the connectors.

The contact sets 41 of the connectors C1 to C14 are connected in multiple on the line side thereof to the conference line CL.

The line side of the contact sets 51 of the connectors C1 to C14 extend respectively to the selective switches A1 to A14, which have access in multiple to the outgoing branches of the main-exchange trunk lines A–T1 to A–T6. The selective switches A1 to A14 are individual respectively to the connectors C1 to C14.

Similarly, the line side of contact sets 61 of the connectors C1 to C14 extend respectively to the selective switches B1 to B14 which have access in multiple to the outgoing branches of the P. B. X interoffice trunk lines B–T1 to B–T4.

The line side of the contact sets 71 of the connectors C1 to C14 are connected in multiple to call line 71 extending to the code-call equipment CCE; the line side of the contact sets 81 of the connectors C1 to C14 are connected in multiple to the call line 81 extending to the code-call equipment CCE; and the line side of the contact sets 91 of the connectors C1 to C14 are connected in multiple to the answer line 91 extending to the code-call equipment CCE.

The line side of the contact sets O1 of the connectors C1 to C14 extend individually to the selective switches S1 to S14 which have access in common to the three trunk lines extending by way of the attendant's trunk circuits ATC–1 to ATC–3 respectively to answering equipment at the attendant's cabinet 500.

The equipment at the attendant's cabinet 500 includes keys K1 to K6 associated respectively with the trunk circuits TC1 to TC6, interposed respectively in the main exchange trunks A–T1 to A–T6. Each of the keys K1 to K6 has a trunk position and a local position as is shown for the key K1 in Fig. 5. Attendant's telephone AT is connected to attendant's line 225, multipled into relay contacts in each of the trunk circuits TC1 to TC6. controlled by relays under the control respectively of the keys K1 to K6, as is shown in Fig. 3 for the trunk circuit TC1.

Additionally, the attendant's cabinet includes keys K7 and K8 associated with the attendant's call line ACL; keys K9 and K10 associated with the conference line CL and the conference call line CCL; keys K11 to K13 associated respectively with the attendant's trunk circuits ATC–1 to ATC–3; and a control key K14 which is used to enable the attendant to make an offering or verifying connection with a busy line.

The repeaters R1 to R4 in office A are inserted in the outgoing branches of the interoffice trunks B–T1 to B–T4 respectively.

The code-call equipment CCE may be of the type shown in the application of Bert A. Wallace, Serial No. 366,041, filed November 18, 1940, now Patent No. 2,292,183. This equipment has the code signal line CSL extending therefrom, to which any desired number of signal devices S1 to SX may be multiply connected.

Office B

The arrangement in Office B of the P. B. X, shown in part 3 of Fig. 1, is similar to that described in connection with Office A, shown in parts 1 and 2 of Fig. 1. The similarity between the parts is made clear by applying the same reference characters to the equipment in Office B as is applied to the corresponding equipment in Office A, the reference characters applied in Office B being primed.

Office B is illustrated as including twelve finder-connector links L1′ to L12′, extending respectively from the finders F1′ to F12′ to the connectors C1′ to C12′.

Certain of the apparatus employed in Office A is not furnished in Office B, being not required. That is, no attendant's cabinet and associated equipment are required in Office B, nor terminating facilities for public-exchange lines. Accordingly, only five selective sets of contacts (41, and 71 to O1) are required to be added to the connectors C1′ to C12, of Office B. These five selective contact sets for each of the connectors in Office B are sets 41 for the conference line CL′; sets 71 to 91 for the two call lines and one answer line extending to the code-call equipment CCE′; and contact sets O1 leading individually to the selective switches B1′ to B12′, which have access in common to the outgoing branches in Office B of the interoffice trunk lines B–T1 to B–T4.

The circuit drawings

The system having been described generally, a general description will now be given of the detailed circuit drawings comprising Figs. 2 to 11. These circuit drawings all show equipment located in Office A of the P. B. X.

The main exchange trunk line A–T1 and the associated trunk circuit TC1 of Fig. 1 are shown in Figs. 2 and 3;

The selective switch A1 of Fig. 1 is shown in Fig. 4, along with the circuit arrangement of line circuits LC–121 to 120 of Fig. 1;

The circuit details of the attendant's cabinet 500 of Fig. 1 are shown in Fig. 5, which drawing shows also the attendant's trunk circuit A–T1 of Fig. 1;

Fig. 6 shows the circuit arrangement of line circuits LC–211 to LC–210 serving the first ten-line group of the Office-A P. B. X subscriber lines;

The Office-A end of the interoffice trunk line B–T1, along with the repeater R1 of Fig. 1, is shown in Fig. 7;

Fig. 8 shows the circuit arrangements of the selective switches B1 to B14 of Fig. 1, part 2, having access to the outgoing branches in Office A of the interoffice P. B. X trunk lines;

Fig. 9 shows the arrangement of the finder-control group relays GR of Fig. 1, to which the mark cables M–1 to M–12 of Figs. 1, 4, and 7 extend, together with the finder F1 of Fig. 1;

Fig. 10 shows the circuit arrangement of the distributor DR of Fig. 1; and

Fig. 11, in three parts, shows the connector C1 of Fig. 1 together with the link L1 between this connector and the finder F1 of Figs. 1 and 9.

Special features

The following are certain special features of the system not particularly covered by the foregoing discussion:

1. As is customary, the subscriber lines of the P. B. X are divided into two classes, non-restricted lines and restricted lines. Calls may be made to the public exchange from the non-restricted lines, but not from the restricted lines. Calls from the public exchange may be made to all lines whether restricted or not, in the discretion of the P. B. X attendant. The attendant may set up a tail-to-tail connection between a line reached by way of the public exchange and any P. B. X line whether restricted or not.

In the illustrated installation, the restricted-service arrangement is carried out by a separate pair of restricted-service leads in each of the finder-connector links arranged to deny the attempted connection (by operating the busy relay of the connector) provided the call is from a restricted level of the concerned finder and provided the call is attempted to one of the trunk lines leading to the public exchange. The restricted-service leads of the link L1 (Figs. 9 and 11) are the leads RS1 and RS2, which may be closed by any desired finder group (level) relay. The connection of conductors RS1 and RS2 to the contacts of any level relay of the finder F1 effectively restricts all the lines (subscriber lines or trunk lines) of that level as regards calls to the trunk lines leading to the public exchange.

2. Each of the attendant's trunk circuits associated respectively with the trunk lines connected with the public exchange, exemplified by the trunk circuit TC1 (Figs. 1 to 3), is so arranged that actuation of the associated key in the attendant's cabinet to what is designated as the trunk position sets up a locked, seized condition in the trunk circuit to give answered supervision in the public exchange if the key is thrown in response to a call received in the P. B. X, and to originate a call to the public exchange provided the associated trunk line is not in use when the key is so actuated. The clearing out of the locked condition when the concerned trunk is extended to a local P. B. X line is accomplished automatically responsive to the receiver being replaced on the connected P. B. X line. Otherwise, the attendant clears out the locked condition by depressing the hookswitch of the attendant's telephone with the trunk key actuated.

Actuation of the above-named trunk key to local position causes extension of the incoming branch of the associated trunk line to an idle connector and places that connector under control of the attendant's calling device. An interlocking circuit arrangement renders the actuation of the above-named key to local position ineffectual until after the attendant has first actuated the key to trunk position to set up the above-mentioned holding condition. By this arrangement, the attendant is prevented from taking the local end of the trunk line for use without having previously actuated the key to trunk position to cause both ends of the concerned trunk line to be guarded.

3. The attendant is provided with what is termed an offer or busy-verification key, by means of which she can unbalance the current flow in the tip and ring conductors of any local connection. The connectors are arranged to respond to this unbalanced current flow in the event that the called P. B. X line is busy to complete a talking and listening circuit from the attendant's cabinet to the busy line whereby the operator can verify that the line is in fact busy and can offer to complete the connection to the busy line.

4. In each office of the P. B. X, a non-busy or conference line is provided whereby at a prearranged time a number of separate P. B. X subscribers may call the conference line and thereby be placed in common communication to enable a conference to be held. When an interoffice conference is required, the attendant, who has access to a multiple of the conference line in the local P. B. X office, may extend a connection from such conference line over a single one of the interoffice P. B. X trunk lines to the conference line in the other office. This arrangement results in a great saving in the number of interoffice trunk lines required. Without it, all persons joining in a conference would have to call the conference number in one or the other of the P. B. X offices thereby temporarily withdrawing from service as many interoffice trunk lines as there might be subscribers in one office desiring to make connection with the conference line in the other office.

5. Arrangements are provided for causing a continuous rotation of the use of the links and trunk lines on successive calls. This feature is particularly valuable during periods of light traffic. The rotation of the use of the finder-connector links is secured by the progressive action to be hereinafter described of the distributor DR of Figs. 1 and 10. The distributor is so arranged that it takes the next succeeding idle finder for use on the next call even though the next call is not made until the call last made has been cleared out and the last used finder has again become idle.

The selective switches through which access is given from the connectors to the trunk lines are provided with a slip arrangement whereby successive ones of these switches have a different choice access to the trunk lines. This arrangement cooperates with the progressive action of the distributor to cause rotation of use of the trunk lines.

6. Specific features of the distributor arrangement as exemplified in Fig. 10 for the distributor DR are that the distributor searches for an idle-indicating battery potential on the test leads of the finders; it contains a pair of interlocked relays which positively cause a progression of the distributor of at least one step on each call handled thereby; and it contains a clear-out timer which operates on any call to clear out the operated group relays in the event that they do not clear out as the result of the attempted or completed finder operation.

7. A specific feature of the selective switches such as A1 to A14 and S1 to S14 of Fig. 1, exemplified at A1 in Fig. 4, is that each constitutes a hunting switch which makes connection successively with the trunk lines accessible thereby until an idle one is found, whose idle condition is indicated by the presence of battery potential on the test conductor thereof.

8. A specific feature of the switches such as B1 to B14 of Fig. 1, exemplified by the circuit drawing (Fig. 8), is that each of these switches comprises a group of relays corresponding respectively to the trunks accessible to such switch, and a

common allotter is provided comprising allotter relays common to all the switches and corresponding respectively to the trunks accessible to such switches. The allotter arrangement is such that upon seizure of any of the switches, the first idle trunk accessible thereto is taken for use immediately by the energization of the corresponding relay of the seized switch. The common allotter carries an individual chain circuit for each of the switches, and the point of access to the chain circuit is rotated on successive switches whereby rotation of the use of the trunk lines on successive calls is effected with a straight, nonslipped, multiple of the trunk lines to the several switches of the group.

9. Divided-ringing, two-party service is available on each P. B. X subscriber line by assigning two hundreds digits (2 and 3) to the same group of one hundred P. B. X subscriber lines. When the normal hundreds digit (2) is dialed (as in #210), connection is made normally to the called line, ringing current being projected over the tip conductor. But, when the alternate hundreds digit (3) is dialed (as in #310) the connector is altered thereby to project ringing current over the ring conductor of the called line.

Other objects and features of the invention will appear as the description progresses.

Detailed Description

A. *A local call; Office A*

A description will first be given of the operations involved in a local call between two P. B. X subscriber lines terminating in office A. For this purpose, it will be assumed that the subscriber at substation #211 (Figs. 1 and 6) desires to converse with the subscriber at substation #210 on the two-party line #210;310 (Figs. 1 and 6).

Referring first to Fig. 1, the desired connection, when completed, is from the calling station #211 by way of the correspondingly numbered line multiple in the group-one cable G–1; through first-level contacts of one of the finders F1 to F14; through the corresponding one of the links L1 to L14; and through the first level contacts of the concerned one of the connectors C1 to C14, to the called line #210;310, by way of the correspondingly numbered line multiple in group-one cable G–1.

A1. *Marking the calling line*

When the receiver (not shown) is removed at substation #211 (Fig. 6), the usual direct-current bridge is closed across the associated tip and ring conductors, thereby closing a circuit through contacts of cutoff relay **704** for line relay **601**. Line relay **601** thereupon applies ground potential to the associated group-mark conductor 1—5 (associated with the first five lines of the ten-line group) and applies ground potential to its individual mark conductor 1, thereby indicating a calling condition and marking the identity of the calling line in the group relays GR (Fig. 9).

A1a. *Units marking*

Assuming that the group relays GR of Fig. 9, and the distributor DR of Fig. 10, are in normal condition at this time, subgroup relay GA–1 and tens-group relay GC–1 operate in series over the following circuit path: from ground on conductor 1—5 in cable M–1, through the winding of relay GA–1, lower contacts of relay GB–1, the winding of relay GC–1, chain-end conductor **1033**, lower contacts of start relay **1005**, chain-out conductor **1034**, chain contacts controlled by the first lower armatures of relays GC–1 to GC–12, chain-in conductor **1032**; contacts of clearout-timer relay **1002**, to battery through the associated resistor.

Upon operating over the above-traced circuit, subgroup relay GA–1 connects the associated conductors 1 to 5 in cable M–1 respectively to the units conductors 1 to 5 in units cable **900**–U, thereby extending ground potential from the grounded conductor 1 in cable M–1 to conductor 1 in units cable **900**–U.

Relay GA–1, at its lower contact pair, disconnects relay GB–1 to prevent operation of the latter relay in the event that a call should be made concurrently from one of the lines 6 to 0 in the same ten-line group.

A1b. *Tens marking*

Upon operating over the above-traced circuit, relay GC–1 locks itself to the chain circuit at its first lower armature, at the same time opening the contact chain. At the back contact of its second lower armature, relay GC–1 disconnects itself from chain-end conductor **901**, after it has locked itself to the contact chain. Chain-end conductor **901** is now isolated from chain-in conductor **1032** to preclude operation of the group relays of any other tens group for the time being.

At the front contact of its third lower armature, relay GC–1 applies ground potential to conductor 1 in the tens cable **900**–T, thereby marking the first tens group as calling.

A2. *Starting the distributor DR*

At its upper contacts, relay GC–1 applies ground potential to start conductor **1031**, thereby closing a circuit, through the front contact of the normally operated busy relay **1001**, for start relay **1005** of the distributor DR. Slow-acting start relay **1005** operates after a slight interval. Clear-out-timer relays **1003** and **1004** operate responsive to the closure of the front contact of the second upper armature of relay **1005**. Relay **1004** opens a point in the restoring circuit of relay **1003**, and relay **1003** disconnects the final clear-out relay **1002**. Relay **1002** is preferably marginally adjusted to prevent its operation in shunt of the resistors associated with the relays **1003** and **1004** in the event that relay **1003** should be slow in operating.

A3. *Freezing progress-control relay 1009*

At the front contact of its lower armature, start relay **1005** applies ground potential to the lower armature of progress-control relay **1009**. By this operation, the present condition of relay **1009** (whether operated or restored) is maintained. If relay **1009** is restored at the time, as it is on about half of the calls, ground potential is extended through the back contact of its lower armature to the left winding terminal thereof, thereby preventing this relay from responding to an operation of stepping relay **1010**. On the other hand, if relay **1009** is in operated condition at the time, as it is on about half of the calls, the grounding of the lower armature thereof extends ground potential through the front contact of such armature to the right-hand winding terminal of the relay to close a locking circuit for it. The utility of this arrangement will appear later.

A4. *Distributor operation*

On the first call to the distributor DR after it has been placed in operation and the battery

supply connections have been closed, none of the relays thereof except busy relay 1001 is in operated condition when start conductor 1032 is grounded as above described to bring about the operation of start relay 1005. Under this condition, the closing of the front contact of the first upper armature of start relay 1005 closes an operating circuit for the #1 distributing relay as follows: from ground, through the normally closed contacts controlled by the first upper armature of the #13 distributor relay 1023, corresponding contacts of the preceding distributor relays including 1014 to 1012, back contacts of the first upper armatures of relays 1010, 1007, and 1006, the front contact of start relay 1005, to battery through the winding of relay 1011.

Upon operating, relay 1011 closes a locking circuit for itself at its first upper armature independent of the contacts of relays 1005 to 1007 and 1010; at the front contact of its second upper armature, it connects the even operating conductor 1047 to the #2 distributor relay 1012; at its third and fourth upper armatures, it connects the test and connect conductors 1034 and 1033 of the finder F1 to the common conductors 1049 and 1048; and at the front contact of its lower armature, it closes an operating circuit for stepping relay 1010. Relay 1010 disconnects operating conductor 1045 from odd conductor 1046 and connects it to even conductor 1047 preparatory to operating the #2 distributor relay 1012.

A4*a*. *Operating progress relay 1008*

The first step has now been taken by the distributor, and progress relay 1008 is now to be operated to denote that fact.

At this time, with the upper armature of stepping relay 1010 in operated condition, and the upper armature of progress-control relay 1009 in restored condition, the following circuit is effective for the upper winding of progress relay 1008, in series with relay 1012: from ground, through the front contact of the upper armature of start relay 1005, conductor 1043, contacts of relays 1006 and 1007, conductor 1044, high-resistance upper winding of progress relay 1008, normally closed contacts controlled by the first upper armature of relay 1008, conductor 1045, front contact of the second upper armature of relay 1010, even conductor 1047, front contact of the second upper armature of relay 1011, and the winding of relay 1012, to battery.

Relay 1008 operates over the above-traced circuit, but relay 1012 is not operated thereover because of the high resistance of the upper winding of relay 1008. Upon operating, progress relay 1008 locks its lower winding energized at its lower contacts, through contacts controlled by the lower armature of relay 1006, to ground on conductor 1041. At its upper contacts, progress relay 1008 connects test relay 1007 to the common test conductor 1049 to enable a test to be made over conductor 1034 of the busy or idle condition of the first finder F1 (Fig. 9). Additionally, relay 1008, at the front contact of its second upper armature connects conductor 1044 directly to conductor 1045 thereby by-passing the high-resistance upper winding of relay 1008 and the upper contacts of relays 1009 and 1010. The upper winding of relay 1008 is open-circuited at this time by the contacts controlled by the second upper armature thereof. The ground potential on conductor 1044 is now extended by way of conductors 1045 and 1047 to the winding of the #2 distributor relay 1012, to enable such relay to operate, subject to the control of test relay 1007.

A4*b*. *Selecting an idle finder*

Progress relay 1008 having operated to indicate that the distributor has advanced one step, by closing conductor 1049 to test relay 1007, the further operation depends on whether the finder F1 (and associated link L1 and connector C1) is busy or is idle. Assuming that the finder F1 is idle, this condition is marked by battery potential on conductor 1034 received from conductor H of link L1 (Figs. 9 and 11), impressed thereon through the back contact of the lower armature of release relay 1104 and the associated resistor. Test relay 1007 accordingly operates quickly from this battery potential responsive to being connected up at the upper contacts of progress relay 1008. The relative adjustment of the relays is such that test relay 1007 operates more quickly than any of the distributor relays 1011 to 1024 can operate. Accordingly, relay 1007 disconnects the grounded conductor 1043 from conductor 1044 to thereby open the circuit of relay 1012 before the latter relay can operate.

At its front contact, test relay 1007 closes an operating circuit for switching relay 1006. Relay 1006 thereupon operates and locks itself directly to conductor 1043, at the same time disconnecting the armature of test relay 1007. At its lower armature, relay 1006 connects conductor 1042 to the grounded conductor 1041 to start the timing operation of the clear-out timer comprising relays 1002 to 1004, at the same time opening the locking circuit of the lower winding of progress relay 1008. Relay 1008 thereupon restores. At its upper contacts, it disconnects test relay 1007 whereupon the latter relay restores, leaving switching relay 1006 operated in its self-locking circuit.

A5. *Operating the selected finder*

At its upper contacts, switching relay 1006 applies ground potential to conductor 1048 thereby operating connecting relay 901 of the finder F1 through the upper contacts of the operated distributor relay 1011 and over conductor 1033. Connecting relay 901 thereupon connects the conductors 1 to 12 in the tens cable 900–T respectively to the finder relays T1–F to T12–F, at the same time connecting the conductors 1 to 6 in the units cable 900–U respectively to the units relays U1–F to U6–F.

Tens conductor 1 in cable 900–T having been grounded at the lower contacts of the operated tens group relay GC–1, level–1 relay T1–F of the finder F1 now operates. Upon so doing, it connects the thirty conductors comprising the ten line multiples carried in cable G–1 respectively to the ten local branches controlled by the units relays. At its lower contacts, relay T1–F prepares a locking circuit for itself to conductor H of the link L1.

Mark conductor 1 in cable M–1 having been grounded at the calling line circuit and having been connected, through contacts of the operated relay GA–1 to units conductor 1 in cable 900–U, units relay U1–F of the finder F1 operates over the latter conductor. At the back contact of its first upper armature, units relay U1–F opens the battery supply connection to units relay U2–F to U5–F to prevent a double connection by the finder F in the event that two lines in the same subgroup of five are calling contemporaneously. Units

switching relay U6–F is not operated at this time because it can operate only when one or another of the relays GB–1 to GB–12 is in operated condition, indicating a call from a line in the second subgroup (6 to 0) of the calling ten-line group.

The tip, ring, and sleeve conductors of the line multiple LM–211 associated with the calling line #211 are now extended through the upper group of three contact pairs of first-level relay F1–F to the #1 set of local conductors of the finder, thence through the upper set of contact pairs of relay U1–F, and through the back contacts of relay U6–F respectively to the tip, ring, and sleeve conductors T, R, and S of the link L1 between the finder F1 of Fig. 9 and the connector C1 of Fig. 11.

A6. *Preparing the connector C1 for operation*

In the connector C1 of Fig. 11, the windings of line relay 1103 are connected, through the windings of differential detector relay 1103 and contacts of supervisory relay 1101, to the tip and ring conductors of the link L1. The lower winding of line relay 1103 is accordingly now energized over the calling line in parallel with the winding of line relay 703 of the calling line circuit LC–211, the upper winding of line relay 1103 being temporarily shunted by the ground connection to the tip conductor of the calling line at contacts of cutoff relay 704.

Upon operating, line relay 1103 operates the slow-restoring release relay 1104. Relay 1104, applies ground potential at the front contact of its lower armature to the hold conductor H of the link L1, thereby locking the operated finder relays U1–F and T1–F. At the front contact of its first upper armature, relay 1104 prepares an operating circuit over conductor 1137 for the counting relays of Fig. 11, part 3; at the back contact of its first upper armature, it removes ground potential at one point from the common busy conductor 1035, leaving this conductor grounded at the similar contacts of each idle connector; and at the front contact of its first upper armature, it applies ground potential to the joined conductors RS1 and 1130, whereupon dial-tone relay 1120 operates through contacts of hundreds-transfer relay 1119 to impress a dial-tone signal on the tip conductor of the calling line, by way of condenser 1134 and contacts of relays 1111, 1113, and 1110.

At its upper contacts, release relay 1104 applies ground potential to sleeve conductor S of the link L1, thereby operating cutoff relay 704 of the calling line circuit LC–211 (Fig. 7). Cutoff relay 704 clears the calling line, whereupon line relay 703 restores. When the calling line is cleared, the calling subscriber hears the dial-tone signal applied at the upper contacts of dial-tone relay 1120, and is thereby informed that he may begin to dial the digits in the desired number.

A7. *Clearing out the group-control relays and distributor*

The restoration of line relay 703 removes ground potential from conductor 1 of cable M–1 thereby opening the initial circuit of units relay U1–F, leaving this relay operated in its locking circuit over conductor H of the link L1. Additionally, if no other line in the first subgroup (lines 1 to 5) of the same tens group is calling, the restoration of line relay 703 results in the removal of ground potential of the subgroup mark conductor 1–5, whereupon the operated subgroup and group relays GA–1 and GC–1 restore. The restoration of relay GC–1 results in the removal of ground potential from tens conductor 1 in cable 900–T, thereby opening the initial circuit of the now-locked tens relay T1–F. Relay GC–1 also removes ground from start conductor 1032, thereby open-circuiting slow-acting start relay 1005 of the distributor DR. It is to be noted that no further operation of the group relays can occur for the time being (until the slow-acting start relay 1005 has restored) because start relay 1005 maintains chain-out conductor 1034 disconnected from chain-end conductor 1033 until it restores.

Upon restoring, start relay 1005 disconnects ground potential from conductor 1041 to terminate the timing action to be hereinafter described of the clear-out timer, as it is necessary for this timer to complete its operation only when the normal clearing-out operation now being described does not occur. Any operated ones of the relays 1002 to 1004 thereupon restore. Start relay 1005 also disconnects ground potential from conductor 1043, thereby unlocking and restoring switching relay 1006. Ground potential is accordingly removed from conductor 1048 and consequently from conductor 1033, whereupon connecting relay 901 restores to disassociate the conductors in cables 900–T and 900–U from the finder F1.

At the front contact of the first lower armature of start relay 1005, ground potential is removed from the lower armature of progress-control relay 1009, thereby removing the short circuit from the winding of this relay and permitting relay 1009 to operate from the ground potential supplied thereto at the front contact of the lower armature of stepping relay 1010 (held operated by the locked #1 distributor relay 1011). Upon operating, relay 1009 prepares a locking circuit for itself at its lower armature, while, at its upper armature, it cooperates with the upper armature of the operated stepping relay 1010 to restore the normal short circuit or bypass around the high-resistance upper winding of progress relay 1008.

At its lower contacts, start relay 1005 rejoins chain-end conductor 1033 to chain-out conductor 1034 thereby again conditioning the group relays GR for further operation under the control of any further calling ones of the line circuits.

A8. *Dialing the hundreds digit (2)*

When the calling subscriber at substation #211 (Fig. 7) dials the hundreds digit 2 in the desired number, the usual calling device (not shown) produces two momentary interruptions in the direct-current bridge across the calling line, thereby causing two momentary restorations of line relay 1103, of insufficient length to permit the slow-restoring release relay 1104 to follow.

Upon each momentary restoration of line relay 1103, an impulse is transmitted at the back contact of the second armature thereof, through contacts of relays 1104, 1111, and 1112, to operating conductor 1137. Series relay 1115 responds to the first of these impulses. Being slow-restoring, it remains operated until the series of impulses is ended. At the left front contact of its first upper armature, series relay 1115 operates the slow-restoring auxiliary relay 1116, from ground on conductor 1130, grounded at contacts of release relay 1104.

The first momentary impulse delivered to operating conductor 1137 passes, through series contacts of relays 1121 to 1127, and through series contacts of driver relays C, B, and A, to counting relay 1. Relay 1 thereupon operates

and closes a self-locking circuit, through the winding of driver relay A, to the counting-relay locking conductor 1138, grounded at this time through the front contact of the first upper armature of the operated dial-tone relay 1120, contacts controlled by the first upper armature of hundreds-transfer relay 1119, and conductor 1131, grounded at contacts of release relay 1104.

Driver relay A remains short-circuited by the ground potential initially applied to counting relay 1 until the momentary impulse is terminated, whereupon relay A operates in the locking circuit of relay 1. Upon so doing, it disconnects operating conductor 1137 from counting relay 1 and transfers it to counting relay 2, through contacts of the operated counting relay 1.

When the second impulse arrives, counting relay 2 is thereby operated, whereupon it locks itself at the front contact of its first lower armature, through the winding of driver relay B to the counting-relay locking conductor 1138.

On the termination of the second impulse, driver relay B operates in the locking circuit of counting relay 2. Upon so doing, it open-circuits and restores driver relay A and counting relay 1 at the back contact of its lower armature, while at its first upper armature it transfers impulse conductor 1137, through contacts of counting relay 2 to counting relay 3.

The counting-relay arrangement is such that a maximum of ten impulses in a series may be received and counted by relays 1 to 0 respectively. The driver relays A, B, and C cooperate respectively with counting relays 1 to 3 incident to the receipt of the three impulses, and they are reoperated in cooperation with counting relays 4 to 6 incident to the receipt of the second set of three impulses, and so forth. It is observed that each driver relay, on operating, open-circuits and restores the driver relay last operated, along with the counting relay locked in series therewith. As a result, when any series of impulses is terminated, only a single driver relay and a single counting relay (the ones last operated) remain in operated condition.

In the present example, the initial, or hundreds, digit is the digit 2, and counting relay 2 and driver relay B are the ones in operated condition at the end thereof.

When slow-restoring series relay 1115 falls back at the end of the series of impulses constituting the hundreds digit 2, it places ground potential on hundreds conductors H1 and H2 over the following circuit path: from ground on conductor 1130, through the back contact of the first upper armature of series relay 1115, conductor 1135, contacts of the operated driver relay B, conductor 1136, back contacts of the first and second lower armatures of tens-transfer relay 1118, and through the front contacts of the second and third lower armatures of the operated dial-tone relay 1120, to hundreds conductors H1 and H2.

With counting relay 2 in operated condition, the grounding of hundreds conductor H1 results in the closure of a circuit, through the front contact of the second lower armature thereof, and over conductor 1141, for hundreds-transfer relay 1119. Hundreds-transfer relay 1119 thereupon operates. At its upper contacts, relay 1119 open-circuits the upper winding of dial-tone relay 1120, but the lower winding of relay 1120 remains energized in a self-locking circuit for the time being to conductor 1136 by way of the contacts of tens-transfer relay 1118.

At its first upper armature, relay 1119 locks itself to the grounded conductor 1131, at the same time disconnecting counting-relay locking conductor 1138 from the grounded conductor 1131, thereby depriving conductor 1138 of locking potential. When this occurs, the operated driver relay B and counting relay 2 restore. The restoration of counting relay 2 opens the initial circuit of hundreds-transfer relay 1119, leaving this relay operated in its above-noted locking circuit. The restoration of driver relay B disconnects the ground potential on conductor 1135 from conductor 1136, thereby unlocking the lower winding of dial-tone relay 1120. Relay 1120 thereupon restores. Upon so doing, it disconnects hundreds conductors H1 and H2 and substitutes tens conductors T1 and T2, at the same time opening a further point in its previously existing locking circuit. At its first upper armature, dial-tone relay 1120 again connects counting-relay locking conductor 1138 to ground, by connecting it to conductor 1143, grounded by virtue of its connection, through the back contact of the first upper armature of relay 1138, to the grounded conductor 1130.

The dial-tone lead DT is disconnected at the upper contacts of dial-tone relay 1120, thereby terminating the dial-tone signal previously transmitted over the calling line.

Slow-restoring auxiliary 1116 restores shortly after relay 1115, but without any particular effect at this time.

A9. Dialing *the tens digit (1)*

When the tens digit 1 is dialed, line relay 1105 is restored once momentarily transmitting a single impulse to operating conductor 1137. Slow-restoring relays 1115 and 1116 respond successively as above described. Additionally, counting relay 1 responds at the beginning of the impulse and driver relay A responds, in the locking circuit of relay 1, at the termination thereof.

When slow-restoring series relay 1115 restores at the end of the tens digit 1, it applies ground potential to tens conductors T1 and T2 by way of conductor 1135, contacts of driver relay A, conductor 1136, contacts of relay 1118, and the back contacts of the second and third lower armatures of the restored relay 1120. With counting relay 1 in operated condition, the application of ground potential to tens conductor T2 results in the closure of a circuit, through the lower contacts of relay 1 and over conductor 1 in cable CA–1100, for the first-level relay T1—C. Relay T1—C thereupon operates to connect up the ten line multiples represented by cable G—1, respectively to the ten local groups 1 to 0 contained in cable CA–1101.

Relay T1–C, at the front contact of its lower armature, extends to operating ground potential over conductor 1139, to tens-transfer relay 1118. Relay 1118 thereupon operates and locks itself to the grounded conductor 1130 at the front contact of its first upper armature, thereby locking ground potential on conductor 1139 to maintain relay T1–C locked operated. At the back contacts of its first and second lower armatures, relay 1118 disconnects conductors 1136 from conductors T1 and T2, and, at the back contact of its first upper armature, it disconnects ground potential from conductor 1143 and consequently from counting-relay locking conductor 1138, whereupon relays A and 1 restore, clearing out the counting chain.

A10. *Dialing the units digit (0)*

When the units digit 0 is dialed, line relay 1103 is restored ten times momentarily, thereby transmitting ten momentary impulses over operate conductor 1137. Series relay 1115 and series auxiliary relay 1116 respond as above. At the right front contact of its first upper armature, series relay 1115 applies ground potential, from conductor 1130, to conductor 1143 and consequently to counting-relay locking conductor 1138.

Units-transfer relay 1117 now operates from ground on conductor 1131, through the lower contacts of relays 1118 and 1115. Upon so doing, it locks itself to conductor 1131 at the front contact of its lower armature. At the front contact of its first upper armature, relay 1117 shunts the first upper armature and right front contact of series relay 1115 to provide a final locking circuit for the counting relays.

Counting relays 1 to 0 are operated over conductor 1137 in a wave-like operation accompanied by the cyclic operation hereinbefore described of the driver relays A and C. At the end of the tenth and final impulse of the series, counting relay 0 is in locked condition, in series with driver relay A, and driver relay A thereupon operates in the locking circuit and restores driver relay C, along with counting relay 9.

Relays A and 0 remain locked operated over conductor 1138.

The tip, ring, and sleeve conductors T, R, and S of the out link OL of the connector are now connected, through contacts of counting relay 0 to the #1 local group of conductors and through the #0 group of contacts of the operated tens relay T1–C, except for the open points at the back contacts of the operated relays 1115 and 1116.

A11. *Testing the called line*

The called line is tested by test relay 1114 when series relay 1115 restores. The circuit path of test relay 1114 is from ground, through the back contact of the second lower armature of switching relay 1112, the winding of test relay 1115, upper contacts of relays 1115 and 1117, conductor S of the out link OL, front contact of the first upper armature of counting relay 0, sleeve conductor S of the 0 group of conductors in cable CA—1101, and through the front contact of the first upper armature of relay T1—C, to the sleeve conductor of line multiple LM—210, extending to the line circuit LC—210 (Fig. 6). The result of the testing operation depends upon whether the called line is busy or is idle.

A11*a*. *The called line is busy*

If the called line is busy, there is a ground potential on the sleeve conductor of the called line multiple, in which case test relay 1114 is unable to operate. Under this condition, when slow-restoring auxiliary relay 1116 restores, responsive to the restoration of relay 1115, busy relay 1111 operates in the following circuit: from ground on conductor 1130, through the back contact of the first upper armature of relay 1115, front contact of the second upper armature of units-transfer relay 1117, contacts of the restored auxiliary relay 1116, normally closed contacts of test relay 1114, back contact of the fourth upper armature of switching relay 1112, to battery through the winding of busy relay 1111. Upon operating, busy relay 1111 closes a self-locking circuit to conductor 1130 at the front contact of its first upper armature; disconnects ground potential from test relay 1114 at its second lower armature; opens the operate conductor 1137 at its second upper armature; and at its third upper armature, it connects the common busy-tone lead BT to the tip talking conductor through condenser 1134. A busy signal is thereby transmitted back to the calling line to inform the calling subscriber that the desired connection cannot be obtained for the time being.

A11*b*. *The called line is idle*

Assuming now that the desired line is idle when called, there is no ground potential on the sleeve conductor of the called line multiple LM–210, wherefore test relay 1114 operates in series with cutoff relay 604. The latter relay clears the called line for ringing and talking purposes.

Test relay 1114 opens a point in the above-traced operating circuit of busy relay 1111, and prepares a circuit for switching relay 1112.

Under the currently assumed condition, when auxiliary relay 1116 restores, relay 1112 operates. Upon so doing, it opens a still further point in the circuit of busy relay 1111 at the back contact of fourth upper armature, and at the front contact thereof it prepares a self-locking circuit which becomes effective upon the subsequent restoration of test relay 1114.

At its second upper armature, switching relay 1112 opens operating conductor 1137, and at its third upper armature, it applies ground potential to the sleeve conductor of the called line in shunt of the winding of relay 1114 to provide a more effective guarding circuit for the called line. When this occurs, relay 1114, being short-circuited, restores and completes the above noted locking circuit of switching relay 1112.

As a further result of its operation, switching relay 1112 operates its auxiliary relay 1113. At the front contacts of its first and second upper armatures, relay 1113 completes the talking circuit between the calling and called lines, while at its second lower armature it completes connection between ringing relay 1110 and the common ringing control conductor 1144, controlled by ringing interrupter 1145.

A12. *The ringing operation*

Since the called line has been called by a number containing the normal hundreds digit 2 (instead of the alternate hundreds digit 3), reversing relay 1109 is not in operated condition, and the ringing current, when applied, is applied over the tip conductor of the called line instead of over the ring conductor thereof.

Each time ringing relay 1110 operates, under the control of interrupter 1145, it opens the talking connection and transfers the called line to the ringing circuit. The tip conductor of the called line is transferred, through the back contact of the second upper armature of reversing relay 1109, and through the winding of trip relay 1108, to the common ringing lead, while the ring conductor of the called line is transferred to ground, through the back contact of the first upper armature of relay 1109.

Each time it restores, ringing relay 1110 opens the ringing circuit and recloses the talking circuit. During the restoring operation, ground potential is temporarily applied to the tip conductor of the called line and battery potential is temporarily applied to the ring conductor of the called line (through the resistors 1132 and 1133 respectively), by way of the momentarily closed make-

before-break contacts of relay 1110. By this operation, the respective potentials of the conductors of the called line are brought approximately to the potentials normally applied through the windings of relays 1106 and 1107 to the portion of the talking circuit between the talking condensers and the contacts of relay 1110, minimizing the tendency of the ringing operation to produce disagreeable clicks in the receiver on the calling line, which might otherwise occur from discharges of the condensers in the ringers on the called line.

The specific way in which the ringing operation is terminated depends upon whether the called subscriber answers during a silent interval or during a ringing interval. If the called subscriber responds during a silent interval, trip relay 1107 responds to terminate the ringing operation. On the other hand, if the called subscriber answers during a ringing interval, trip relay 1108, which is sufficiently retarded in its action that it does not respond to the flow of alternating current during a normal ringing operation, responds to the resulting flow of direct current because the ringing current on the common ringing lead is superimposed on the negative potential of the exchange battery. Upon the operation of either of the trip relays 1107 and 1108, busy relay 1111 responds and locks itself operated at the front contact of its third upper armature. The busy-tone circuit is not closed at this time because the back contact of the second upper armature of relay 1113 is now open. Ringing relay 1110 is open-circuited at the back contact of the second lower armature of busy relay 1111.

A13. *Answered supervision*

Talking current is supplied to the called line through the windings of trip relay 1107 and supervisory control relay 1106. When relay 1106 operates over the called line, it operates supervisory relay 1101 to reverse the connections between the windings of line relay 1103 and the tip and ring conductors of the link L1, thereby reversing the current flow over the calling line to give answered supervision. This answered supervision is not utilized in a call from a local P. B. X line, but is utilized in other calls made through the connector C1, as will hereinafter appear.

The called and calling subscribers may now converse as desired.

A14. *Disconnect supervision*

In case the called subscriber replaces his receiver first on the termination of the conversation, supervisory relay 1101 responds to the restoration of supervisory control relay 1106 to reverse the current flow in the calling line back to normal direction to give disconnect supervision in those calls which may require it.

A15. *Clearing out the connection*

When the calling subscriber replaces his receiver, line relay 1103 restores, followed by the restoration of release relay 1104. At its upper contacts, relay 1104 removes ground from the sleeve conductor S of the link L1, permitting the cutoff relay 704 of the calling line to restore and reconnect line relay 703. At the front contact of its first upper armature, release relay 1104 removes ground potential from conductor 1130 thereby unlocking and restoring relays 1111 to 1113, 1118 and 1119, A, 0, and T1-C. At the front contact of its lower armature, relay 1104 disconnects ground from hold conductor H and from conductor 1131, whereupon units-transfer relay 1117 is unlocked and restored, along with relays T1-F and U1-F of Fig. 9.

At the back contact of the lower armature of release relay 1104, battery potential through the associated resistor is reapplied to conductor H and consequently to test conductor 1034 to again mark the finder F1 as idle to the distributor DR (Fig. 10).

B. *Two-party operation*

As previously noted, the connectors are so arranged that any P. B. X subscriber line may be used as a two-party line with divided ringing by connecting the ringers at the two substations between opposite conductors of the line and ground. This arrangement includes reversing relay 1109 which, as hereinbefore described, is not operated when the normal hundreds digit 2 is dialed, permitting the ringing current to go out on the tip conductor of the called line. When the hundreds digit 3 is dialed, the reversing relay 1109 is thereby operated to cause the ringing current to be applied to the ring conductor of the called line instead of the tip conductor thereof.

Assuming, for example, that a call is being made to substation #310 on party line #210;310 (Fig. 7), upon the dialing of the hundreds digit 3, a circuit is prepared at the front contact of the second lower armature of counting relay 3, over the #3 conductor 1143 for reversing relay 1109. Relay 1109 is accordingly operated at the end of the hundreds digit, upon the restoration of relay 1114, in a circuit as previously traced to conductor H2, and thence over conductor 1142 to battery through the winding of relay 1109. Upon operating, relay 1109 connects the then grounded conductor 1142 to conductor 1141, to operate hundreds-transfer relay 1119 with the hereinbefore described results.

When relay 1119 closes a locking circuit for itself, at its first upper armature, it thereby locks ground potential on conductor 1141 to complete a locking circuit for reversing relay 1109, through the front contact of the lower armature thereof. Relay 1109 accordingly remains operated until the connection is cleared out. Consequently, when the ringing operation ensues, the ringing current passes from the common ringing lead, through the winding of trip relay 1108, and thence through the front contact of the first upper armature of relay 1109, and through the front contact of the third upper armature of ringing relay 1110, to the ring conductor of the called line. At the same time, the tip conductor of the called line is connected to ground through the front contact of the second upper armature of relay 1109 and the front contact of the fourth upper armature of relay 1110.

C. *Further operation of the distributor DR*

The operation of the distributor DR on calls succeeding the one described will now be discussed. It will be recalled that the #1 distributor relay 1011 was left locked operated through the front contact of its first upper armature, and through the normally closed contact chain controlled by the first upper armatures of distributor relays 1012 to 1023. Additionally, relay 1011 is holding stepping relay 1010 operated at the front contact of its first lower armature, and stepping relay 1010 is holding progress-control relay 1009 operated.

When start relay 1005 operates in response to

the next call, the resulting grounding of the lower armature of progress-control relay 1009 closes a locking circuit for the latter relay to hold it operated independenet of stepping relay 1010, thus marking the fact that the current distributor operation started with an odd-numbered distributor relay in operated condition.

With relays 1009 to 1011 in operated condition, the grounding of conductor 1043 by start relay 1005 results in the operation of the #2 distributor relay 1012 over the following circuit: from ground on conductor 1043, through contacts of relays 1006 and 1007, conductor 1044, front contacts of the operated relays 1009 and 1010, conductor 1045, front contact of the second upper armature of stepping relay 1010, even conductor 1047, front contact of the second upper armature of relay 1011, and through the winding of relay 1012 to battery. Upon operating, relay 1012 connects the common connect and test conductors 1048 and 1049 to the corresponding conductors extending to the #2 finder; it prepares a circuit at its second upper armature for the #3 distributor relay 1013; and at the front contact of its first upper armature, it closes a self-locking circuit through contacts of relays 1013 to 1023, at the same time open-circuiting and restoring the #1 distributor relay 1011.

Upon restoring, relay 1011 disconnects the connect and test conductors 1033 and 1034 of the first finder from common conductors 1048 and 1049; it disconnects the winding of the now-locked relay 1012 from even conductor 1047; and it open-circuits and restores stepping relay 1010.

At its upper armature, relay 1010 removes the normally applied shunt from around the upper winding of relay 1008 (relay 1009 being held locked operated as above pointed out). The operation of the #3 distributor relay 1013 is thereby temporarily delayed, and progress relay 1008 operates over the following circuit: from ground on conductor 1044, through the high-resistance upper winding of relay 1008, contacts of the latter relay, conductor 1045, back contact of the second upper armature of relay 1010, odd conductor 1046, contacts of relay 1012, and through the winding of relay 1013 to battery. Relay 1008 operates over the above-traced circuit, but relay 1013 cannot operate thereover because of the high resistance of the upper winding of relay 1008.

Upon operating, relay 1008 connects test relay 1007 to the common test conductor 1049 to enable the latter relay to operate to prevent operation of the #3 distributor relay 1013 in the event that the #2 finder is idle. Additionally, relay 1008 locks itself operated at its lower contacts, while at its first upper armature it by-passes the upper contacts of relays 1009 and 1010, at the same time open-circuiting its own upper winding to prevent it from being slow restoring.

If the #2 finder is idle, test relay 1007 operates to prevent further operations of the distributor relays and to cause seizure of the #2 finder.

On the other hand, if the #2 finder is busy, relay 1007 fails to operate at this time because of the absence of battery potential from the test conductor thereof. Under this condition, the #3 distributor relay 1013 operates over the above-traced circuit, from the high-resistance upper winding of relay 1008 and contacts of relays 1009 and 1010 have been excluded at the front contact of the first upper armature of relay 1008. Upon operating, relay 1013 connects up the test and connect conductors of the #3 finder at its second and third upper armatures; prepares a circuit for relay 1014 over even conductor 1047 at its second upper armature; locks itself to the locking chain and open-circuits and restores relay 1012 at its first upper armature and associated contacts; and at its lower armature, reoperates stepping relay 1010.

Stepping relay 1010 disconnects the grounded conductor 1045 from odd conductor 1046 and transfers it to even conductor 1047, thereby closing a circuit through contacts of relay 1013 for the #4 distributor relay 1014.

If the #3 finder is idle, test relay 1007 now operates before relay 1014 can operate. Otherwise, the operation of relay 1014 is permitted to occur and relay 1013 (and consequently stepping relay 1010) is thereby restored.

Operations as above described occur on the same or succeeding calls depending upon the busy or idle condition of the concerned finders.

When the progressive action of the distributor relays reaches relay 1023, and that relay operates to connect up the thirteenth finder, it locks itself to ground at the front contact of its first upper armature through contacts controlled by the first upper armature of the fourteenth distributor relay 1024. At the normally closed contacts controlled by relay 1023, ground potential is removed from the holding chain to release the immediately preceding distributor relay. Additionally, relay 1023, being an odd-numbered relay, reoperates stepping relay 1010 to apply ground potential to the even conductor 1047, thereby completing a circuit through contacts of relay 1023 for the #14 distributor relay 1024. If the #13 finder is busy at this time, test relay 1007 fails to operate, permitting relay 1024 to operate.

Upon the operation of relay 1024, the fourteenth finder F14 is connected up, and relay 1023 is open-circuited and restored. Relay 1024 locks itself operated at its lower contacts, through the lower contacts of the #1 distributor relay 1011.

Upon the restoration of relay 1023, stepping relay 1010 again restores. With relays 1010 to 1023 in restored condition, the operating circuit hereinbefore traced for the #1 distributor relay 1011 is again closed, resulting in the reoperation of relay 1011 at this time unless test relay 1007 operates to open-circuit relay 1011 as a result of the finder associated with relay 1024 being idle. In the latter case, relay 1007 open-circuits relay 1011 at its first upper armature before the latter relay can operate, and the operating circuit of relay 1011 is maintained open at the back contact of the upper armature of switching relay 1006 after relay 1007 has restored and until start relay 1005 restores.

When distributor relay 1011 is next operated (on the same or a succeeding call, depending upon the busy or idle condition of the finders), it performs the hereinbefore described results. Additionally, at the back contact of its lower armature, it open-circuits and restores the fourteenth distributor relay 1024.

From the foregoing, it will be seen that the distributor relays are capable of operation indefinitely in a cycle, the operation being wave-like with each newly operated relay unlocking and restoring the preceding one.

After the initial operation of the distributor first described, the one of the distributor relays

1011 to 1024 last used remains in operated condition until the next call is made, and is then invariably restored responsive to the operation of the next succeeding distributor relay, for the test relay 1007 cannot operate until connected up by progress relay 1008, and progress relay 1008 cannot operate before the next succeeding distributor relay has operated, for its upper winding is maintained short-circuited until that time by the joint action of progress-control and stepping relays 1009 and 1010 as previously described.

C1. *The clear-out timer*

As previously pointed out, the normal clearing out of the group relays GR of Fig. 9 and of the distributor DR of Fig. 10 occurs responsive to the restoration of the line relay on the calling line when disconnected by the cutoff relay, which latter operation occurs incident to the selected finder having completed its operation and the associated connector having been thereupon prepared for operation, to ground the sleeve conductor. The hereinbefore described clearing out operation of the group relays and distributors is initiated responsive to the ungrounding of the concerned one of the conductors 1—5 and 6—0 of any one of the mark cables M–1 to M–12.

There are two comparatively rare conditions in which the above-noted normal clearing out does not occur. First, if there is another call waiting in the same subgroup of five lines with the found calling line, the concerned subgroup mark conductor 1—5 or 6—0 remains grounded by the line relay of the unfound calling line, preventing the initiation of the clearing-out operation responsive to the restoration of the line relay of the found calling line.

Second, if for any reason the finder fails to operate completely, or one of the contact pairs through which the connection is required to be completed through the finder fails to close properly, or there is a defect in the link or in the associated connector, the operation of the finder fails to result in the operation of the sleeve relay of the calling line to disconnect and restore the line relay.

Under either of the above conditions, the clearing out of the group relays and of the distributor is initiated by the clear-out timer comprising relays 1002 to 1004. As previously noted, relays 1003 and 1004 are operated over conductor 1041 when start relay 1005 operates, but the timing operation is not started until switching relay 1006 operates to effect connection with a selected idle finder. At such time, the ground potential on conductor 1041 is extended to conductor 1042, as previously explained. This operation results directly in the placing of a shunt around the winding of relay 1004, resulting in the slow demagnetization of the magnetic structure of the relay. As a result, relay 1004 restores a short interval following the operation of relay 1006.

Upon restoring, relay 1004 places a shunt around the winding of relay 1003. As a result, relay 1003 restores shortly thereafter.

Normally, the finder operation is completed and the normal clearing out operation is initiated to clear out the group relays GR and restore start relay 1005 before the above noted restoration of the second clear-out timer relay 1003 occurs, and relay 1002 is not operated because conductors 1041 and 1042 become ungrounded as the result of the restoration of relay 1005.

When the normal clearing-out operation fails to occur, start relay 1005 remains operated until after relay 1003 has restored. Thereupon, the ground potential on conductor 1042 is extended, through contacts of relay 1003, to relay 1002. Relay 1002 thereupon operates and removes battery potential from chain-in conductor 1032, thereby restoring any operated ones of the group relays GR, Fig. 9. Upon the restoration of the operated one of the relays GC–1 to GC–12, ground potential is removed from start conductor 1031, permitting start relay 1005 to restore. When this occurs, the resulting ungrounding of conductors 1041 and 1042 permits relay 1002 to restore to again place battery potential on chain-in conductor 1032 to permit a new cycle of operations to occur. Because of the hereinbefore described progressive action of the distributor DR, the new cycle of operations results in another finder being taken for use.

C2. *All links busy*

When all of the finder-connector links are in use, ground potential is removed at all points from busy conductor 1035, permitting busy relay 1001 to restore. Upon restoring, relay 1001 disconnects the incoming start conductor 1031 from start relay 1005 to thereby avoid useless distributor operation during the busy condition.

At its back contact, the restored busy relay 1001 connects start conductor 1031 to the magnet winding of the meter M. The meter is accordingly operated to indicate the number of times start conductor 1031 becomes grounded while all links are busy.

D. *Calls through the additional contact sets*

The general method of handling calls through the additional contact sets of the connectors (contact sets 41 to 01 of Fig. 1) will now be explained.

The additional contact sets 41 to 01 for the connector C1 of Figs. 1 and 11 are shown in Fig. 11, part 2. They are the contact sets of the #4 to #0 relays 1121 to 1127 respectively.

It will be recalled that line and release relays 1103 and 1104 and dial-tone relay 1120 of the connector C1 are operated responsive to the link being taken for use as hereinbefore described. In what may be termed a normal call (one to a local P. B. X subscriber line), the first digit dialed into a connector is the hundreds digit 2 or the hundreds digit 3, as hereinbefore described. But, if connection is desired through one of the additional contact sets of the connector, the first digit dialed is any one of the digits from 4 to 0, depending upon the additional contact set through which connection is desired. Accordingly, one or the other of the counting relays 4 to 0 of Fig. 11, part 3, is operated as hereinbefore described in accordance with the number of impulses contained in the first digit dialed, and a circuit is prepared over the corresponding one of the conductors 4 to 0 in cable CA–1100. Then, when series relay 1115 restores at the end of the first digit, and thereby brings about the grounding of the hundreds conductors H1 and H2 as hereinbefore described, the prepared circuit is completed, through the contacts of the operated one of the counting relays 4 to 0, for the selected one of the relays 1121 to 1127.

Upon the operation of any one of the relays 1121 to 1127, the closure of the first lower contact pair thereof extends the operating ground of the relay, by way of conductor 1139, to the tens-

transfer relay 1118. Relay 1118 thereupon operates and locks itself to conductor 1138, thereby locking ground potential on conductor 1139 to hold the operated one of the relays 1121 to 1127.

At the front contact of the lower armature of relay 1118, the ground potential on conductor 1131 is extended to conductor 1140, and thence through contacts of the operated one of the relays 1121 to 1127 to conductor 1141, thereby operating hundreds-transfer relay 1119. Dial-tone relay 1120 is thereby restored to bring the transfer relays into the position they occupy in a normal call at the end of the tens digit. The counting chain (comprising relays A to C and 1 to 0) is cleared out by the operation of relay 1119 and the restoration of relay 1120, because of the consequent ungrounding of the counting-relay-locking conductor 1138.

In a call of the type under consideration, the initial digit (from 4 to 0) is followed invariably by the digit 1 assigned as the second and final digit of the number.

When the final digit 1 is dialed, the single impulse delivered over conductor 1137 does not reach the counting chain because conductor 1137 is open at the first upper contacts of the operated one of the relays 1121 to 1127. Series relay 1115 is operated over conductor 1137, however, and operates its auxiliary relay 1116. At its lower contacts, relay 1115 operates units-transfer relay 1117, through contacts of the operated tens-transfer relay 1118. Relay 1117 thereupon locks itself operated at its lower contacts, while at the front contact of its second upper armatures it prepares for operating either the switching relay 1112 or the busy relay 1111, under the control of test relay 1114, whose circuit is prepared at the front contact of the third upper armature of relay 1117.

The usual busy test, involving the sleeve conductor S connected up by the operated one of the relays 1121 to 1127, is made responsive to the restoration of series relay 1115, and one or another of the relays 1111 and 1112 is operated as hereinbefore described responsive to the restoration of auxiliary relay 1116.

On the class of call being considered, ringing current is prevented from being applied to the called terminals, because the common ringing interrupter lead 1144 is disconnected at contacts of the operated one of the relays 1121 to 1127.

The established connection is cleared out as previously described when the receiver is replaced on the calling line.

E. *Code calls*

When one of the P. B. X subscribers is away from his telephone, but is somewhere about the premises, he may be signalled through the operation of the code call equipment CCE of Figs. 1 and 11. This code-call equipment may be reached for calling purposes through contact set 71 of relay 1124 or through contact set 81 of relay 1125.

When the initial digit of either of the code-call numbers 71 and 81 is dialed, the corresponding one of the relays 1124 and 1125 is operated with results as hereinbefore described, including the connection up of the tip, ring, and sleeve conductors of the called one of the multiples 71 and 81. Units-transfer relay 1117 is operated as described responsive to the dialing of the final digit 1, and test relay 1114 is connected up upon the restoration of series relay 1115. If the code-call equipment CCE is idle at the time, there is a battery potential on the sleeve conductor of each of the sets 71 and 81, with the result that test relay 1114 is operated to open a point in the circuit of busy relay 1111 and to prepare a circuit for switching relay 1112. Accordingly, the restoration of auxiliary relay 1116 is followed by the operation of switching relay 1112 and its auxiliary relay 1113 to make connection with the tip and ring conductors of the called group (71 or 81, as the case may be) and to apply ground potential to the sleeve conductor thereof. As is clear from an inspection of the Wallace application hereinbefore referred to, the application of ground potential to the sleeve conductor of either set of incoming call conductors of the code-call equipment grounds the sleeve conductor of the other set for guarding purposes.

The relay in the code-call equipment CCE corresponding to relay 117 in the Wallace application is preferably connected between the tip conductor and ground instead of in a loop relation, whereby said relay 1117 is now operated in series with trip relay 1107 through the inner upper contacts of line relay 1103. Trip relay 1130 incidentally operates busy relay 1111, but without any particular effect at this time.

In the code-call equipment CCE, the operation of the above-mentioned relay 117 of the Wallace application prepares the equipment for responding to the final code digit to select the desired code to be sent out. Such digit is repeated at the inner upper contacts of line relay 1103.

When the called subscriber hears his code being signalled, over the code signal line CSL of Figs. 1 and 11, he may proceed to the nearest telephone substation and call the answer number 91. The relay in the link then seized corresponding to relay 1126 of the connector C1 is operated in response to the digit 9 to prepare a connection to the answer leads 91, which connection is closed responsive to the dialing of the final digit 1 in the answer number 91. The calling and called subscribers may thereupon converse, the talking circuit passing through the two finder-connector links, by way of code-call equipment CCE.

The call and answer code-call connections are cleared out in the usual manner when the calling and called subscribers replace their receivers.

F. *Local conference calls*

Local conference calls over the common conference line 41 in office A (Figs. 1 and 11) may be made by the dialing of the numeral 41 by each of the parties to the conference. Each conference party, upon removing his receiver, is connected, through a separate finder and link, to a separate connector such as C1 of Fig. 11.

When the first digit 4 of the conference number is dialed into the connector C1, relay 1121 is operated through contacts of counting relay 4 with results as previously described. The tip and ring conductors of the conference line 41 are thereby connected to the tip and ring conductors of the out link OL, and battery potential (through the illustrated resistor individual to the connector C1) is applied to the sleeve conductor S of the out link OL subject to the operation of the units-transfer relay 1117, which occurs as described when the final digit 1 of the conference number is dialed.

Since the multiple of the conference line does not contain a sleeve conductor, the conference number tests idle to all connectors calling it, for each connector has his own individual con-

ference sleeve resistor as above noted. The restoration of series relay 1114 following the final conference digit is accordingly invariably followed by the operation of test relay 1114 to prepare a circuit for switching relay 1112. This circuit is completed, and relays 1112 and 1113 operate, upon the restoration of auxiliary relay 1116, completing connection to the conference line 41. Since the conference line 41 is not bridged, relays 1106 and 1107 are not operated when connection is made thereto.

Each of the connections to the conference line is cleared out in the usual manner when the receiver is replaced at the calling substation.

G. *Office A to Office B*

The operations involved in making calls from Office A to Office B will now be described. For this purpose, it may be assumed that the subscriber at substation #211 (Figs. 1 and 6) desires to converse with the subscriber at substation #210' (Fig. 1) in Office B.

It may be assumed that operations as hereinbefore described occur to extend connection through the finder F1 of Fig. 1 to the connector C of Fig. 11 when the receiver is removed at substation #211 (Fig. 6). The connector C1 is accordingly prepared for operation as hereinbefore described.

To cause connection to be completed over an interoffice trunk line leading from Office A to Office B, the calling subscriber at substation #211 (Fig. 6) dials the Office-B number 61; waits for dial tone from Office B; and then calls the desired substation number (210 in the present example) assigned to the desired line in Office B.

G1. *Dialing the Office-B number, 61*

The dialing of the first digit 6 in the number assigned to Office B results in the operation of the #6 relay 1123 through contacts of counting relay 6, followed by the operation of transfer relays 1118 and 1119, the release of relay 1120, and the clearing out of the counting chain.

Upon the dialing of the succeeding digit 1, relays 1115 and 1116 respond, and units-transfer relay 1117 operates and locks.

The operations which now occur depend upon the busy or idle condition of the interoffice trunk lines. For example, if the first trunk line B–T1 of Figs. 1 and 7 is in use, guard relay 701 of the repeater R1 (Fig. 7) or release relay 703 is operated to maintain ground potential on the sleeve conductor S of the outgoing branch 821 of the trunk line. As a result, allotter relay AL–1 of Fig. 8 is in operated condition and all of the associated selecting chains are transferred to the next succeeding trunk line to prevent selection of the trunk line B–T1. Similarly, each of the other allotter relays AL–2 to AL–4 of Fig. 8 is operated or not depending upon the busy or idle condition of the respective associated interoffice trunk lines.

In the present example, it may be assumed that the trunk line B–T1 is idle, in which case sleeve conductor S of branch 821 is not grounded and allotter relay AL–1 is in a restored condition.

G2. *Seizing and operating switch B1*

Under the present assumed condition, when series relay 1115 restores following the operation of relays 1123 and 1117, it completes the following circuit: from ground through the back contact of the second lower armature of busy relay 1111, the winding of test relay 1114, contacts of relays 1115, 1117, and 1123, sleeve conductor S of link 61 (individual to the connector C1), chain contacts of relays B1–1 to B1–4 of the selective switch B1 of Fig. 8 (also individual to the connector C1), back contact of armature 1 of allotter relay AL–1, contacts controlled by the first lower armature of relay B1–1, and thence to battery through the winding of relay B1–1.

Selecting relay B1–1 and test relay 1114 operate over the above-traced circuit. Upon operating, relay B1–1 locks itself to the associated incoming sleeve conductor at the front contact of its first lower armature, at the same time disconnecting the associated allotter chain from the incoming sleeve conductor of switch B1 to preclude operation of any succeeding one of selecting relays B1–2 to B1–4 responsive to the changing position of the allotter relays AL–1 to AL–4.

G3. *Allotting next idle trunk line*

Additionally, relay B1–1 extends the incoming conductors (T, R, S, and C) of the switch B1 respectively to the corresponding conductors of the outgoing trunk line 821 leading to the repeater R1. When this occurs, the ground potential on the incoming sleeve conductor S is extended to the sleeve conductor S of the outgoing trunk 821, operating allotter relay AL–1 to denote the busy condition of the outgoing trunk line 821. Allotter relay AL–1, at its armatures 1 to 14, disconnects each of the chain circuits from the first-trunk relays B1–1 to B14–1 and extends them to the corresponding armatures of the next succeeding allotter relay AL–2. Accordingly, the next call incoming to the selecting switches of Fig. 8 is handled through an idle one of the other outgoing trunk lines 821 to 824 during the busy condition of the now-seized outgoing trunk line 821.

The tip, ring, sleeve, and control conductors T, R, S, and C of the out link OL of the connector C1 have been extended through contacts of the operated relay B1–1 of the selecting switch B1 (Fig. 8) to the trunk line 821 outgoing therefrom to the repeater R1.

When test relay 1114 operates over its previously traced circuit in series with relay B1–1, it prepares a circuit for switching relay 1112 which is closed when series auxiliary relay 1116 restores, whereupon relays 1112 and 1113 operate as above described. When this occurs, trip relay 1107 operates over the ring conductor R of the established connection in series with line relay 702 of the repeater R1.

G4. *Preparing seized repeater R1 for operation*

In the repeater R1, line relay 702 operates over the ring conductor of the connection, followed by the operation of slow-restoring release relay 703. At the front contact of its upper armature, release relay 703 places an additional ground potential on the sleeve conductor S of trunk line 821 to maintain this trunk line guarded (by maintaining allotter relay AL–1 operated) independent of the calling connector, until the repeater R1 clears out. At the front contact of its first upper armature, release relay 703 extends the incoming control conductor C, through the lower right-hand winding of repeating coil 700 to the associated outgoing branch of the ring conductor of the interoffice trunk line for a control purpose to be hereinafter explained.

At its lower armature, release relay 703 operates transfer relay 705. At the back contact of its first armature, relay 705 isolates guard relay 701 from the sleeve conductor S of the incoming

branch 708 of the trunk line B–T1. At its second and third armatures, transfer relay 705 disconnects the tip and ring conductors of the trunk line B–T1 from the corresponding conductors of the incoming branch 708 and transfers them to the outgoing tip and ring conductors of the repeater R1. The tip and ring conductors of the trunk line B–T1 are now bridged, which bridge may be traced from the tip conductor T through the front contact of the third armature of transfer relay 705, upper right-hand winding of repeating coil 709, windings of the polarized supervisory relay 704 shunted by resistor 707, upper contacts of line relay 702, lower right-hand winding of repeating coil 709, and through the front contact of the second armature of transfer relay 705 to the ring conductor R of the interoffice trung line.

G5. *Seizing an idle link in Office B*

In the exchange B (Fig. 1, part 3), the incoming branch of the trunk line B–T1 extends to the line circuit LC–124' whose line relay thereupon operates to indicate a calling condition. A link such as L1' is thereupon taken for use through the action of the finder F1', for example, controlled by group relays GR' and distributor DR'. The associated connector such as C1' is thereupon prepared for operation as hereinbefore described and the dial-tone signal is returned therefrom over the trunk line B–T1 to the calling line in office A by way of the connector C1 of Fig. 11.

Upon hearing the dial-tone signal from office B, the calling P. B. X subscriber in office A may now operate his calling device in accordance with the digits in the number of the desired line in Office B (2, 1, and 0 in the present example).

G6. *Repeating digit impulses to Office B*

Each time a digit is dialed, line relay 1103 of the connector C1 is restored momentarily a corresponding number of times. No resulting action takes place in the connector C1 at this time, because conductor 1137 is open at the contacts of relays 1111 and 1112. At its inner upper contacts, line relay 1103, on each momentary restoration, momentarily disconnects the winding of trip relay 1107 from the ring conductor extended through switch B1 of Fig. 8 to the repeater R1 of Fig. 7. As a result, line relay 702 of the repeater R1 is momentarily restored a corresponding number of times. Slow-restoring release relay 703 remains operated during the repeating of the digit impulses. At the upper contacts of line relay 702, the digit impulses are repeated over the interoffice trunk line to bring about the desired operation of the seized connector in office B (Fig. 1).

G7. *Answered supervision*

When the called subscriber in office B responds, the resulting reversal of current flow in its incoming conductors results in the reversal of current flow over the trunk line B–T1 and through the polarized supervisory relay 704. When this occurs, relay 704 operates to connect guard relay 701 to the tip conductor incoming to the repeater R by way of the upper left-hand winding of repeating coil 709. Thereupon, supervisory-control relay 1106 of the connector C1 operates in series with relay 701 to operate supervisory relay 1101.

G8. *Disconnect supervision*

In case the called subscriber is the first to replace his receiver, relays 704, 1106, and 1101 thereupon restore as a result of the reversal of current flow back to normal direction over the interoffice trunk line.

G9. *Clearing out*

When the receiver is replaced at the calling substation, line relay 1103 of the connector C1 restores, permitting line relay 702 of the repeater R1 to restore and repeat the disconnect condition over the trunk line to the connector in use in exchange B.

Responsive to the consequent restoration of release relay 1104 of the connector C1, the connector C1 clears out as previously described.

Responsive to the restoration of line relay 702 of the repeater R1, release relay 703 restores permitting transfer relay 705 to restore. Ground potential is removed from the sleeve conductor of the connection between the connector C1 and the repeater R1 as a result of the clearing out of the connector C1 or of the restoration of release relay 703 of the repeater R1, whichever occurs last. When this takes place, selecting relay B1–1 of selecting switch B1 restores, along with allotter relay AL–1.

The outgoing trunk line branch 821 extending from the switches of Fig. 8 to the repeater R1 is thereby again rendered selectable.

H. *Office B to Office A*

Referring first to Fig. 1, part 3, the way in which calls from Office B to Office A are handled will now be described more particularly.

Let it be assumed that the subscriber at substation #211', for example, in Office B desires to make a call to Office A. When the receiver is removed at the calling substation #211', the associated line circuit LC–211' operates as previously described for the line circuit LC–211 (Figs. 1 and 6) to impose a marked calling condition on the group relays GR' by way of the mark cable M–1'. Through the resulting action of the distributor DR', an idle finder is selected, the finder F1', for example. The finder F1' thereupon operates to make connection with the calling line whereupon the associated connector C1' is prepared for operation.

When the connector C1' is operated in response to the call number 01 assigned to Office A, the additional contacts 01 of the connector C1' are thereby closed. This operation is accomplished by a relay corresponding to relay 1127. Connection is thereby extended to the switch B1', whereupon this switch operates in the manner described for the switch B1 (Fig. 8) to extend connection to an idle one of the repeaters R1' to R4'.

It may be assumed that the repeater R1' is the one selected, in which case the Office-B end of the trunk line B–T1 is transferred from the incoming branch thereof to the outgoing branch in which the repeater R1' is located. The conductors of trunk line B–T1 are thereby bridged, closing a circuit through the back contacts of the second and third upper armatures of transfer relay 705 of the repeater R1, Fig. 7, and over the tip and ring conductors of the incoming Office-A branch 708, to line circuit LC–117, shown in Fig. 1.

Responsive to the operation of line circuit LC–117 (Fig. 1), an idle finder operates under the control of guard relays GR and distributor DR to extend the incoming branch 608 of the trunk line B–T1 to an idle connector, which is prepared for operation as previously described. When this occurs, and ground potential is returned on

the sleeve conductor of the line multiple associated with the line circuit LC–117, this ground potential is extended back over the sleeve conductor S of the incoming branch 708 (Fig. 7). Guard relay 701 of the repeater R1 is thereby operated, through the back contact of the first armature of transfer relay 705, and through resistor 706, to place ground potential on the sleeve conductor S of the outgoing branch 821 of the interoffice trunk line. Allotter relay AL–1 is thereby operated to denote the busy condition of the trunk line and prevent selection thereof by any one of the relays B1–1 to B14–1 of the selecting switches B1 to B14.

The calling subscriber in Office B now receives a dial-tone signal from the connector in use in Office A.

When the number of the desired line in Office A is then dialed the digits thereof are repeated by the repeater R1′ (Fig. 1) as hereinbefore described for the repeater R1 of Fig. 7, resulting in the connector in use in Office A being operated to complete the connection as previously described.

The established connection is cleared out as previously described when the calling subscriber in Office B replaces his receiver.

I. *Rotating the use of the interoffice trunk lines*

The switches B1 to B14 of Figs. 1 and 8 (and the same applies to the switches B1′ to B12′ of Fig. 1) are so arranged that the use of the interoffice trunk lines B–T1 to B–T4 is rotated and more or less equalized, as will now be pointed out.

As previously noted the allotter chain circuit associated with the switch B1 of Fig. 8 is so connected that the trunk line B–T1 (represented by the outgoing branch trunk 821) is first choice to the switch B1.

When outgoing trunk line 821 is busy, and trunk line 822 is idle, the latter trunk line is taken for use if the switch B1 is then seized over its incoming conductors 801. This is because armature 1 of relay AL–1 disconnects the associated #1 allotter conductor from the winding of relay B1–1 and transfers it, through armature 1 and its back contact of relay AL–2, to relay B1–2 associated with the second outgoing trunk line.

Similarly, if the first and second outgoing trunk lines are in use, the choice is shifted to the third trunk line through the operated armatures 1 of relays AL–1 and AL–2 and the unoperated armature 1 of relay AL–3.

Finally, if trunk lines 821 to 823 are in use, and trunk line 824 is idle, seizure of the switch B1 over conductors 801 results in the operation of relay B1–4 through armatures 1 of the operated allotter relays AL–1 to AL–3 and the back contact of armature 1 of relay AL–4.

The allotter conductor associated with the conductors 802 incoming from the connector C2 to the switch B2 of Fig. 8 is connected to an armature of the #2 allotter relay AL–2 instead of to an armature of the #1 allotter relay AL–1, whereby the outgoing trunk choice from the standpoint of the switch B2 is trunks 822 to 824 as the first three choices, and outgoing trunk 821 as the fourth choice.

The allotter conductor for the switch B3 (not shown), connects to an armature of relay AL–3, whereby the outgoing trunk choice from the standpoint of switch B3 (associated with connector C3) is trunk lines 823 and 824 as the first and second choices, and trunk lines 821 and 822 as the third and fourth choices.

It will be noted that the allotter conductor of the fourth switch B4 (not shown), associated with connector C4, is connected to an armature of the fourth allotter relay AL–4. As a result, the first choice outgoing trunk from the standpoint of switch A4 is trunk 824, while trunks 821 to 823 are the second, third, and fourth choices respectively.

The switches B5 to B8 may have choice connections similar to those above noted for switches B1 to B4, and the same is true for the switches B1 to B12. The allotting contacts on relays AL–1 to AL–4 for switches B5 to B12 have been omitted to conserve drawing room.

It is to be noted that the first-choice outgoing trunk line for the switch B13 (not shown) is the trunk line 821 in that the corresponding allotter conductor is connected to armature 13 of relay AL–1. The allotter conductor for switch B14 is connected to armature 14 of allotter relay AL–2, giving the same trunk choice for the switches B13 and B14 as above noted for the switches B1 and B2.

J. *All interoffice trunk lines busy*

When all of the interoffice trunk lines B–T1 to B–T4 are in use, ground potential is maintained on the sleeve conductor S of each of the corresponding branches 821 to 824 accessible to the switches B1 to B14 (Fig. 8). Under this condition, all of the allotter relays AL–1 to AL–4 are in operated condition. All of the incoming sleeve conductors of the incoming lines 801 to 814 are disconnected in this case from all of the relays B1–1 to B14–4. None of these selecting relays can, therefore, be operated as a result of the seizure of any one of the switches B1 to B14. Under this condition, if one of the switches B1 to B14 is seized, by the dialing of the Office-B number 61 into the corresponding connector, the test relay thereof (relay 1114 of the connector C1) fails to operate, resulting in the operation of busy relay 1111 to deny the connection and return a busy-tone signal to the calling line.

K. *Office A to the public exchange*

The handling of calls from P. B. X subscriber lines of Office A to the public exchange will now be described. For this purpose, it may be assumed that the subscriber at substation #211 (Fig. 6) desires to converse with a subscriber of the public exchange. For this purpose, he removes his receiver; waits for dial tone; and then dials the public exchange number 51.

It may be assumed that the link L1 is idle at this time and that the finder F1 thereof (Fig. 9) is operated as previously described to extend connection to the connector C1 of Fig. 11 which is thereupon prepared for operation.

K1. *Dialing the public-exchange number, 51*

As a result of the dialing of the first digit 5 in the public exchange number, relay 1122 operates followed by the previously described operation of transfer relays 1118 and 1119 and the restoration of dial-tone relay 1120.

As a result of the dialing of the final digit 1 in the public-exchange number, relays 1115 and 1116 are operated successively, and units-transfer relay 1117 operates and locks.

K2. *Seizing switch A1*

Upon the restoration of series relay 1115, test relay 1114 is operated over the sleeve conductor of trunk line 51 extending individually from the connector C1 to the selecting switch A1 of Fig. 4. The operating circuit of test relay 1114 includes contacts of relays 1115, 1117, 1122, the sleeve conductor S of link 51, contacts controlled by the first upper armature of switching relay 401, and the winding of start relay 402. With relay 1114 of the connector C1 operated, the restoration of auxiliary relay 1116 results in the operation of switching relay 1112 and its auxiliary relay 1113 as previously described.

K3. *Trunk selection at switch A1*

In the switch A1 of Fig. 4, start relay 402 operates over the incoming sleeve lead. At the front contact of its second lower armature, it applies ground potential to conductor 411 to energize the contact chain extending through the contacts controlled by the first lower armatures of relays 406 to 404. At the front contact of its first lower armature, start relay 402 completes a circuit over the above noted contact chain for the first selecting relay 404. Relay 404 thereupon operates and locks itself to the chain circuit independent of the contacts of the start relay. At the front contacts of its fourth, third, and second upper armatures, relay 404 makes connection with the tip, ring, and sleeve conductors of the first trunk line 229 accessible to the switch A1, being the outgoing branch of the public exchange trunk line A–T1.

At the front contact of its first upper armature, relay 404 connects operating conductor 413 with the second selecting relay 405, thereby closing the following operating circuit: from ground through the front contact of the upper armature of start relay 402, the winding of the marginal test relay 403, conductor 412, back contact of the first upper armature of switching relay 401, back contact of the upper armature of test relay 403, operating conductor 413, front contact of the first upper armature of relay 404, to battery through the winding of relay 405.

The operation which now occurs depends upon whether the public-exchange trunk line A-T1, having outgoing branch 229, is busy or idle. If it is busy, there is no battery potential on the sleeve conductor thereof, whereby the marginally adjusted test relay 403 does not receive sufficient current (in series with relay 405) to operate the test relay. In this event, connecting relay 405 operates over the above circuit with results to be later described.

K4. *Seizing public-exchange trunk line A–T1*

In the present example, it may be assumed that the first public-exchange trunk line is idle, in which case marginal test relay 403 receives sufficient additional current over the outgoing sleeve conductor thereof to bring about its operation before the second selecting relay 405 can operate. The circuit path over which relay 403 receives the additional current is as follows: from ground, through the front contact of the upper armature of start relay 402, through the winding of relay 403, conductor 412, back contact of the second upper armature of relay 404, the sleeve conductor S of outgoing branch trunk line 229, and thence to battery through the busy lamp 526 in the attendant's cabinet 500.

Relay 403 operates over the above-traced circuit, and busy lamp 226 becomes lighted to inform the P. B. X attendant of the busy condition of the trunk line.

At its upper contacts, relay 403 disconnects conductor 413 to prevent the next succeeding selecting relay 405 from operating. At its lower contacts, relay 403 connects the grounded conductor 411 to switching relay 401, whereupon the latter relay operates.

At its lower contacts, relay 401 makes an additional application of ground potential to conductor 411; at its first upper armature, it locks itself to the incoming sleeve conductor, at the same time disconnecting start relay 402, which restores shortly thereafter. At its second upper armature, relay 401 disconnects conductor 412 from the operating conductor 413 at an additional point and connects it to ground to provide a more direct circuit for busy lamp 226. The incoming tip and ring conductors are now extended, through contacts of relays 401 and 404, to the corresponding conductors in trunk line branch 229, leading to the public exchange A–T1 by way of the repeating coil 208 of the trunk circuit TC1.

K5. *Answered supervision*

Line relay 209 of the trunk circuit TC1 is now operated in series with trip relay 1107 of the connector C1 over the ring conductor of the connection established through the switch A1. At the same time, supervisory control relay 1106 of the connector is operated over the tip conductor of the connection in series with retard coil 208 to bring about the operation of supervisory relay 1101.

K6. *Preparing trunk circuit TC1 for outgoing operation*

In trunk circuit TC1, release relay 207 responds to the above-noted operation of line relay 209. At its upper contacts, it applies an additional ground connection to the associated sleeve conductor to maintain busy lamp 226 lighted until the trunk circuit is cleared out. At its inner contacts, release relay 207 operates trunk-transfer relay 206.

Upon operating, trunk-transfer relay 206 disconnects the local terminals of the left-hand windings of repeating coil 208 from relays 201 and 203, and transfers them to the loop resistor 261, closed at the upper contacts of line relay 209. The conductors of trunk line A–T1 are thereby looped, or bridged, under the control of line relay 209, causing line relay 254 in the public exchange to operate through contacts of cutoff relay 253.

K7. *Indicating the call in the public exchange*

The operation of line relay 254 in the public exchange indicates an originated call in any desired manner. The public exchange may be a manual exchange, in which case the line relay 254 may light a line lamp. On the other hand, the public exchange may be an automatic exchange, in which case line relay 254 may make the usual marking connections to cause an idle finder to set itself on the terminals of switchboard multiple 252.

K8. *Dialing the public exchange number*

If the public exchange is an automatic exchange, the usual dial-tone signal is now returned to indicate to the calling P. B. X subscriber that he may dial the digits in the desired public-exchange number. In this event, the dialed digits

are repeated at the upper contacts of line relay 1103 of the connector C1 to line relay 209 of the trunk circuit TC1. They are thence repeated, at the upper contacts of line relay 209, to the switching equipment in the public exchange.

K9. *Monitoring the outgoing call*

If the attendant whose equipment is shown in Fig. 5 desires to monitor the outgoing call (the busy condition of the trunk line being indicated by the previously noted lighted condition of the busy lamp 226), she may do so by actuating the key K1 to trunk position with the receiver 505 at the attendant's telephone AT removed from the stand to permit the hookswitch contacts 507 to be closed, bridging the attendant's talking conductors 225.

Trunk relay 218 responds to the operation of the key K1 to trunk position. At the front contacts of its fourth and fifth upper armatures, relay 218 connects the trunk line conductors 223 with the branch talking conductors 224, joined to the main talking conductors 225 through condensers 231. The attendant is thus unable to listen to any conversation occurring over the trunk line A–T1.

At the front contacts of its second and third lower armatures, relay 218 extends the operator's conductors 225, through the back contact of the first and second upper armatures of local-transfer relay 210, to the windings of retard coil 211, to provide the attendant's telephone with talking current in enabling the attendant to talk over the connection now being monitored. The negative pole of the exchange battery is connected to the lower winding of retard coil 211, while the grounded pole of the exchange battery is connected to the upper winding of retard coil 211, the ground-supply connection being from ground through the back contact of the armature of signal relay 203, conductor 225, lower contacts of hold relay 217 (operated at the inner upper contacts of relay 218), and the front contact of the lower armature of the operated trunk transfer relay 206.

When the operator restores the trunk key K1 to normal position, trunk relay 218 is thereby restored, followed by the restoration of relay 217. Hold relay 217 does not hold operated at this time because its holding circuit is open at the front contact of the third upper armature of the unoperated local transfer relay 210.

K10. *Clearing out the outgoing connection*

When the receiver is replaced at the calling P. B. X substation, the connection through the finder F1 of Fig. 9 and the connector C1 of Fig. 11 is cleared out as previously described. The resulting removal of ground potential from the sleeve conductor S incoming to the switch A1 of Fig. 4 unlocks and restores the operated switching relay 401 to free the outgoing branch 229 of the public exchange trunk. The removal of ground potential from conductor 411 by relay 401 unlocks and restores selecting relay 404, returning the switch A1 to its illustrated normal position.

In the trunk circuit TC1, line relay 209 restores responsive to the restoration of the line relay of the connector C1 when the receiver is replaced at the calling substation. At its upper contacts, line relay 209 unbridges resistor 261 from the trunk line conductors to initiate the clearing out operation in the public exchange. At the same time, line relay 209 open-circuits slow-restoring release relay 207. When release relay 207 restores, it permits trunk transfer relay 206 to restore, completing the clearing out of the trunk circuit TC1. The busy lamp 226 is extinguished responsive to the removal of ground potential from the sleeve conductor of outgoing branch 229 at the upper contacts of release relay 207, or upon the clearing out of the selecting switch A1, whichever occurs last.

L. *Further operation of selecting switch A1*

Referring again to the selecting switch A1 of Fig. 4, it will be recalled that the previous description of the operation of this switch was made on the assumption that the first trunk line accessible thereto was idle, in which case the selecting operation was terminated by test relay 403, with selecting relay 404 operated, and before selecting relay 405 could operate. Let it be assumed now that the outgoing branch trunk line 229 is busy when the switch A1 is taken for use as previously described; that the usual fuse provided in the battery supply lead (not shown) to the trunk circuit TC1 is open; or that the busy lamp 226 is burned out. Under any of these conditions, when start relay 402 and selecting relay 404 operate as pointed out, the marginally adjusted test relay 403 is unable to operate because of the comparatively small amount of current it receives in the operating circuit of any one of the relays such as 404 to 406. The circuit previously traced for relay 405 accordingly remains established permitting selecting relay 405 to operate. At its lower armature, relay 405 locks itself to conductor 411 by way of contacts of the succeeding selecting relays, at the same time unlocking and restoring relay 404. A test connection is now made with the second outgoing trunk line. At the same time, operating conductor 413 is extended, through contacts of the restored relay 404, and through contacts of the operated relay 405, to the third selecting relay (not shown).

If the second trunk line accessible to the switch A1 is in selectable condition, test relay 403 operates over the sleeve conductor thereof and in circuit with the busy lamp corresponding to lamp 526. The circuit of the third selecting relay is thereby opened at the upper contacts of test relay 403 before such selecting relay can operate. Relay 405 accordingly remains operated and locked, and connection is completed to the second trunk line upon the ensuing operation of switching relay 401, responsive to the closure of the lower contacts of test relay 403.

If the preceding trunk lines are all either busy or otherwise unavailable when the switch A1 is seized, the successive operation of the selecting relays occurs until the final (sixth) selecting relay 406 operates. At this point, the operation depends upon whether or not the sixth outgoing trunk line is idle and in normal condition. If it is, test relay 403 operates to cause switching relay 401 to respond in the usual manner to lock itself and restore start relay 402. On the other hand, if the final trunk line is in use, or is defective as above noted, test relay 403 fails to operate as a result of the operation of selecting relay 406. Under this condition, switching relay 401 remains unoperated and start relay 420 remains operated. Under this condition, a busy-tone connection extends, from the common busy-tone lead 407, through contacts of the operated relays 406 and 402 to the incoming ring conductor R of link 51, and thence back through the established connec-

tion to the calling line to inform the calling subscriber of the all-trunks-busy condition.

As is indicated by the note of the drawing adjacent the switch A1 "Slipped multiple," referring to the indicated multiple of the outgoing trunks to the switches A2 to A14 (Fig. 1), the trunk multiple accessible to the switches A1 to A14 is slipped between successive switches to give each succeeding switch an order of choice to the outgoing trunks different from that of the preceding switch, for purposes noted hereinbefore.

M. *Calls incoming from the public exchange*

The way in which calls incoming from the public exchange are handled will now be described. For this purpose, it may be assumed that the trunk line A–T1 is taken for use in the public exchange by way of switchboard multiple 252. Cutoff relay 253 is thereupon operated over the sleeve conductor of this multiple to clear the tip and ring conductors.

M1. *Guarding the trunk line in the branch exchange*

It is to be noted that the tip and ring conductors are reversed between the line circuit comprising relays 253 and 254 and the switchboard multiple 252. Accordingly, ground potential (supplied through a cord circuit if the public exchange is manual, and supplied through the usual back bridge of the calling connector if the public exchange is automatic) instead of battery potential is applied to the ring conductor of the trunk line A–T1, and battery potential is applied to the tip conductor of the trunk line instead of the ground potential normally applied through the upper contacts of cutoff relay 253. Accordingly, the ground-connected high-resistance guard relay 201 in the trunk circuit TC1 is operated over the tip conductor of the trunk line A–T1, but any supervisory relay which may be connected to such conductor (in the calling cord circuit or connector) is not operated because of the high resistance of relay 201. Upon operating, relay 201 operates the slow-releasing guard relay 202. At its upper contacts, guard relay 202 applies ground potential to the associated local sleeve conductor to light busy lamp 526 to inform the P. B. X attendant of the busy condition of the trunk line, and to mark the trunk line busy to the selecting switches, such as A1 of Fig. 4.

At its lower contacts, guard relay 202 prepares a holding circuit for the slow-restoring signal relay 204.

M2. *Signalling the branch-exchange attendant*

The usual intermittent ringing operation may now take place. The arrangement of the guard relays 201 and 202 and of the signal relays 203 to 205 is such that the local guarding circuit for busy lamp 526 is maintained continuously closed independent of any specific arrangement of the public-exchange ringing circuit. For example, when the ringing circuit is closed, guard relay 201 may restore, but guard relay 202 is slow-restoring to maintain the associated sleeve conductor grounded until signal relay 204 has operated.

When the ringing current is applied, signal relay 203 is operated through the left-hand windings of repeating coil 206, the back contact of relay 206, and condenser 221. Relay 203 is preferably arranged to follow the ringing current in a buzzer-like action. The first time it responds, relay 203 operates relay 204. Relay 204 makes an additional ground connection to the associated sleeve conductor at its upper contacts, and at its lower contacts it prepares a circuit for relay 205. Being slow-restoring, relay 204 remains operated throughout the application of ringing current. Each time it restores, relay 203 operates relay 205 through contacts of relay 204. Relay 205, being a quick-acting relay, accordingly follows the buzzer-like action of relay 203. The line lamp 527 is accordingly flickeringly lighted during the ringing operation, through the back contact of the armature of the relay 203 and the front contact of the lower armature of relay 205.

When the first application of ringing current is terminated, relay 203 comes to rest in a restored condition and relay 205 comes to rest in an operated condition, slow-restoring relay 204 remaining operated for an interval.

If relays 201 and 202 have restored during the ringing operation (depending upon the specific ringing arrangement employed in the public exchange), they are now reoperated before relay 204 can restore. At the lower contacts of relay 202, a holding circuit is closed for relay 204 which includes the inner contacts of the operated relay 205 and the back contact of the armature of relay 203. The line lamp 527 is now lighted steadily, through the back contact of relay 203 and the lower contacts of relay 205.

If the attendant does not respond until the next application of ringing current occurs, the line lamp 527 is again caused to flicker throughout the next succeeding application of ringing current and again becomes steadily lighted at the termination thereof.

The foregoing action of the line lamp enables the attendant to answer the call during a silent interval, avoiding the disagreeable ringing noise which might otherwise be produced in her receiver 505 if she answered during a ringing period.

M3. *Answering the call*

To answer the call indicated by the lighted condition of line lamp 527, the attendant, with the hookswitch contacts 507 closed at the attendant's telephone AT, throws the key K1 to trunk position, operating trunk and hold relays 216 and 217 successively. At its inner lower contacts, relay 217 lights supervisory lamp 528, through contacts of supervisory relay 214.

A talking connection is made between conductors 223 and 224 through the front contacts of the fourth and fifth upper armatures of relay 218. At the same time, conductors 225 are extended, through the front contacts of the second and third upper armatures of relay 218, to local conductors 222, now connected through back contacts of local transfer relay 210 to the windings of retard coil 211. No current flows in the operator's telephone circuit as a result of such connection at this time because the ground supply to the upper winding of retard coil 211 is now open at the front contact of the lower armature of the unoperated trunk transfer relay 206.

M4. *Preparing trunk circuit TC1 for incoming operation*

At the front contact of its lower armature, hold relay 217 extends the grounded conductor 226 through the back contact of the lower armature of trunk transfer relay 206 to the winding of local transfer relay 210. Relay 210 thereupon operates and locks itself independent of the back contact of the lower armature of relay 206. At its third upper armature, local transfer relay 210 prepares a holding circuit for the upper

winding of hold relay 217, while at its first and second upper armatures it disconnects the attendant's battery-supply leads 222 from the windings of retard coil 211 and transfers them to retard coil 208 and line relay 209, whereby the attendant's telephone AT is provided with a source of transmitter current.

M5. *Answered supervision*

Line relay 209 now operates from the attendant's telephone line 225, followed by the operation of release relay 207 and trunk transfer relay 206. At its first and second upper armatures, relay 206 disconnects the local terminals of the left-hand windings of repeating coil 200 from relays 201 and 203 and connects them to the bridging resistor 261, by way of the upper contacts of line relay 209. The flow of direct current which now takes place over the trunk line A–T1 and through the resistor 261 terminates the ringing operation in the public exchange in the usual manner and gives answered supervision.

Guard relay 201 now restores, followed shortly thereafter by the restoration of relay 202. At its lower contacts, relay 202 open-circuits signal relay 204. Signal relay 204 restores shortly thereafter, followed by the restoration of relay 205. Line lamp 527 is disconnected and extinguished at the lower contacts of relay 205. The local sleeve conductor is now maintained guarded at the contacts of release and hold relays 207 and 217, maintaining busy lamp 526 lighted.

As a further result of the operation of local transfer relay 210, the fourth and fifth upper armatures thereof disconnect the local terminals of the right-hand windings of repeating coil 200 from retard coil 208 and line relay 209 and transfer them to the closed local bridge including polarized supervisory relay 212, preparatory to extending the incoming call.

The attendant may now converse with the calling public-exchange subscriber and ascertain the purpose and destination of the call.

M6. *Clearing out without extending the call*

Assuming that the call can be handled satisfactorily by the attendant without extension to a P. B. X subscriber line, the attendant may clear out the trunk circuit TC1 at the end of the conversation by depressing the hookswitch 507 at her telephone AT, while the key K1 remains thrown to trunk position. When this occurs, line relay 209, being open-circuited, restores. Disconnect supervision is given to the main exchange by the opening of the upper contacts of line relay 209. The restoration of relay 209 is followed successively by the restoration of relays 208 and 206. Relay 210 remains operated under the control of hold relay 217, held in turn by relay 218.

When the trunk key K1 is then restored, relays 218 and 217 restore successively (trunk transfer relay 206 having restored to open the holding circuit of relay 217 at its inner upper contacts). Lamp 528 is extinguished by relay 217. Local transfer relay 210 restores responsive to the opening of the lower contacts of relay 217, completing the clearing out of the trunk circuit TC1.

In the event that the connection to the trunk line A–T1 in the public exchange is not yet cleared out, the above-described restoration of trunk transfer relay 206 is followed by the reoperation of guard relays 201 and 202. Guard relay 202 maintains the busy lamp 526 lighted and the outgoing branch 229 of the trunk line marked busy.

When the connection is cleared out in the public exchange, cutoff relay 253 restores, reconnecting line relay 254. The high-resistance guard relay 201 thereupon restores, followed by the restoration of guard relay 202 to extinguish the busy lamp 526, and again render the trunk line accessible to the selecting switches such as A1 of Fig. 4.

M7. *Extending the incoming call*

Let it be assumed now that the P. B. X attendant discovers that the incoming call received as above described requires to be extended to one or another of the subscriber lines of the P. B. X. Under this condition, the attendant, without opening the hookswitch contacts 507, transfers the key K1 from trunk position to local position.

M8. *Maintaining locked condition of answered supervision*

When the key K1 is moved from trunk position, relay 218 restores. Relay 217 remains locked operated in the following circuit with line relay 209: from ground, through the winding of line relay 209, front contact of the first upper armature of local transfer relay 210, to the ring conductor of pair 222, and thence through the normally closed contacts controlled by the second upper armature of relay 218, upper winding of hold relay 217, contacts of the operated relays 206 and 210, upper contacts of clear-out relay 215, upper contacts of hold relay 217, and contacts controlled by the third upper armature of relay 218, to the tip conductor of pair 222, and thence through the front contact of the second upper armature of local transfer relay 210, to battery through the winding of retard coil 208. The locked condition of answered supervision to the public exchange is thus maintained by the holding of line relay 209 in circuit with the upper winding of hold relay 217, and supervisory lamp 528 remains lighted by ground potential supplied thereto through the front contact of the first lower armature of hold relay 217 and the back contact of the third lower armature of supervisory relay 214.

Relays 206, 207, 209, 210, and 217 are now in operated condition.

M9. *Seizing an idle local link*

When the key K1 is moved to local position, ground potential from the circuit of supervisory lamp 528 is thereby extended to local relay 220, operating such relay. Relay 220 operates connecting relay 219, through contacts of the restored relay 218, and the front contact of the first lower armature of hold relay 217. Connecting relay 219 locks itself operated under the control of relays 218 and 217. By the closing of the front contacts of its first and second upper armatures, connecting relay 219 prepares for the connecting together of sections 223 and 230 of the incoming public-exchange trunk line A–T1 after the section 230 has been extended.

As a further result of the operation of local relay 220, the tip and ring conductors 225, bridged at the attendant's telephone AT through contacts 507 and through contacts 508 of the calling device CD, are extended respectively to the tip and ring conductors 230 leading to line circuit LC–120 (Fig. 4). By the resulting operation of line relay 421, the group control relays GR of Fig. 9 and the distributor DR of Fig. 10 are oper-

ated as previously described to cause an idle finder (the finder F1, for example) to operate to extend the calling line multiple LM–120 of Fig. 4 to an idle connector. Such idle connector, the connector C1 (Fig. 11) in the assumed example, is thereupon prepared for operation as described, whereupon cutoff relay 422 operates; line relay 421 restores; and the impressed dial-tone signal is heard in the receiver 505 of the attendant's telephone AT.

M10. *Dialing the extension number*

The attendant may now operate her calling device 508 in accordance with the digits required to extend the connection to the desired P. B. X subscriber line, which may be a line of either office A or office B. Each time the calling device CD is moved from its normal position, off-normal contacts 509 shunt the receiver R to avoid clicking and shunt the transmitter 506 to improve the dialing circuit.

The circuit at the attendant's telephone may be of the usual three-conductor type as illustrated, employing the induction coil 504, having the illustrated condenser in circuit with the lower winding thereof.

As the calling device CD returns to its normal position, the selected number of circuit interruptions is produced at the contacts 508.

Having dialed the desired local number, the attendant may either wait for the local subscriber to answer and then give him any special information which she may have concerning the call, or she may restore the key K1 immediately upon the completion of dialing.

M11. *Holding the extended connection*

If the key K1 is restored as soon as the operator has completed dialing, relay 220 thereupon restores, but connecting relay 219 remains locked operated. At its first and second armatures and associated contacts, relay 220 transfers the incoming branch 230 from the attendant's talking conductors 225, and extends them, through contacts of the operated connecting relay 219, to conductors 223. With local transfer relay 210 in operated condition, there is a holding bridge across conductors 223, through the right-hand repeating coil windings, the front contacts of the fourth and fifth upper armatures of relay 210 and the windings of polarized supervisory relay 212. The extended connection is held by the resulting current flow through polarized supervisory relay 212, relay 212 remaining in normal position at this time.

M12. *Monitoring unanswered extended calls*

So long as the extended call remains unanswered, such fact is indicated to the attendant by the continued lighted condition of supervisory lamp 528. If the attendant desires to monitor the call during the unanswered condition, she may again actuate the key K1 to trunk position, causing trunk relay 218 to operate again.

With supervisory relay 213 not in operated condition, connecting relay 219 now restores, or not, depending upon whether the dotted conductor 260 is absent or is present.

If conductor 260 is absent, relay 219 restores responsive to the opening of the lower contacts of relay 218, clearing out the unanswered extended connection without requiring any special act for that purpose on the part of the attendant. But, if conductor 260 is present, relay 219 remains locked operated thereover, through the back contact of the lower armature of the unoperated clear-out relay 215.

If the dotted conductor 260 is present so as to hold connecting relay 219 operated, and the attendant is requested by the calling public-exchange subscriber to extend the connection to another local line in an attempt to reach a P. B. X subscriber with whom conversation is desired, the operator moves the key K1 from trunk position to local position, restoring relay 218 and operating relay 220. With relay 220 reoperated, the extended connection is again held over conductors 225, and may be cleared out by the attendant by the act of temporarily opening hookswitch contacts 507. When the hookswitch contacts 507 are again closed, another idle local link is seized over extension conductors 230 enabling the operator to make the desired new extension of the incoming call.

M13. *Local answered supervision*

When the extended incoming call is answered, the resulting operation of supervisory relay 1101 of the connector C1 reverses the current flow over the extended connection causing supervisory relay 212 to operate. The operation of relay 212 is followed by the operation of relays 213 and 214 in succession. At the back contact of its third lower armature, relay 214 disconnects supervisory lamp 528 to give the attendant answered supervision. At the front contact of its first lower armature, relay 214 prepares a circuit for recall relay 216, while at the front contact of its second lower armature it operates clear-out relay 215 preparatory to clearing out the established connection when the local subscriber replaces his receiver. At the front contact of its lower armature, clear-out relay 215 locks itself operated through the lower contacts of trunk relay 218, to ground through the front contact of the first lower armature of hold relay 217.

At its upper contacts, relay 215 opens a point in the holding circuit of the upper winding of relay 217 and line relay 209, but this latter operation is of no effect at this time because the holding circuit has been closed through a more direct path, at the front contact of the upper armature of supervisory relay 214.

M14. *Monitoring answered incoming calls*

The attendant may monitor answered incoming calls by actuating key K1 to trunk position, thereby operating relay 218. The locking circuit of connecting relay 219 is not disturbed at this time, for the lower contacts of relay 218 are shunted at the lower contacts of supervisory relay 213.

Relay 218 again transfers the holding circuit (over conductors 222) for line relay 209 to the attendant's talking conductors 225, whereby the attendant's telephone is provided with transmitter current. The attendant may, therefore, bring about the restoration of line relay 209 along with release and trunk transfer relays 207 and 206, by depressing the hookswitch 507 while the key K1 is in trunk position. The attendant, however, is unable to unlock hold relay 217 to clear out the connection by this operation. If the attendant restores the key K1 while the hookswitch contacts 507 are depressed and relays 209, 207, and 206 are restored, hold relay 217 becomes relocked through its upper winding in series with line relay 209 (notwithstanding that its normal locking circuit is then open at the front contact of the first upper armature of relay 206), because of the substitute holding circuit closed at the front con-

tact of the first upper armature of the operated supervisory relay 214.

The attendant while unable to release the incoming, extended, and answered public-exchange call, may nevertheless signal the public exchange operator by depressing the hookswitch 507 temporarily while the key K1 is in trunk position. This causes line relay 209 to be restored and reoperated to open and close the supervisory bridge including resistor 261.

When the attendant restores the key K1, relay 218 transfers local conductors 222 back to the locking circuit of the upper winding of relay 217 through the closed upper contacts of the operated relay 214.

The attendant likewise may not interfere with the extended and answered local connection, as by operating call-in relay 220 to split the connection. If the attendant attempts to do this (by throwing the key K1 to local position after the P. B. X subscriber has answered), relay 220 fails to operate because its operating current is obtained in parallel with the supervisory lamp 528, which has been extinguished by the back contact of the third lower armature of supervisory relay 214.

M15. *Recalling the attendant*

Recall relay 216 enables a P. B. X subscriber to which a public-exchange call has been extended to recall the attendant, as when the call is to be transferred to some other P. B. X line. To do this, the called P. B. X subscriber operates his calling device in accordance with the digit 1, thereby causing supervisory-control relay 1106 of the connector C1 to restore momentarily. Supervisory relay 1101 of the connector is thereby momentarily restored to momentarily reverse the current flow in its incoming conductors to normal direction. When this occurs, the polarized supervisory relay 212 restores momentarily and then reoperates. Supervisory relay 213 may be momentarily restored by this operation but supervisory relay 214 remains operated.

Upon the momentary restoration of relay 212 to its normal position, recall relay 216 is operated through the front contact of the first lower armature of the operated supervisory relay 214. Relay 216 locks itself operated at its inner contacts, through the inner lower contacts of trunk relay 218, in parallel with the winding of the operated clear-out relay 215.

At its lower contacts, relay 216 closes a lighting circuit, through the lower contacts of relay 214, for line lamp 527, whereby lamp 527 becomes lighted as a recall signal.

Upon observing the lighted condition of line lamp 527, the attendant may actuate the key K1 to trunk position to bring about the actuation of trunk relay 218. The attendant's secondary talking conductors 224 are thereby connected to the talking circuit at conductors 223, and conductors 225 are supplied with transmitter current by way of conductors 222. At its inner lower contacts, relay 218 unlocks and restores recall relay 216 to extinguish line lamp 527.

The attendant may now converse with the called P. B. X subscriber, who may give such directions as he sees fit about transferring the incoming call to another line.

The originally called P. B. X subscriber is expected to thereupon replace his receiver to permit the local extension of the incoming connection to be cleared out.

When the receiver is replaced at the called P. B. X substation, the consequent restoration of relays 1106 and 1101 permits supervisory relay 212 in the trunk circuit TC1 to restore to normal position. Recall relay 216 is thereby temporarily reoperated, but it does not now lock, because relay 218 is in operated condition. Relays 213 to 215 restore successively responsive to the restoration of relay 212, as the locking circuit of clear-out relay 215 is held open at the lower contacts of relay 218. Supervisory lamp 528 is relighted at the back contact of the third lower armature of the restored supervisory relay 214, while the normal holding circuit of the upper winding of relay 217 is reprepared at the upper contacts of the restored clear-out relay 215.

With relay 218 in operated condition, the restoration of supervisory relay 213 opens the locking circuit of connecting relay 219, permitting the latter relay to restore and disconnect conductors 230 from conductors 223, thereby clearing out the extended connection.

As soon as the supervisory lamp 528 becomes relighted to indicate that the local subscriber has replaced his receiver, the attendant may throw the key K1 from trunk position to local position thereby restoring relay 218 and operating relay 220 in parallel with the supervisory lamp 528. Upon the restoration of relay 218, the circuit of the lower winding of hold relay 217 is opened, but the upper winding of this relay is again locked operated over conductors 222 through contacts of relays 206, 210, 215, and 217.

With relay 218 again restored, connecting relay 219 is operated through the lower contacts of local relay 220 to prepare for rejoining conductors 223 and 230 upon the restoration of local relay 220.

Conductors 225 and 230 are again joined at the contacts of relays 220 to permit the attendant to extend the incoming connection to any other local line, which extension may be effected as previously described. Relay 220 then restores, when key K1 is restored, leaving relay 219 locked operated.

M16. *Normal clear-out of extended calls*

When the extended incoming call is answered, relays 212 to 215 operate as described. Under this condition, when the called P. B. X subscriber replaces his receiver, relay 212 is thereby restored. Relay 216 is temporarily operated under this condition, but without any particular result other than momentarily lighting line lamp 527. Relay 213 restores, followed shortly by the restoration of relay 214. Relay 215 remains locked operated for the time being through the front contact of its first lower armature, back contact of the second lower armature of relay 218 and the inner lower contacts of relay 217.

With relay 215 operated, the normal holding circuit of the upper winding of hold relay 217 is open at the upper contacts thereof. Then, when relay 214 restores as noted, and opens the substitute holding circuit of such upper winding, relay 217 restores, unlocking and restoring relay 215. Recall relay 216 is thereby unlocked and restored. Connecting relay 219 restores responsive to the opening of the inner lower contacts of relay 217, and local transfer relay 210 restores responsive to the opening of the lower contacts of relay 217.

The unlocking of the upper winding of relay 217 results in the restoration of line relay 209 followed by the successive restoration of relays 207 and 206.

Busy lamp 526 is extinguished and the outgoing branch 229 of the public-exchange trunk line is unguarded responsive to the restoration of release relay 207. However, if the connection has not been taken down in the public exchange, the previously noted illustrated reversal in the tip and ring conductors between line multiple 252 and the line circuit in the public exchange results in guard relay 201 operating responsive to the restoration of trunk transfer relay 206 to reoperate guard relay 202. The latter relay reapplies ground potential to the sleeve conductor to guard the trunk line in the P. B. X and to light busy lamp 526, until the connection is cleared out in the public exchange, whereupon relays 201 and 202 restore.

N. *Attendant's calls*

Calls incoming to and outgoing from the attendant's position will now be described. Calls incoming to the attendant will be considered first.

N1. *Attendant's incoming calls*

P. B. X subscribers may call the attendant by dialing the attendant's number 01 into any of the connectors in office A. For example, if the connector C1 is seized in a call from a P. B. X subscriber of either office, the dialing of the initial digit 0 operates counting relay 0 (Fig. 11, part 3), with the result that the #0 relay 1127 is operated responsive to the ensuing restoration of series relay 1115. Connection is made with the tip, ring, and sleeve conductors of the associated individual line 01 upon the subsequent dialing of the final digit 1 in the attendant's number, whereupon the individual switch S1, indicated in Fig. 1, is now operated as described in connection with the similar switch A1 of Figs. 1 and 4 to select and seize an idle trunk. It may be assumed that trunk 515 (Figs. 1 and 5) is idle and is the one seized by the selecting switch S1. With trunk circuit ATC–1 in idle condition, battery potential is supplied to sleeve conductor S of the incoming link 515, by way of line lamp 510 and the lower contacts of release relay 514, to denote such idle condition.

When the trunk circuit ATC–1 is seized, supervisory relay 513 is operated over the ring conductor in series with trip relay 1107 of the connector C1. Upon operating, relay 513 operates release relay 514 and the latter relay closes a circuit for line lamp 510, through the back contact of the lower armature of line relay 511. Ringing tone from the common ringing-tone lead RT is sent back over the established connection, through the upper contacts of relays 511 and 513 to simultate a normal ringing operation.

When the operator notes the lighted condition of line lamp 510, she actuates the answer key K11 with the hookswitch contacts 507 closed. When this occurs, line relay 511 operates over conductors 225 and closes an additional circuit for release relay 514, at the same time extinguishing line lamp 510. The ringing-tone circuit is opened at the upper contacts of relay 511. At the inner upper contacts of relay 511, retard coil 512 is connected up, whereupon supervisory-control relay 1106 of the connector operates to cause supervisory relay 1101 to operate for any desired purpose.

The attendant may now converse as desired with the calling P. B. X subscriber.

Assuming that the P. B. X subscriber replaces his receiver and causes the portion of the connection between the connector C1 of Fig. 11 and the trunk circuit ATC–1 of Fig. 5 to clear out before the operator restores her answer key K11, release relay 514 remains operated through contacts of the operated line relay 511 and the line lamp 511 is relighted, through the back contact of the lower armature of relay 513 and the front contact of the armature of release relay 514, as a disconnect signal.

When the operator restores the key K11, line relay 511 restores, followed by the restoration of release relay 514 to return the trunk circuit ATC–1 to its illustrated normal condition, the line lamp 510 being thereby extinguished.

N2. *Attendant's outgoing calls*

In case the attendant desires to call a P. B. X number, she may do so over the attendant's call line ACL (Figs. 1 and 5), by actuating the call key K7, with contacts 507 closed. This operation results in the bridging of the conductors of the line ACL to operate line relay 423 of the line circuit LC–122. The operation of this relay causes the associated line multiple to be extended by finder operation to an idle connector, whereupon cutoff relay 424 operates to clear the calling line at the line circuit.

The attendant now hears the usual dial-tone signal indicating that she may dial the digits in the desired number in the usual manner, using the calling device CD.

In the event that the attendant must attend to other duties while the connection over her call line ACL is established, she may hold that connection, through resistor 501, by actuating hold key K8. The attendant may then free her common talking conductors 225 by restoring the call key K7. Later, the attendant may again connect with the line ACL by actuating the key K7, followed by the restoration of key K8.

The connection set up over line ACL is cleared out in the usual manner when the operator restores the call key K7 without having actuated the hold key K8.

O. *Delayed calls*

Delayed calls between a public-exchange line and a P. B. X subscriber line may be set up by the attendant. Such a delayed call may be set up either because a public-exchange subscriber (unable to obtain connection with a desired P. B. X subscriber) requests the attendant to call him back when the line is available, or because a P. B. X subscriber (unable to obtain a desired connection for the time being through the public exchange) calls the attendant and requests her to call him when she is able to reach the public-exchange subscriber.

To set up a delayed-call connection, over the trunk line A–T1 for example, the attendant first actuates the key K1 to trunk position, at a time when the trunk circuit TC1 is idle. When this occurs, relays 218 and 217 operate as previously described. The local outgoing branch of the trunk line is guarded, and busy lamp 526 is lighted, responsive to the closure of the inner upper contacts of relay 217. Local transfer relay 210 is operated through the lower contacts of trunk transfer relay 206 and locks operated. Line relay 209 now operates over conductors 222 and the operator's conductors 225, and operates relays 207 and 206. A calling condition is imposed on the trunk line A–T1 by the bridging of resistor 261 across the conductors thereof, through contacts of relays 209 and 206.

Assuming that the public exchange is an auto-

matic exchange, the attendant may now dial the digits in the desired number by the usual operation of the calling device CD, the resulting impulse being repeated to the main exchange at the upper contacts of line relay 209.

When the public-exchange subscriber answers, the attendant may inform him of the call and request him to wait while she connects with the P. B. X subscriber.

The attendant may thereupon transfer the key K1 from trunk position to local position. Relay 218 is thereby restored, but relay 217 is held locked over conductors 222 in circuit with line relay 209 as previously described.

Relay 220 operates responsive to the actuation of the key K1 to local position, followed by the operation and locking of connecting relay 219.

The operator may now dial the number of the local subscriber; wait until he answers; and then restore the key K1 to permit local relay 220 to restore to complete the connection. The local subscriber having answered, the restoration of relay 220 results in the previously described operation of supervisory relays 212 to 214 and clear-out relay 215.

The established connection is cleared out as previously described responsive to the restoration of supervisory relay 212, which occurs when the called P. B. X subscriber replaces his receiver.

P. *Barring restricted-line calls*

The arrangement for barring calls attempted from restricted lines to the public exchange will now be explained more fully. The restricted lines include the incoming branches in Office A of the interoffice trunk lines, together with any other lines which may be connected to the eleventh level of the finders in Office A. This arrangement restricts all lines of Office B, preventing the Office-B subscribers from calling the public exchange. This arrangement is based on the assumption that the principal officers, and employees in supervisory positions, in establishments using the illustrated private branch exchange are those served by Office A.

Additionally, in the illustrated example, the subscriber lines connected to the tenth level of the connectors and finders are barred from making calls to the public exchange.

In the finder-connector link including the finder F1 of Fig. 9 and connector C1 of Fig. 11, the barring arrangement includes the conductors RS1 and RS2 of the link L1 as previously noted. These conductors are adapted to be joined by the contacts of the tenth-level finder relay T0–F when the finder F1 handles the call from the tenth level, and also by the eleventh-level relay T11–F when the finder is handling a call from the eleventh level, serving the trunk lines incoming from Office B.

The barring arrangement is duplicated in each of the other finder-connector links in Office A.

Let it be assumed now that the finder F1 is operated in response to a call from either the tenth level or the eleventh level, in which case one or the other of the relays T0–F and T11–F operates pursuant to the making of the connection between the calling line and the connector C1. The conductors RS1 and RS2 of the link L1 are thereby joined. If the present calling subscriber dials the initial digit 5 in the public-exchange number 51, and thereby operates relay 1122, a circuit is immediately closed for busy relay 1111 as follows: from ground, through the front contact of the second upper armature of release relay 1104, conductor RS1, contacts of the operated one of the relays T0–F and T11–F, conductor RS2, inner lower contacts of relay 1122, to battery through the winding of busy relay 1111. Upon operating, busy relay 1111 effectively bars further operation pursuant to the setting up of the connection by disconnecting the counting-relay operating conductor 1137 at the back contact of its second upper armature. At the front contact of its upper armature, relay 1111 connects the busy-tone lead BT to the talking connection to give the calling subscriber a busy signal.

The partially established connection is cleared out in the usual manner when the calling subscriber replaces his receiver.

Q. *Offering incoming calls to busy lines*

The arrangement for enabling the attendant to override a returned busy signal and make special connection with a called busy line to verify the busy condition thereof (as distinct from an out-of-order condition) and to offer to complete an incoming connection thereto will now be described.

Q1. *Offering calls to Office-A lines*

Assume that an incoming call has been received by the attendant over trunk line A–T1 and the trunk circuit TC1 of Figs. 2 and 3, and has been extended by way of line circuit LC–120 (Fig. 4), finder F1 (Fig. 9), connector C1 (Fig. 11), and line circuit LC–211 (Fig. 6), to P. B. X line #211 at a time when such line is busy. Completion of the connection is denied at the connector C1 of Fig. 11 as previously described, busy relay 1111 becoming operated, with relays 1112 and 1113 unoperated.

If offer key K14 is now operated, with key K1 in local position and local relay 220 operated, ground potential is thereby placed directly on the ring conductor of the connection established from the trunk circuit TC1 by way of the finder F1 of Fig. 9 to the connector C1 of Fig. 11, thereby unbalancing the normally balanced current flow through the two windings of the differential detector relay 1102. Relay 1102 operates, closing a circuit, through the front contact of the first lower armature of busy relay 1111, and the back contact of the first lower armature of relay 1113 for offer relay 1105. At the front contact of its lower armature, relay 1105 completes a circuit for switching relay 1112 in parallel with its own winding.

Switching relay 1112 now operates, as does its auxiliary relay 1113, placing the connector C1 in the circuit condition normally existing when an idle line is called and seized and the call has been answered, except that offer relay 1105 is now operated, and is held locked operated in parallel with the winding of now-locked switching relay 1112.

The attendant may now restore offer key K14, thereby restoring the normal balanced condition to the associated talking conductors, whereupon detector relay 1102 restores, leaving offer relay 1105 locked operated at its lower contacts. Relay 1105 maintains relays 1106 and 1107 disconnected to prevent interference.

The attendant may now converse with the subscriber on the busy called line and inform him of the incoming public-exchange call, following which the attendant may clear out the extended connection through the finder F1 and the connector C1 in the usual manner by opening hook-

switch contacts 507 at the attendant's telephone AT.

If the subscriber on the busy called line has agreed to accept the incoming call, and the parties to the concerned conversation have replaced their receivers to permit the connection involving the busy line to be cleared out, the attendant may re-extend the incoming call to the desired called line and make connection therewith in the usual manner.

With the key K1 still in local position, the attendant makes the desired new extension by merely releasing the hookswitch contacts 507 to their illustrated closed position; waiting for dial tone from the newly seized finder-connector link; and redialing the number by the use of the calling device CD.

Q2. *Offering calls to Office-B lines*

Assume that a call incoming over trunk line A–T1 to the trunk circuit TC1 of Fig. 3 has been extended by way of the connector C1 of Fig. 11, switch B1 of Fig. 8, repeater R1 of Fig. 7, and the interoffice trunk line B–T1, to a busy called line of Office B. If, with the key K1 in local position, the attendant then depresses the offer key K14, detector relay 1102 of the connector C1 is thereby operated as previously described. Under this condition, offer relay 1105 of the connector C1 is not operated because relay 1113 is in operated condition. Instead, relay 1102 extends ground potential over conductor C of the connection, as follows: from ground, through contacts of detector relay 1102, contacts of relay 1111 (relay 1111 has been operated by trip relay 1107, operated over the ring conductor of the connection established with the repeater R1, Fig. 7), front contact of the first lower armature of auxiliary relay 1113, conductor C of the out link OL, contacts of relay 1123, conductor C in the link extending to the switch B1 (Fig. 7), through contacts of the operated relay B1–1, conductor C of group 821, contacts of the operated release relay 703 of the repeater R1, lower right-hand winding of repeating coil 700, and the front contact of the second upper armature of transfer relay 705, to the ring conductor R of the interoffice trunk line B T1. The current flow over the interoffice trunk line is thereby unbalanced, to operate the detector relay (similar to relay 1102) in the connector in use in Office B. The offer relay thereof (corresponding to relay 1105) is thereby operated to bring about the operation of the associated switching and auxiliary relays (corresponding to relays 1112 and 1113). The offering connection is thereby made to the busy called line as hereinbefore described.

R. *Extending the Office–A conference line*

The attendant may extend the conference line CL in office A to include one or more additional parties to a conference established thereover. For this purpose, the office-A conference line CL, shown at 41 in Fig. 11, part 2 (multipled to the front contacts of the third and fourth upper armatures of the #4 relays, such as 1121, in all of the Office-A connectors) is extended to the attendant's equipment, as shown in Fig. 5. It is inductively coupled by condensers 503 with the holding section thereof, across which retard coil 502 is bridged.

The attendant may be called over one of the trunk circuits such as ATC–1 of Fig. 5 and informed of any desired extension of the Office-A conference line. To make such an extension, the attendant actuates the key K9 to call position, with hookswitch contacts 507 closed. By this operation, the attendant's telephone AT is connected with her conference-call line CCL, leading to line circuit LC–121 (Fig. 4). Through the usual operation of this line circuit, one or another of the finder-connector links in Office A is taken for use. Over such link the attendant may dial the number of any line terminating in either office of the P. B. X. This operation includes the dialing of the public-exchange number, whereby the attendant may extend the conference-call line CCL by way of the trunk circuit TC1 and the trunk line A–T1, for example, to the public exchange to include any desired public-exchange line in the conference.

After the attendant has extended the conference-call line CCL as desired, she may actuate the hold key K10 and restore the key K9. The conference-call line CCL, with its extension, is thereby transferred into talking connection with the Office-A conference line by way of condensers 503. The extended connection is held by the current flow over the conference line CCL through retard coil 502.

The attendant may monitor the extended conference connection by actuating the key K9 to listen position from time to time.

To clear out the connection extended over the line CCL, the attendant restores keys K9 and K10.

R1. *Interoffice conference connections*

When requested to do so, the attendant may extend the conference-call line CCL, through an idle one of the finder-connector links in office A, and through the corresponding one of the selecting switches B1 to B14 of Fig. 8, and thence, by way of an idle repeater such as R1, over an interoffice trunk line such as B–T1, to an idle finder-connector link in Office B, and then (after receiving dial tone from Office B) dial the conference number 41 in Office B. The attendant's conference-call line CCL of Fig. 5 is thereby extended to the conference line CL' (Fig. 1), and remains connected therewith so long as the attendant leaves the extended connection established. By then actuating the hold key K10, the attendant may telephonically connect the conference line CCL (and consequently the called conference line CL', Fig. 1, of exchange B) with the conference line CL of Office A.

The desired interoffice conference connection may now be completed by the act of the concerned P. B. X subscribers of the two offices calling their respective conference lines CL and CL', by dialing the conference number 41.

Upon listening in, by the key K9 in listen position, and learning that the conference has ended, the operator may restore the keys K9 and K10, causing the extension over CCL of the Office-A conference line CL to be cleared out.

I claim:

1. In a telephone system, a connector having contacts sets arranged in ten groups of ten through which it can make connection with any called one of one hundred lines responsive to the transmissions of a tens digit and a units digit thereto, said connector having additional sets of contacts through which it can make connection with any line of an additional group, means in said connector responsive to the transmission of a hundreds digit thereto and depending on the value thereof for determining whether connection is to be made to one of said hundred lines

or to one of said additional lines, and means responsive to the receipt of a hundreds digit determining that connection is to be made with one of said additional lines for determining which such line.

2. In a telephone system, a connector having contact sets arranged in ten groups of ten through which it can make connection with any called one of one hundred lines responsive to the transmissions of a tens digit and a units digit thereto, said connector having additional sets of contacts through which it can make connection with any line of an additional group, means in said connector responsive to the transmission of a hundreds digit thereto and depending on the value thereof for determining whether connection is to be made to one of said hundred lines or to one of said additional lines, said connector requiring the transmission of three digits thereto to complete connection to any one of said one hundred lines, and requiring but two digits to make connection to any line of said additional group.

3. In a telephone system, a group of finders interlinked respectively with a group of connectors, each of said finders and connectors having regular contact sets, line multiples connected respectively to the regular contact sets of each finder and connector, additional incoming line multiples, each finder having additional contact sets to which the last named line multiples are respectively connected, such line multiples being not accessible to the connectors, and additional outgoing line multiples, each connector having additional contact sets to which the last-named line multiples are respectively connected, such line multiples being not accessible to the finders.

4. In a telephone system, a group of finders interlinked respectively with a group of connectors, each of said finders and connectors having regular contact sets, lines multiply connected to said contact sets and accessible therethrough to each finder and connector, each of said finders and connectors having additional contact sets, lines multipled to the additional contact sets of the finders but not to the connectors, other lines multipled to certain of the additional contact sets of the connectors but not to the finders, and still other lines connected individually to the connectors through other of the additional contact sets thereof.

5. In a telephone system, a group of finders interlinked respectively with a group of connectors, a first group of lines accessible in common to all the finders and connectors, a second group of lines accessible in common to all the finders but not to any of the connectors, and a third group of lines individually accessible to said connectors respectively.

6. In a telephone system, a group of connectors, lines accessible in common to said connectors, other lines individually accessible to said connectors respectively, selecting switches terminating said other lines respectively, and trunk lines accessible in common to said selecting switches.

7. In a selecting switch having an incoming path and a plurality of outgoing paths, each outgoing path including a test conductor, connecting relays corresponding respectively to said outgoing paths, means controlled over said incoming path for operating said connecting relays successively, and means responsive to current flow over the test conductor of the first idle one of said outgoing paths, through contacts closed by the operation of the corresponding connecting relay, for stopping said successive operation and for making connection between the incoming path and the last-named outgoing path.

8. In a selecting switch as set forth in claim 7, means responsive to the operation of the final connecting relay when all of the outgoing paths are in use for impressing a busy signal on the incoming path.

9. In combination, a group of selecting switches each having an individual incoming path, a group of outgoing paths accessible in common to all said switches, each switch including selecting relays corresponding respectively to said outgoing paths, an allotter common to said switches and controlled in accordance with the busy or idle condition of said outgoing paths to allot an idle outgoing path to each idle one of said switches, and means controlled over the path incoming to any idle one of said switches for operating the selecting relay thereof corresponding to the idle outgoing path then allotted to such switch to seize such allotted path.

10. In combination, a selecting switch having an incoming path and a plurality of outgoing paths, said switch comprising connecting relays corresponding respectively to said outgoing paths, any such relay serving, when operated, to connect the incoming path to the corresponding outgoing path, said incoming path including a conductor for operating any one of said relays, allotter relays corresponding respectively to said outgoing paths, means for controlling said allotter relays, each according to the busy or idle condition of the corresponding outgoing paths, and means including contacts of said allotter relays for normally maintaining said operating conductor extended to one of said connecting relays whose corresponding outgoing path is idle, so long as any outgoing path is idle.

11. In combination, a group of selecting switches having each an incoming path and having outgoing paths in common, each switch comprising connecting relays corresponding respectively to said outgoing paths, any such relay serving, when operated, to connect the associated incoming path to the corresponding outgoing path, the incoming path of each switch including a conductor for operating any connecting relay of such switch, allotter relays corresponding respectively to said outgoing paths, means for separately controlling said allotter relays according to the busy or idle condition of the respective outgoing paths, said allotter relays having separate contact chains thereon associated respectively with said switches, each such contact chain including contacts of all said allotter relays and serving to maintain the operating conductor of the associated switch extended individually to a connecting relay thereof corresponding to an idle outgoing path, provided any outgoing path is idle.

12. In combination, a group of selecting switches having each an incoming path and having outgoing paths in common, each switch comprising connecting relays corresponding respectively to said outgoing paths, any such relay serving, when operated, to connect the associated incoming path to the corresponding outgoing path, the incoming path of each switch including a conductor for operating any connecting relay of such switch, allotter relays corresponding respectively to said outgoing paths, means for separately controlling said allotter relays according to the busy or idle condition of the respective outgaing paths, said allotter relays hav-

ing separate contact chains thereon associated respectively with said switches, each such contact chain including contacts of all said allotter relays and serving to maintain the operating conductor of the associated switch extended individually to a connecting relay thereof corresponding to an idle outgoing path, said operating conductors being connected to non-corresponding points in the contact chains to provide a distributed order of choice of outgoing paths.

13. In a telephone system, lines, line finders having common access thereto, a distributor for distributing calls to said finders, said distributor including distributor relays operable successively in an endless chain responsive to a calling condition on any one of said lines, each finder having a test lead, a test relay in said distributor operable over the test lead of an idle finder through contacts of the last operated distributor relay to terminate the successive operation of the distributor relays, the last-named finder thereupon operating to make connection with the calling line and terminate the calling condition thereof.

14. In a telephone system, lines, line finders having common access thereto, a distributor for distributing calls to said finders, said distributor including distributor relays operable successively in an endless chain responsive to a calling condition on any one of said lines, each finder having a test lead, a test relay in said distributor operable over the test lead of an idle finder through contacts of the last operated distributor relay to terminate the successive operation of the distributor relays, the last-named finder thereupon operating to make connection with the calling line and terminate the calling condition thereof, means in said distributor for maintaining operated the last-operated distributor relay until the next call is made, means for maintaining said test relay disabled upon and following any new calling condition of any of said lines while permitting resumption of said successive operation of the distributor relays, and means responsive to the operation of the next succeeding distributor relay for terminating the disabled condition of said test relay.

15. In a telephone system, lines, line finders having common access thereto, a distributor for distributing calls to said finders, said distributor including distributor relays operable successively responsive to a calling condition on any one of said lines, each finder having a test lead, a test relay in said distributor controlled over the test lead of an idle finder through contacts of the last operated distributor relay to terminate the successive operation of the distributor relays, the last-named finder thereupon operating to make connection with the calling line and terminate the calling condition thereof, a timer and means for starting it responsive to the operation of said test relay, and means controlled by said timer for clearing out said distributor at the end of a predetermined interval provided the operation of the last-named finder has not resulted in the termination of the calling condition of said calling line.

16. In an automatic telephone system, a link comprising an answer switch and a call switch linked together, groups of lines accessible to the answer switch, means responsive to a call originated on any of said lines for operating said answer switch to associate itself with the group containing the calling line and to make connection with the calling line in such group, groups of lines accessible to said call switch, said call switch being thereafter controllable over the calling line and through the answer switch to extend the connection to a called line accessible to the call switch, said call switch completing the connection by associating itself with the group containing the called line and causing connection to be completed to a line of such group, and means in said link for barring completion of extension of an attempted connection dependent upon the identity of the group with which the answer switch is then associated and upon the identity of the group with which the call switch is then associated.

17. In an automatic telephone exchange system, a first office and a second office interconnected by trunk lines, conference lines in said offices respectively, switching means including automatic switching apparatus in each office for enabling conference connections to be established between the conference line therein and a plurality of subscriber lines thereof, and means effective when desired and including automatic switching apparatus in both offices for joining said conference lines telephonically by way of one of said trunk lines to permit an interoffice conference to be held over the joined conference lines.

18. In a telephone system including a main exchange and an attended branch exchange, a conference line in said branch exchange having a number assigned thereto, means enabling talking connections to be set up between said conference line and each of several subscriber lines of said branch exchange, and means including switching equipment controlled by the attendant at such exchange for extending said conference line to any desired line of either the branch exchange or the main exchange.

19. In a telephone system including a public main exchange and a private branch exchange, two-way lines interconnecting said exchanges, trunk circuits in the branch exchange terminating said lines respectively, each such trunk circuit including a hold relay, attendant's common equipment in the private branch exchange; means enabling the attendant to associate such equipment temporarily with any one of said trunk circuits pursuant to answering calls incoming from, and pursuant to initiating calls outgoing to, the main exchange; means responsive to such association with respect to any trunk circuit for operating and locking the hold relay thereof; when operated and locked, such hold relay serving after such temporary association is terminated to maintain answered supervision in the main exchange on calls incoming therefrom and to maintain a calling condition in the main exchange over the associated line on calls to the main exchange; and a release device included in said common equipment and effective to unlock and restore said hold relay when the release device is actuated during a said temporary association and maintained actuated to the end thereof.

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