Sept. 23, 1947. P. BAKKER 2,427,650

MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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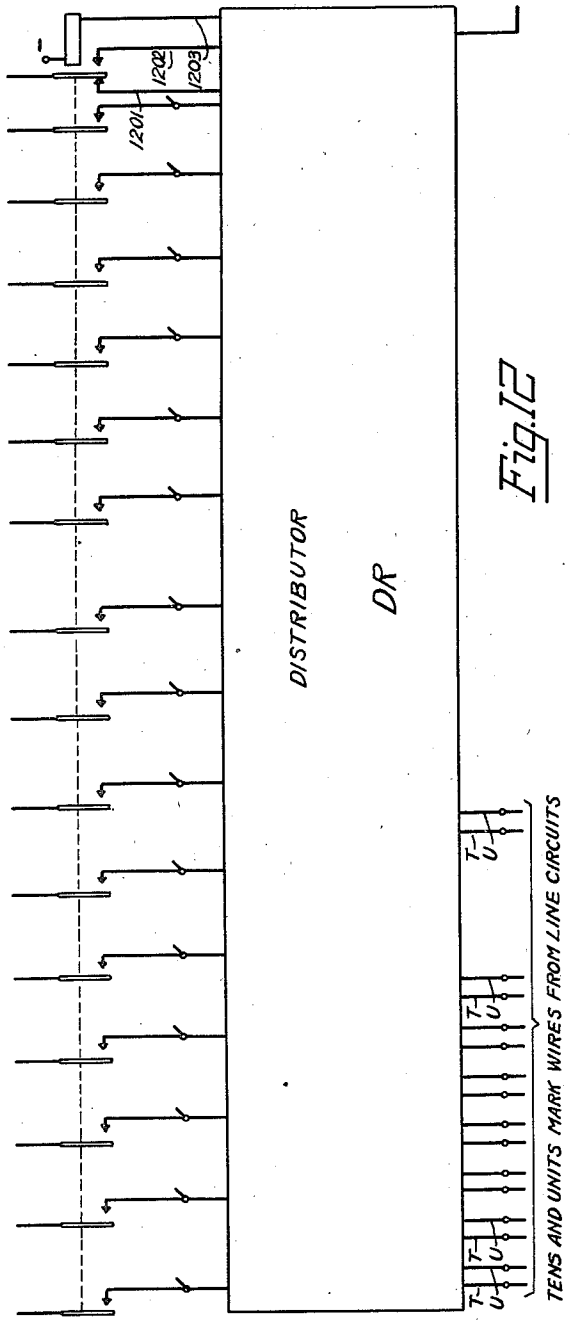

Fig. 12

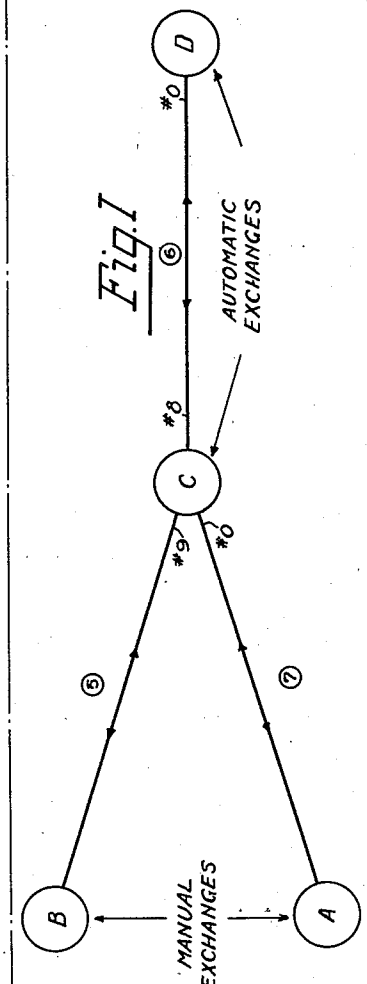

Fig. 1

Inventor:
Pier Bakker
By C. P. Soper
Atty.

Sept. 23, 1947. P. BAKKER 2,427,650

MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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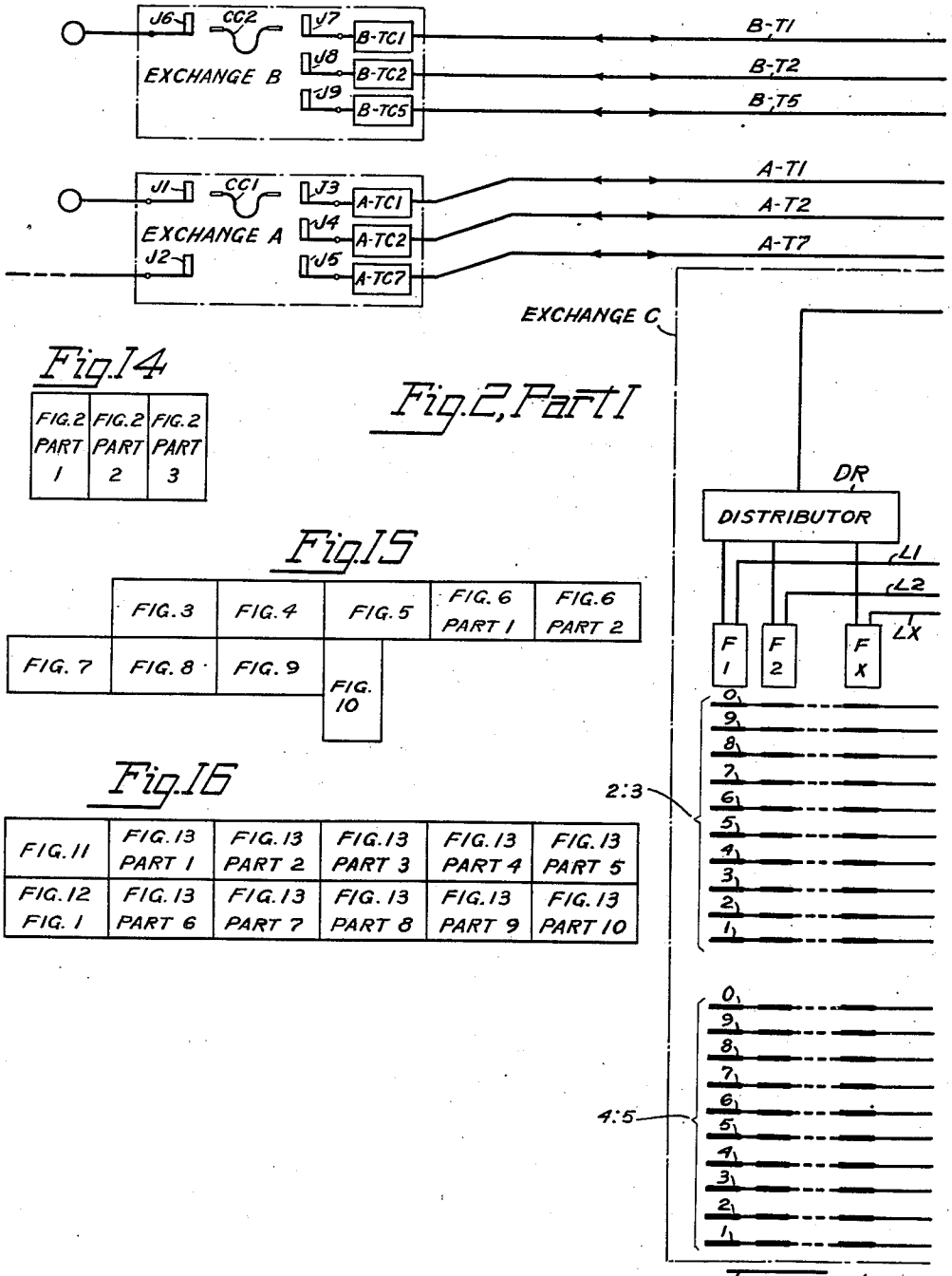

Fig.14

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

Fig.2, Part 1

Fig.15

	FIG.3	FIG.4	FIG.5	FIG.6 PART 1	FIG.6 PART 2
FIG.7	FIG.8	FIG.9	FIG. 10		

Fig.16

FIG.11	FIG.13 PART 1	FIG.13 PART 2	FIG.13 PART 3	FIG.13 PART 4	FIG.13 PART 5
FIG.12 FIG. 1	FIG.13 PART 6	FIG.13 PART 7	FIG.13 PART 8	FIG.13 PART 9	FIG.13 PART 10

Inventor:
Pier Bakker
By C. P. Soper
Atty.

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MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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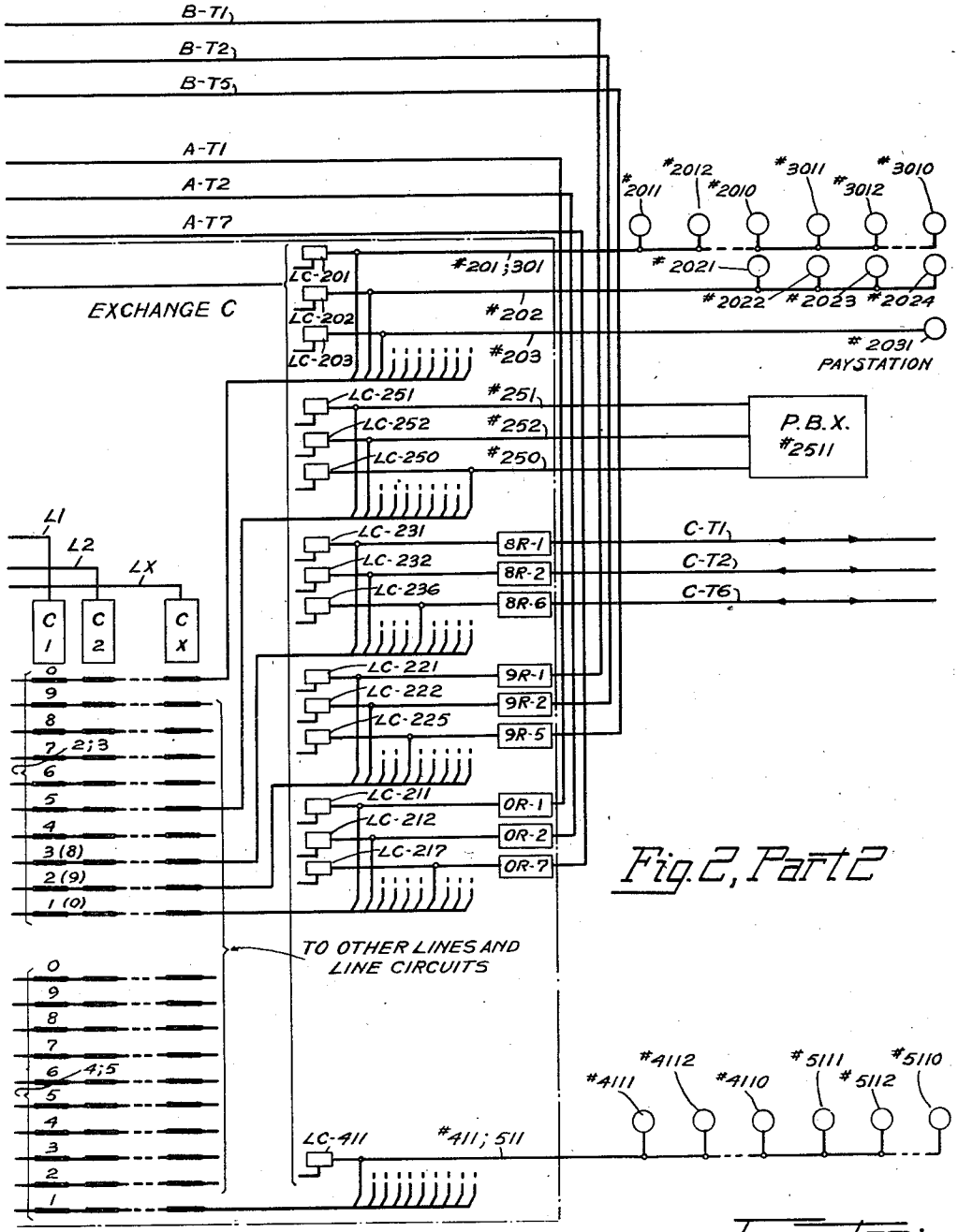

Fig. 2, Part 2

Inventor:
Pier Bakker
By C. C. Soper
Atty.

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MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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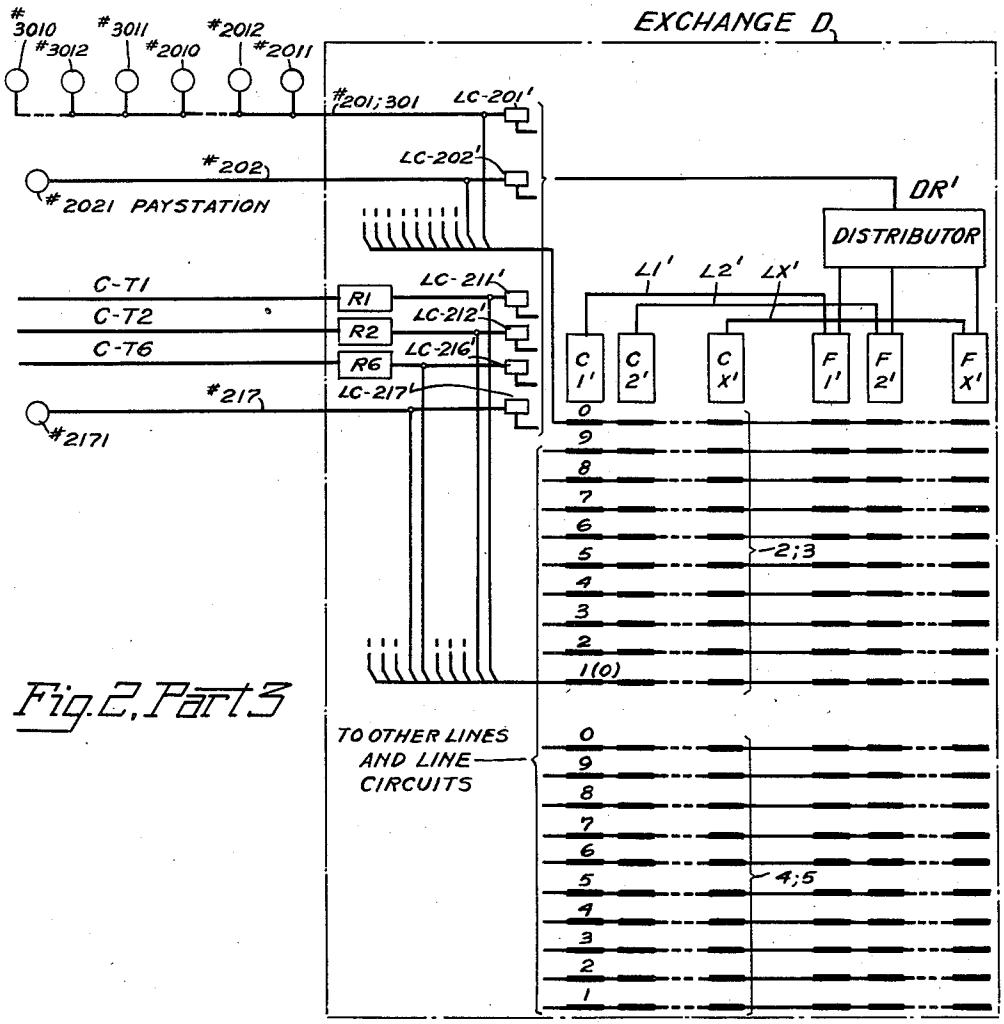

Fig. 2, Part 3

Inventor:
Pier Bakker
By C. C. Soper
Atty.

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MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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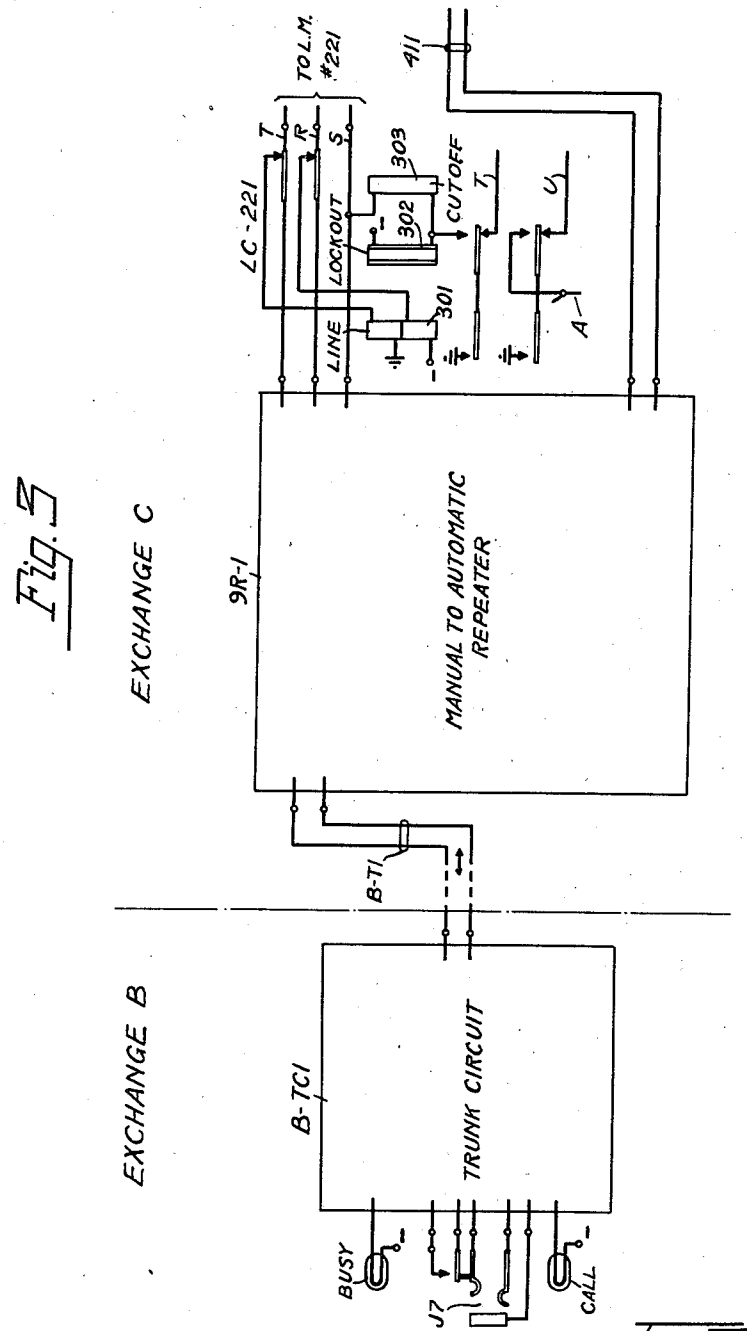

Fig. 5

Inventor:
Pier Bakker
By C. P. Soper
Atty.

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MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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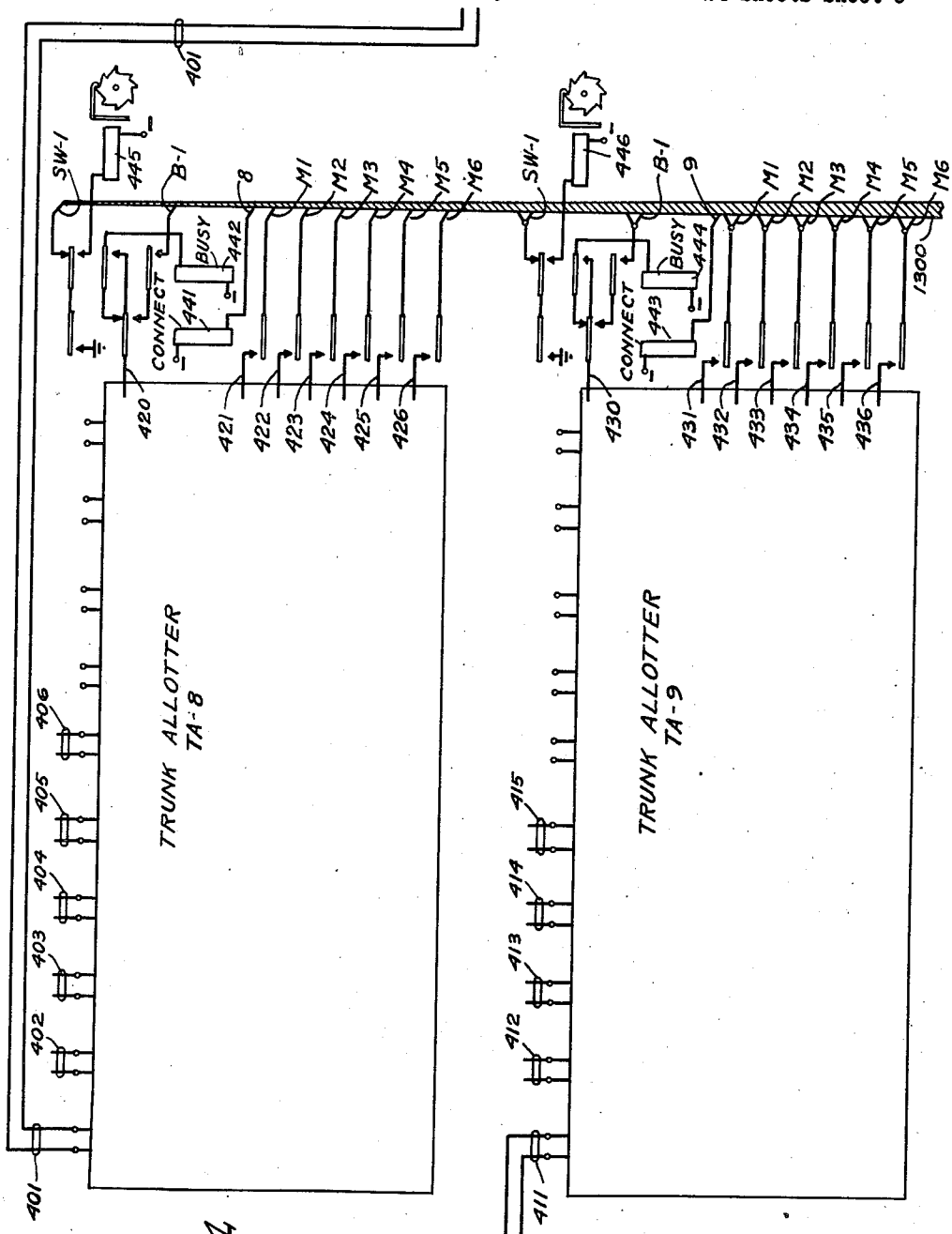

Fig. 4

Inventor:
Pier Bakker
By C. P. Soper
Atty.

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MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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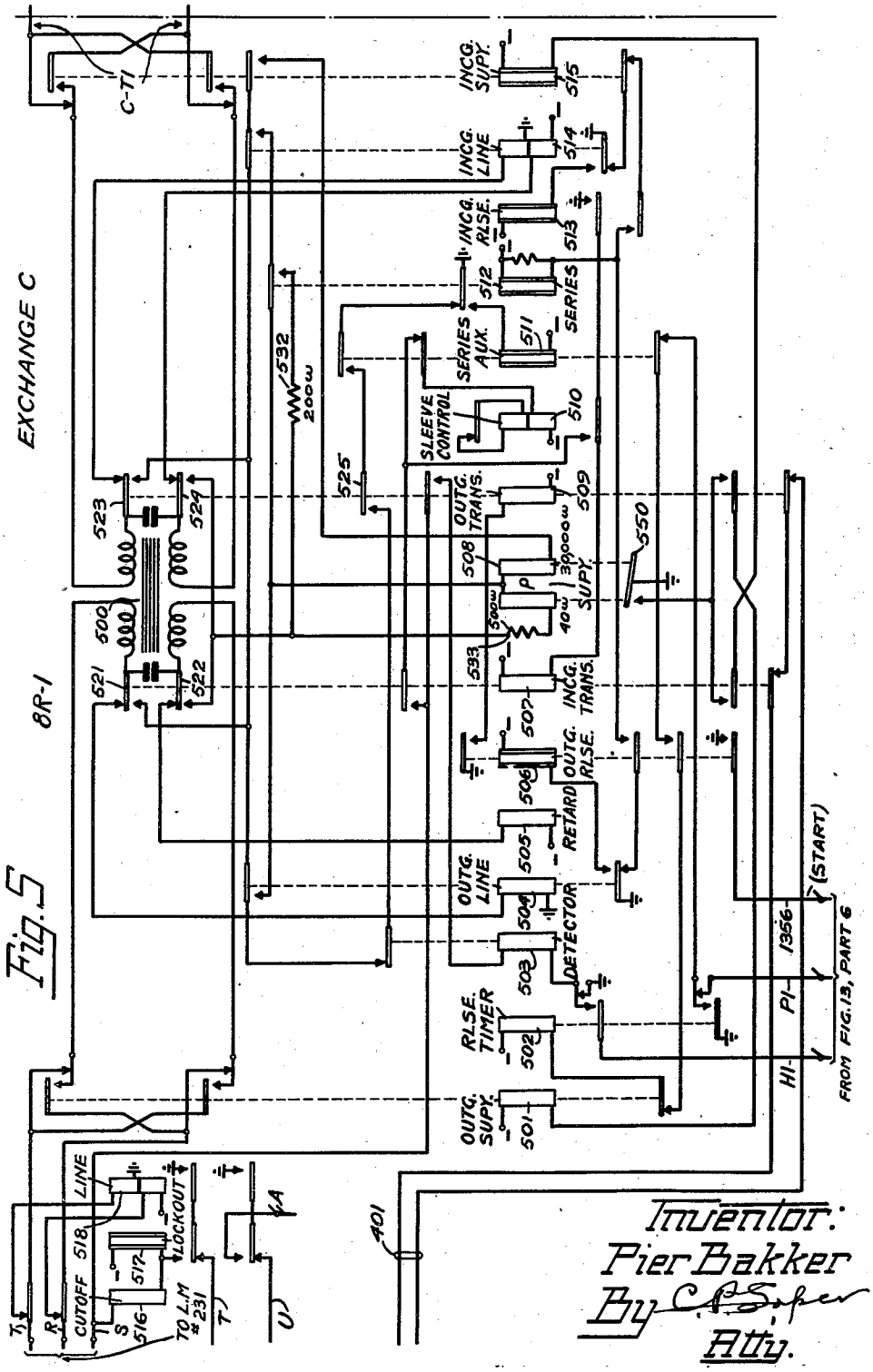

Fig. 5

Inventor:
Pier Bakker
By C. P. Soper
Atty.

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MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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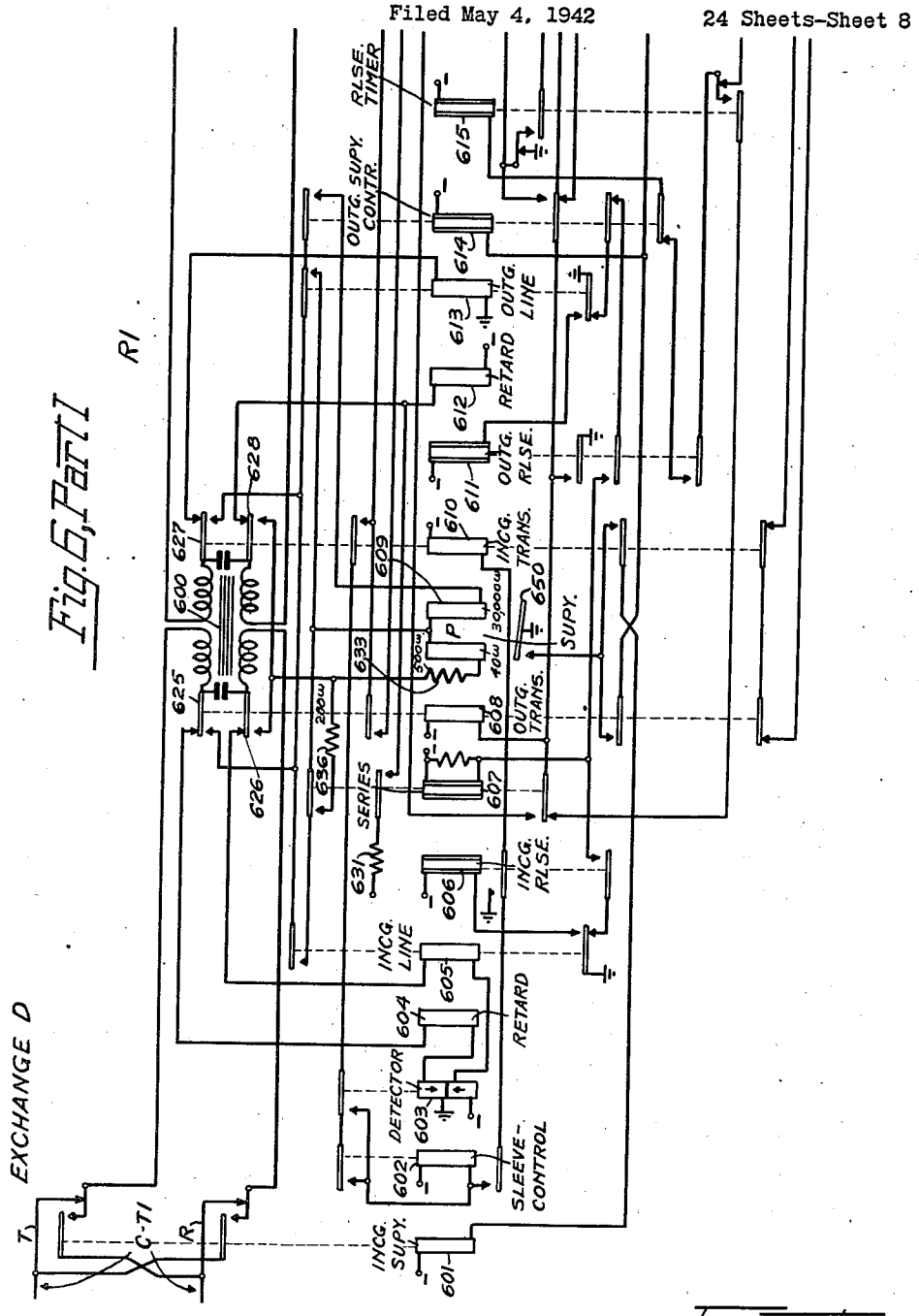

Inventor:
Pier Bakker
By C. P. Soper
Atty.

Sept. 23, 1947. P. BAKKER 2,427,650

MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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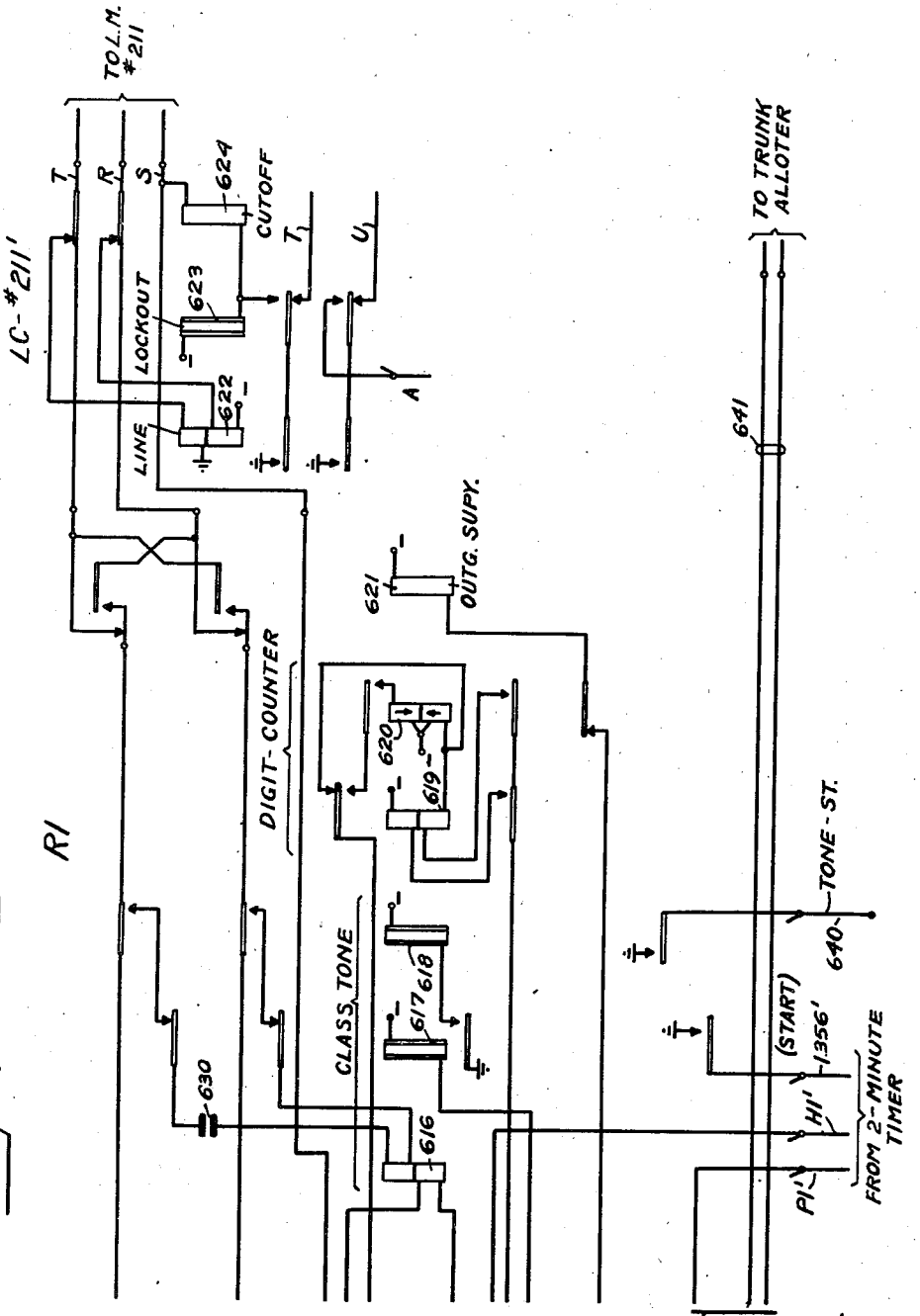

Fig. 6, Part 2

Inventor:
Pier Bakker
By C. P. Soper
Atty.

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MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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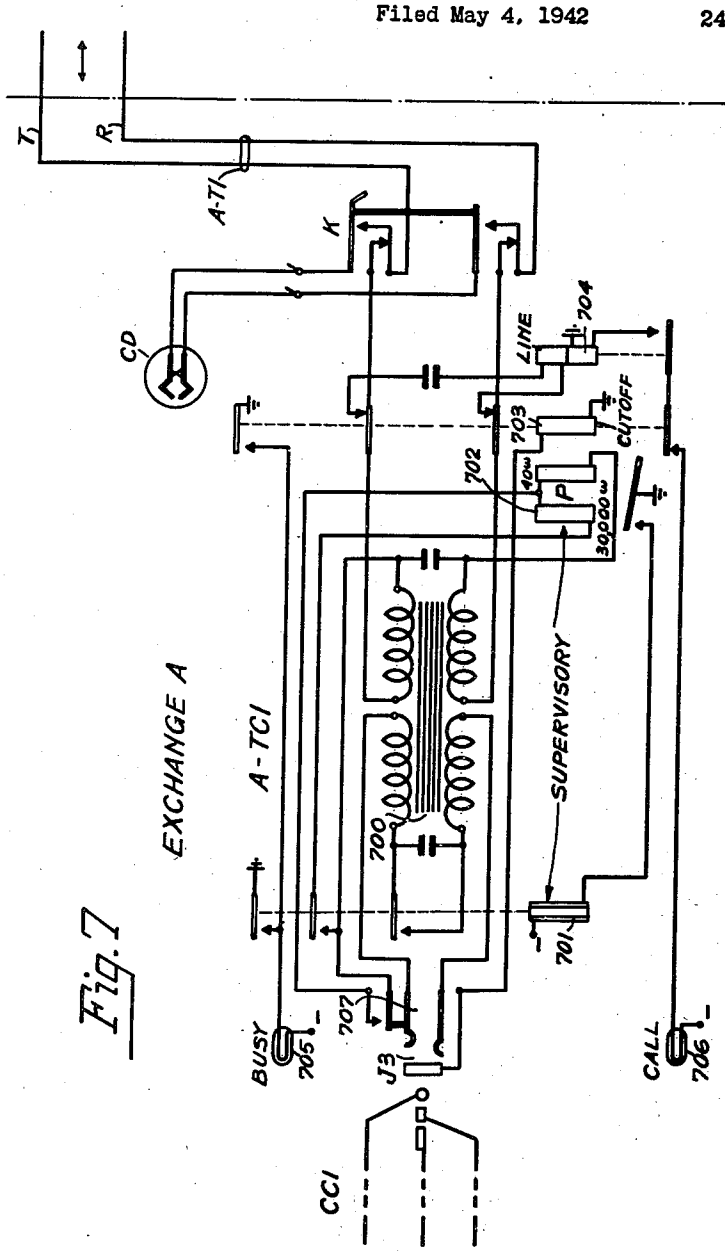

Fig. 7

Inventor:
Pier Bakker
By C.S.
Atty.

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MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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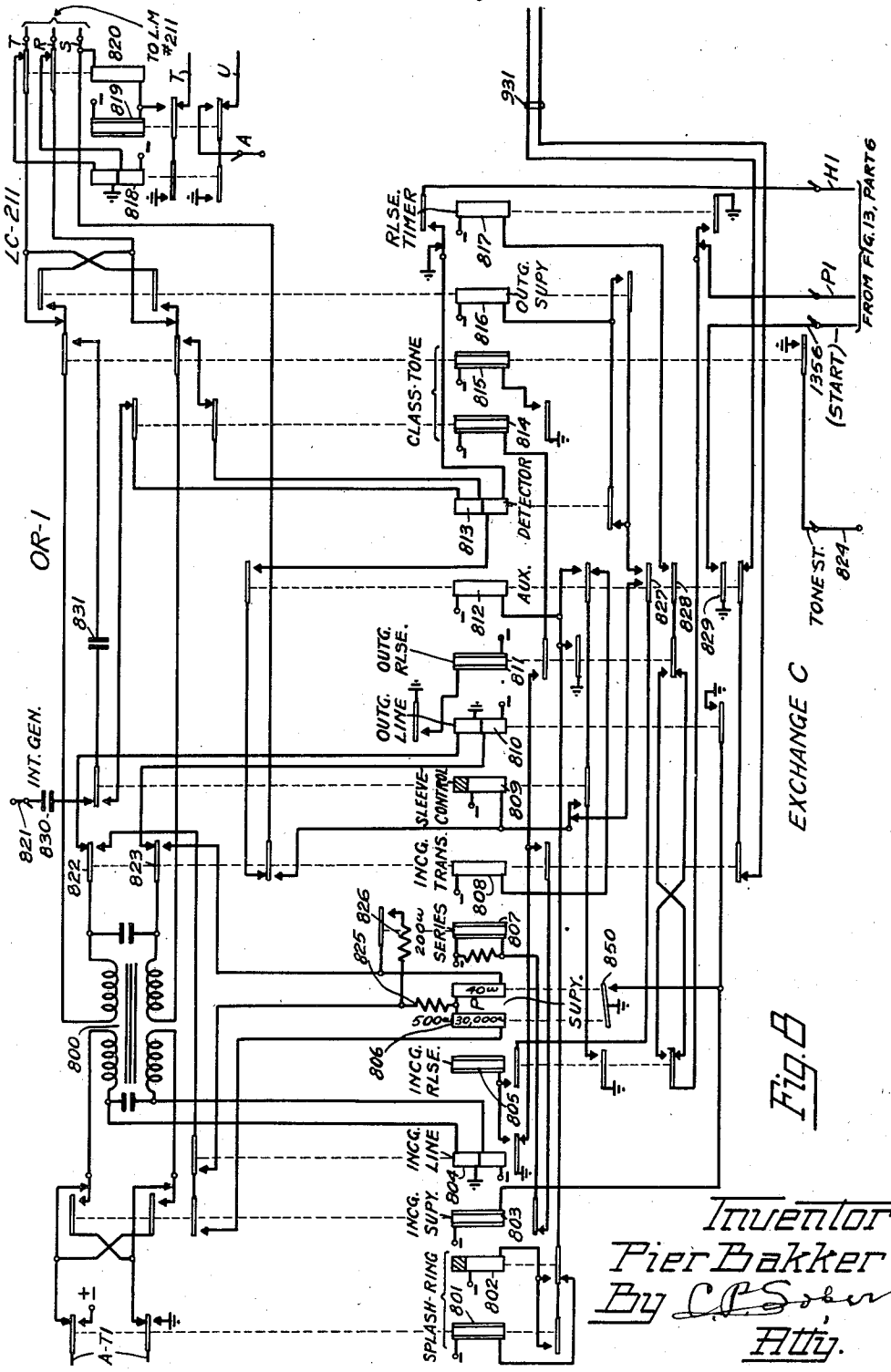

Fig. 8

Inventor:
Pier Bakker
By C. P. Soler
Atty.

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MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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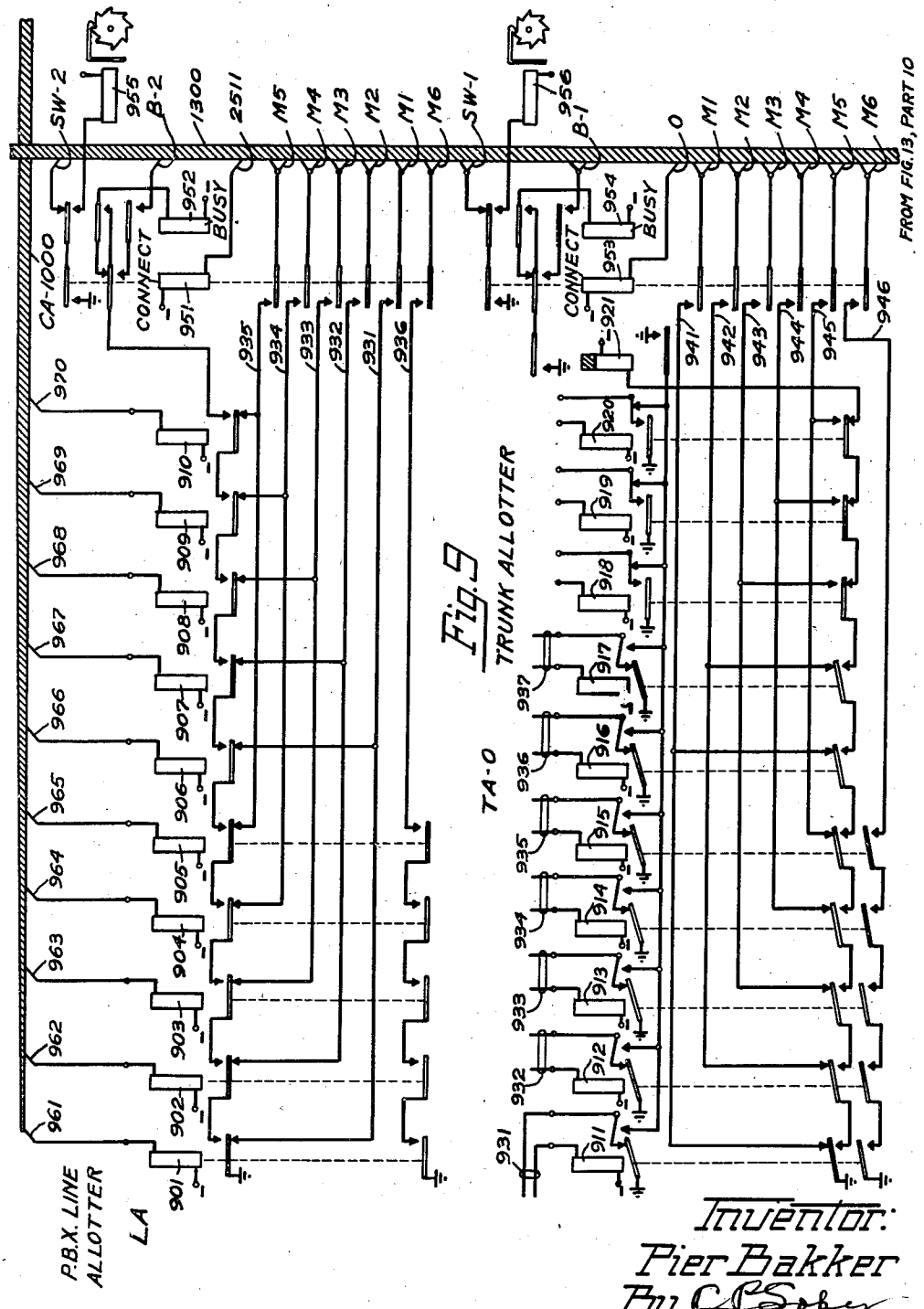

Fig. 9

Inventor:
Pier Bakker
By C. C. Soper
Atty.

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MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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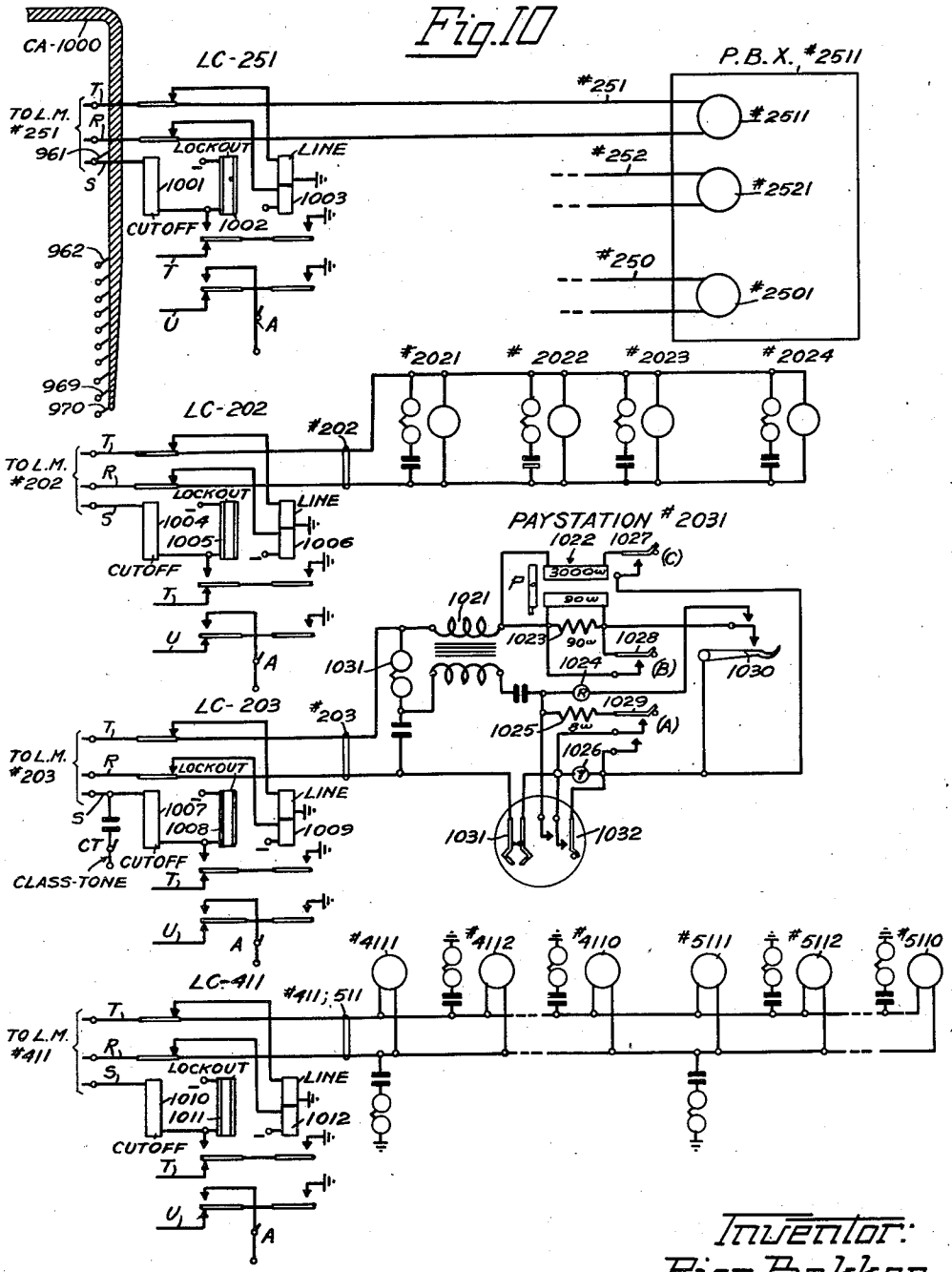
Fig. 10



Inventor:
Pier Bakker
By C. P. Soper
Atty.

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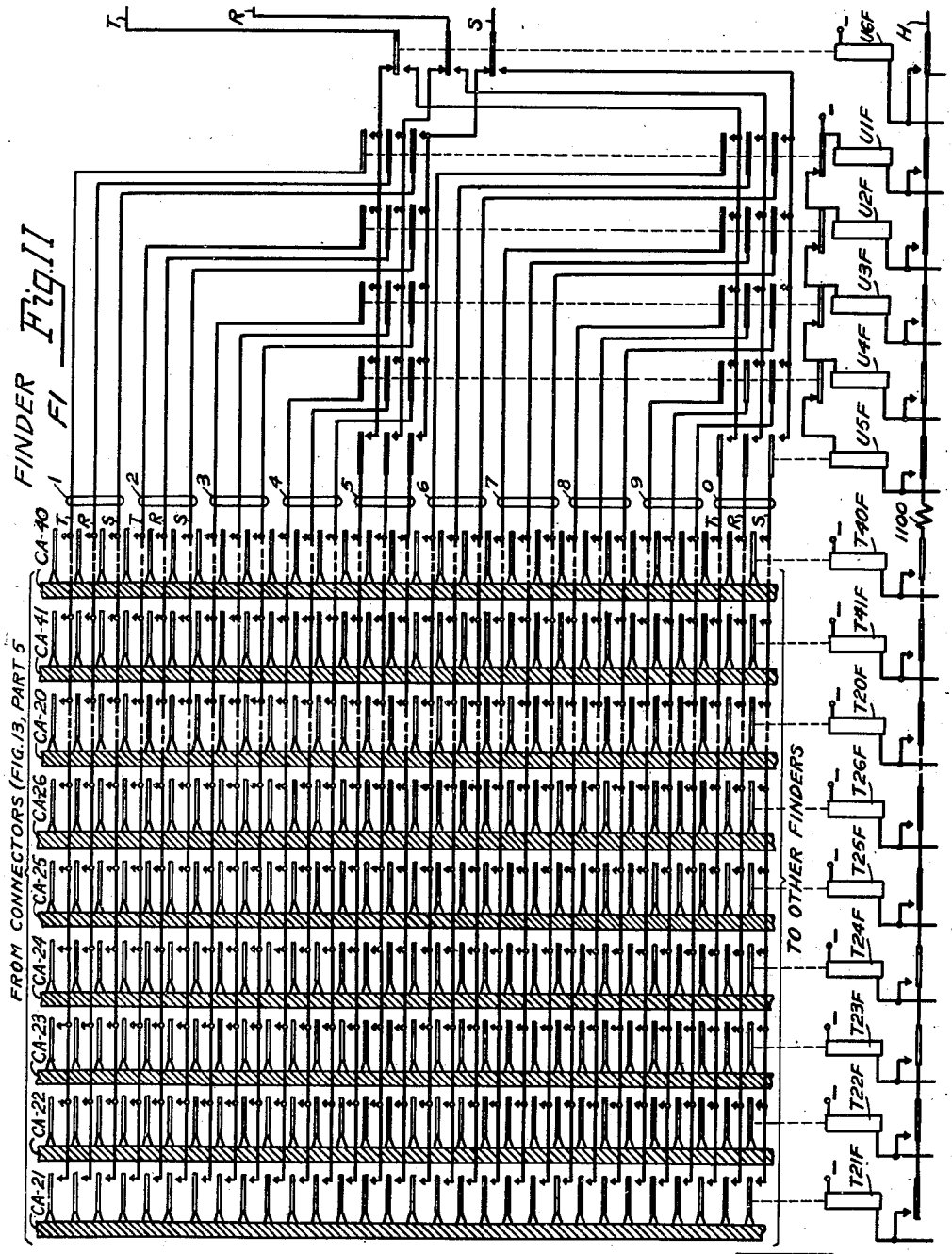

Inventor:
Pier Bakker
By C. C. Soper
Atty.

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MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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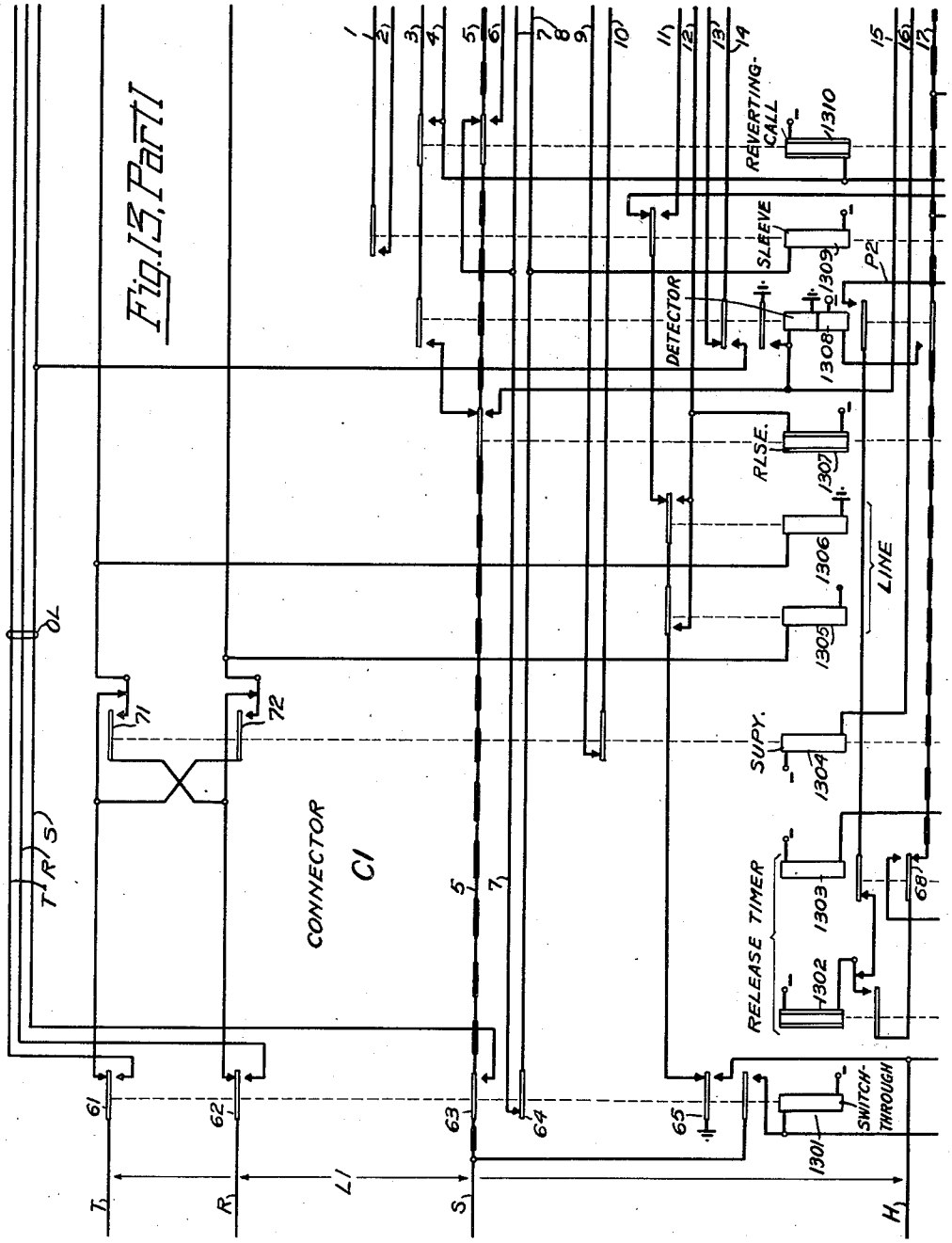

Inventor:
Pier Bakker
By C. A. Sofen
Atty.

Sept. 23, 1947. P. BAKKER 2,427,650

MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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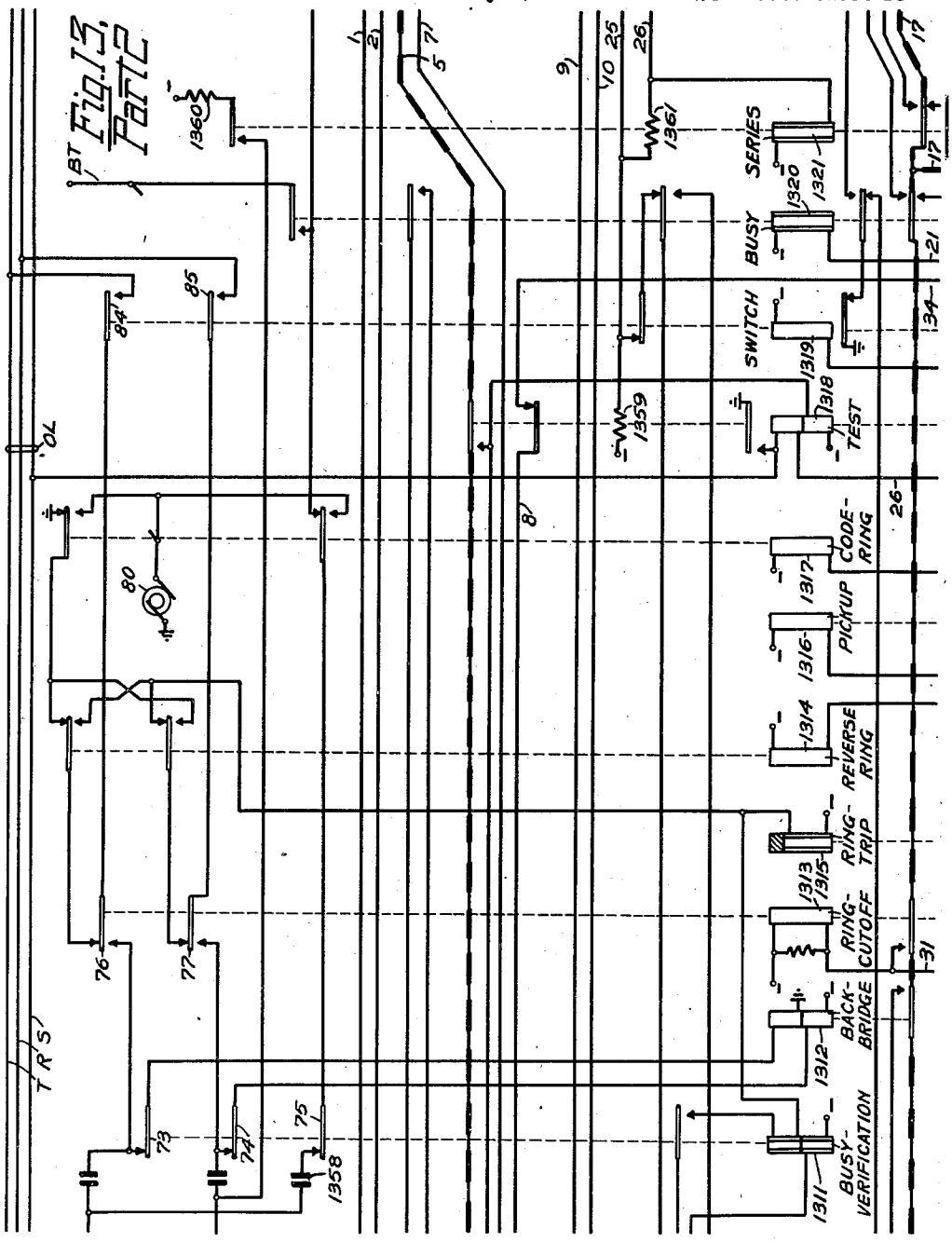

Inventor:
Pier Bakker
By C. P. Soper
Atty.

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MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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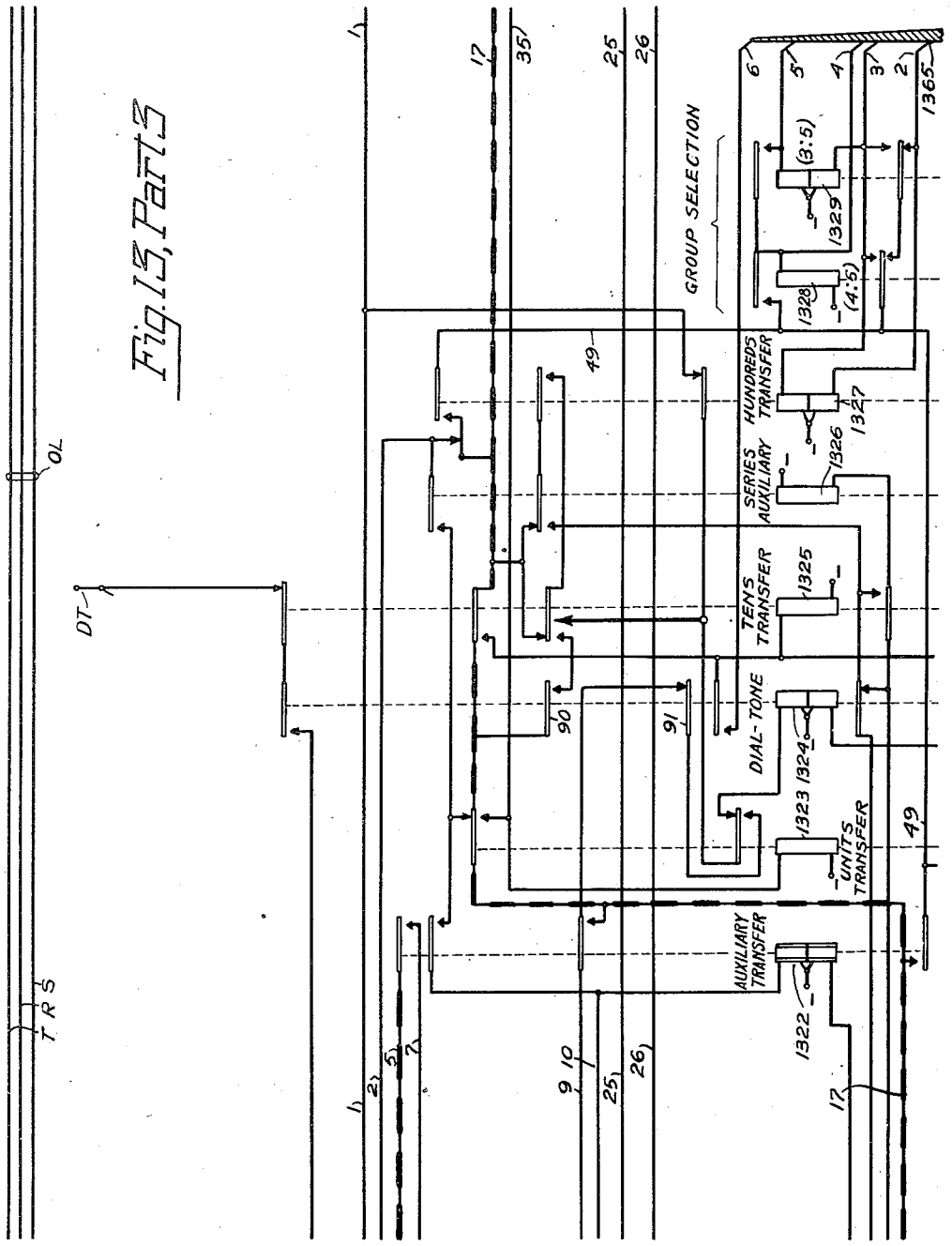

Inventor:
Pier Bakker
By C. P. Soper
Atty.

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MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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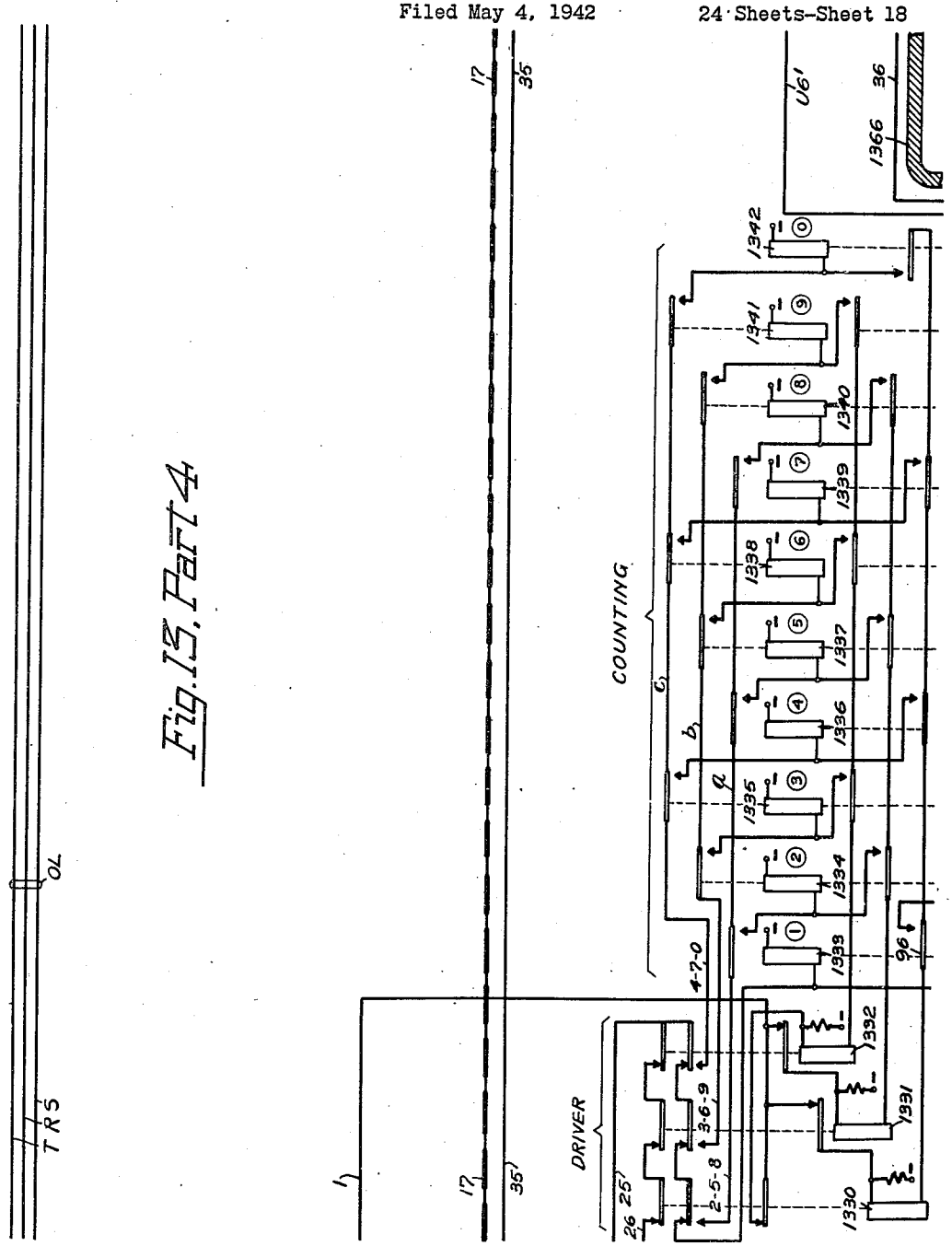

Fig. 13, Part 4

Inventor:
Pier Bakker
By C. C. Soper
Atty.

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MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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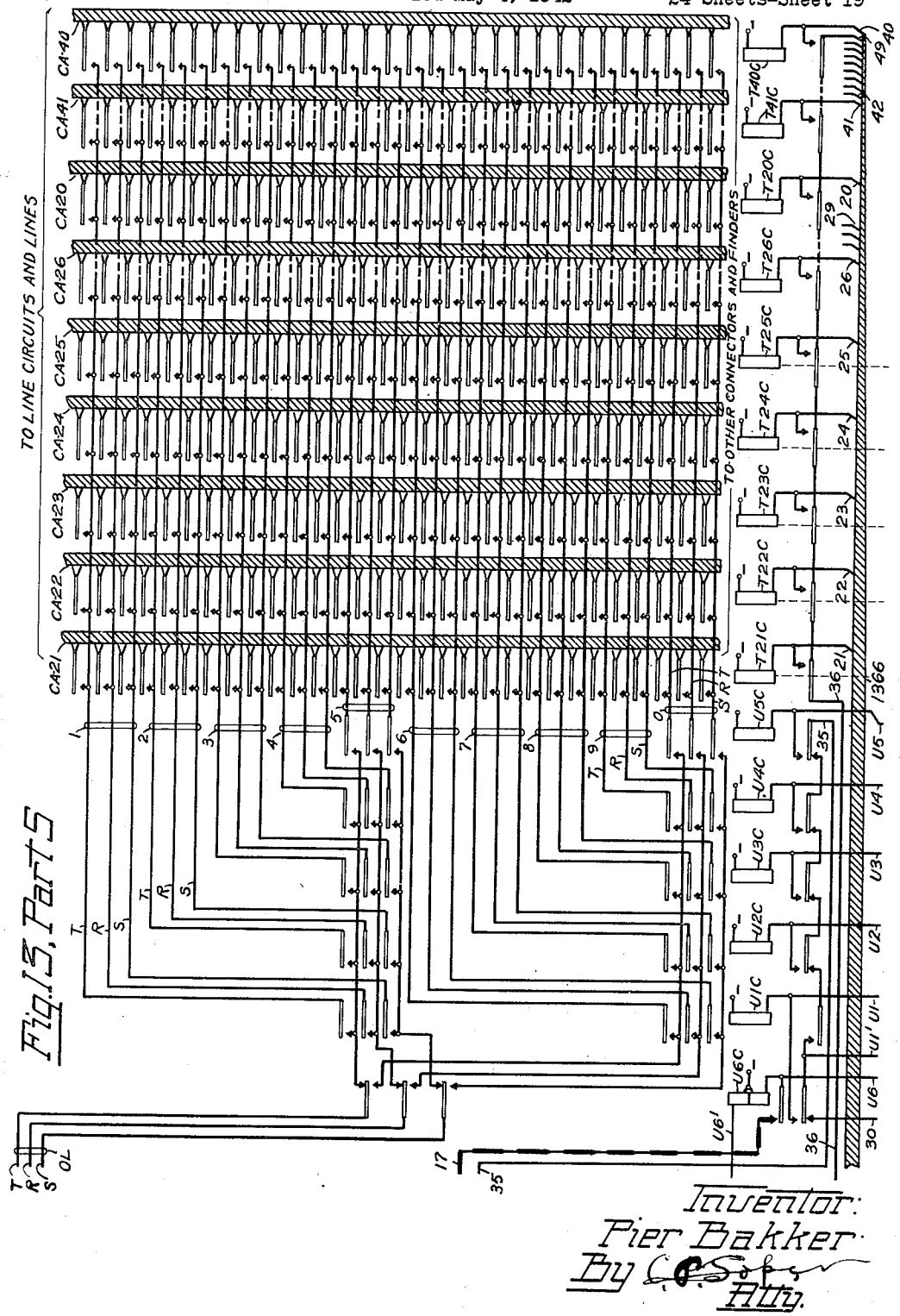

Fig. 13, Parts 5

Inventor:
Pier Bakker
By C. Sofer
Atty.

Sept. 23, 1947. P. BAKKER 2,427,650

MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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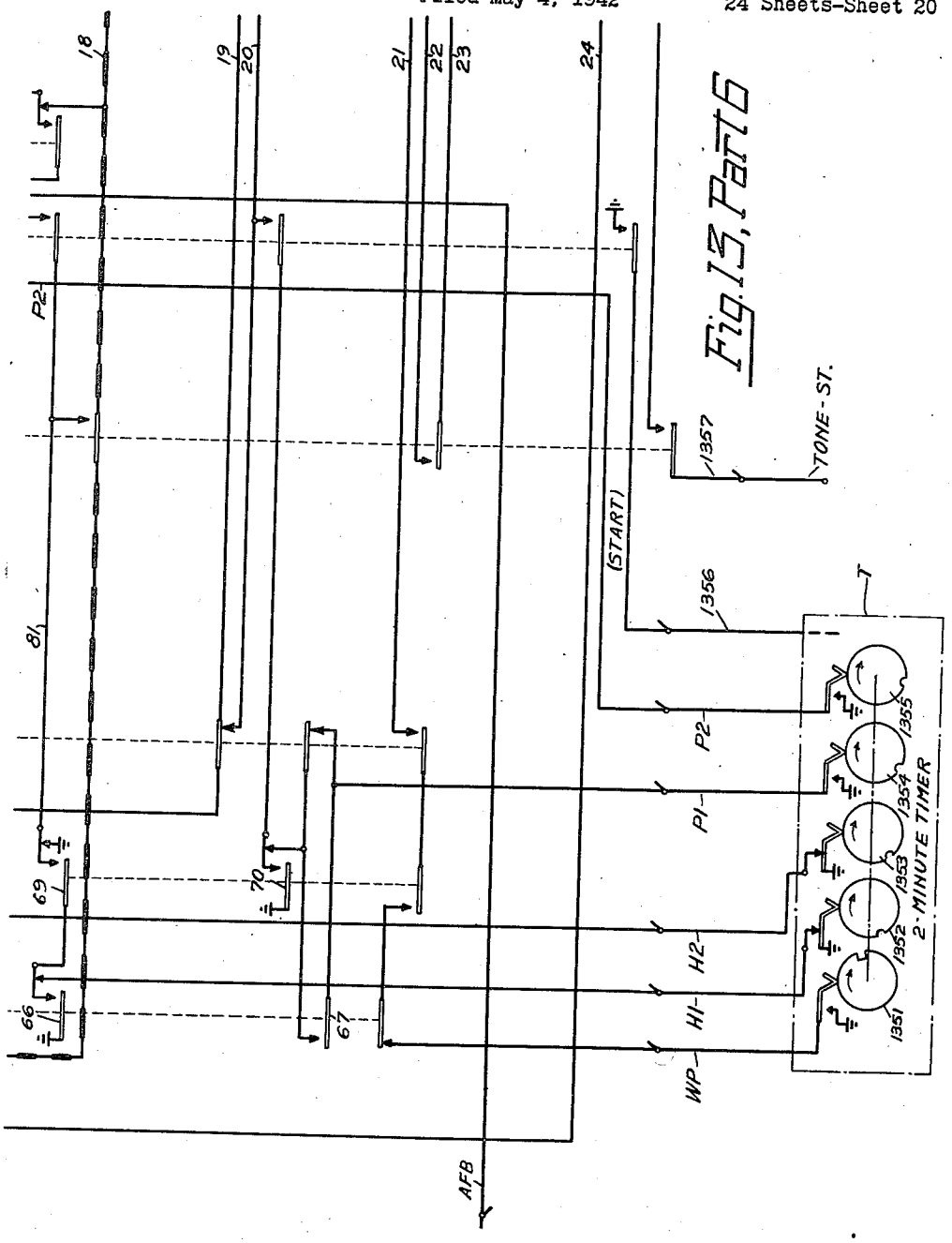

Fig. 13, Part 6

Inventor:
Pier Bakker
By C. P. Soper
Atty.

Sept. 23, 1947. P. BAKKER 2,427,650

MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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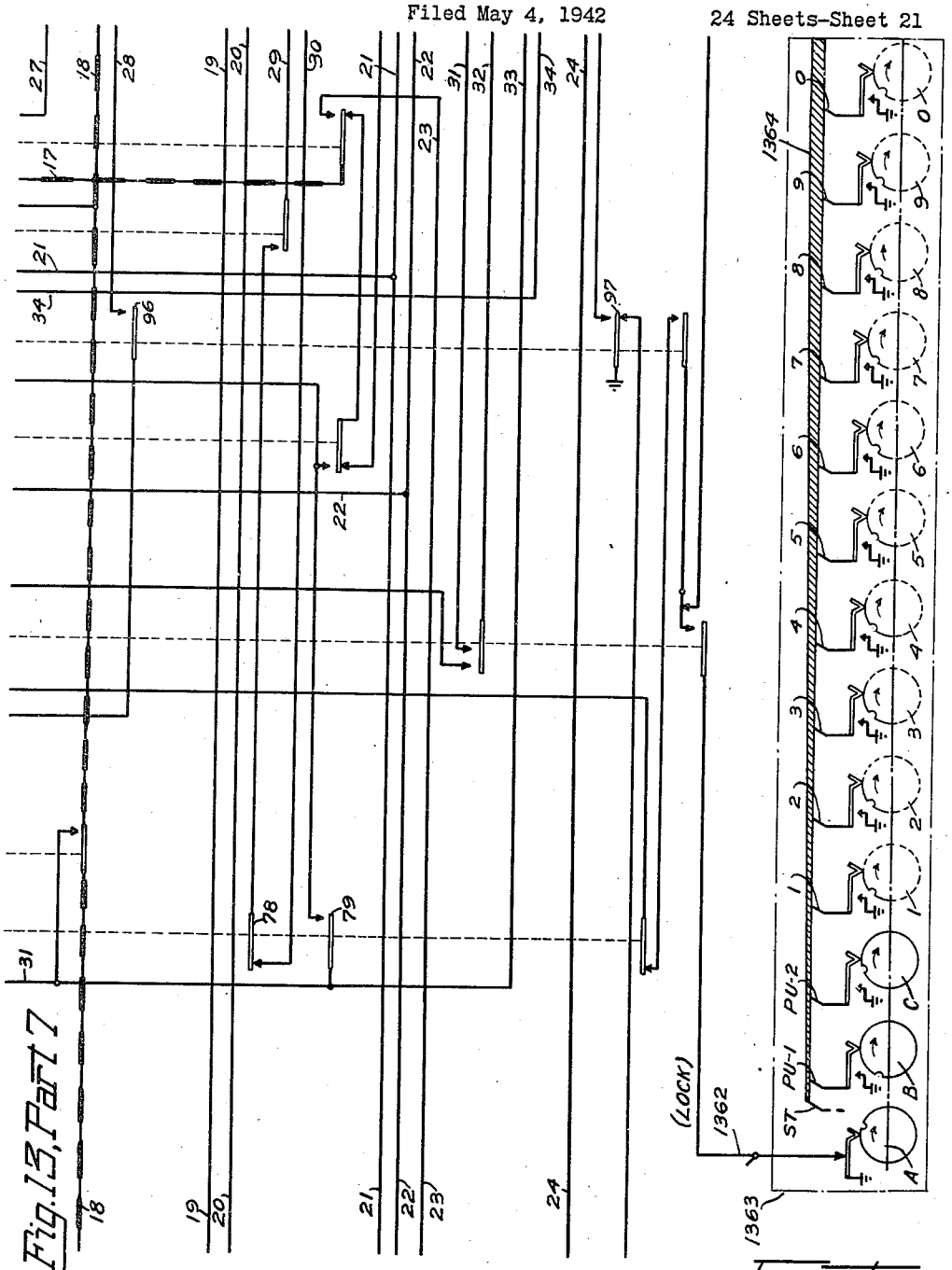

Fig. 13, Part 7

Inventor:
Pier Bakker
By C. P. Sabin
Atty.

Sept. 23, 1947. P. BAKKER 2,427,650

MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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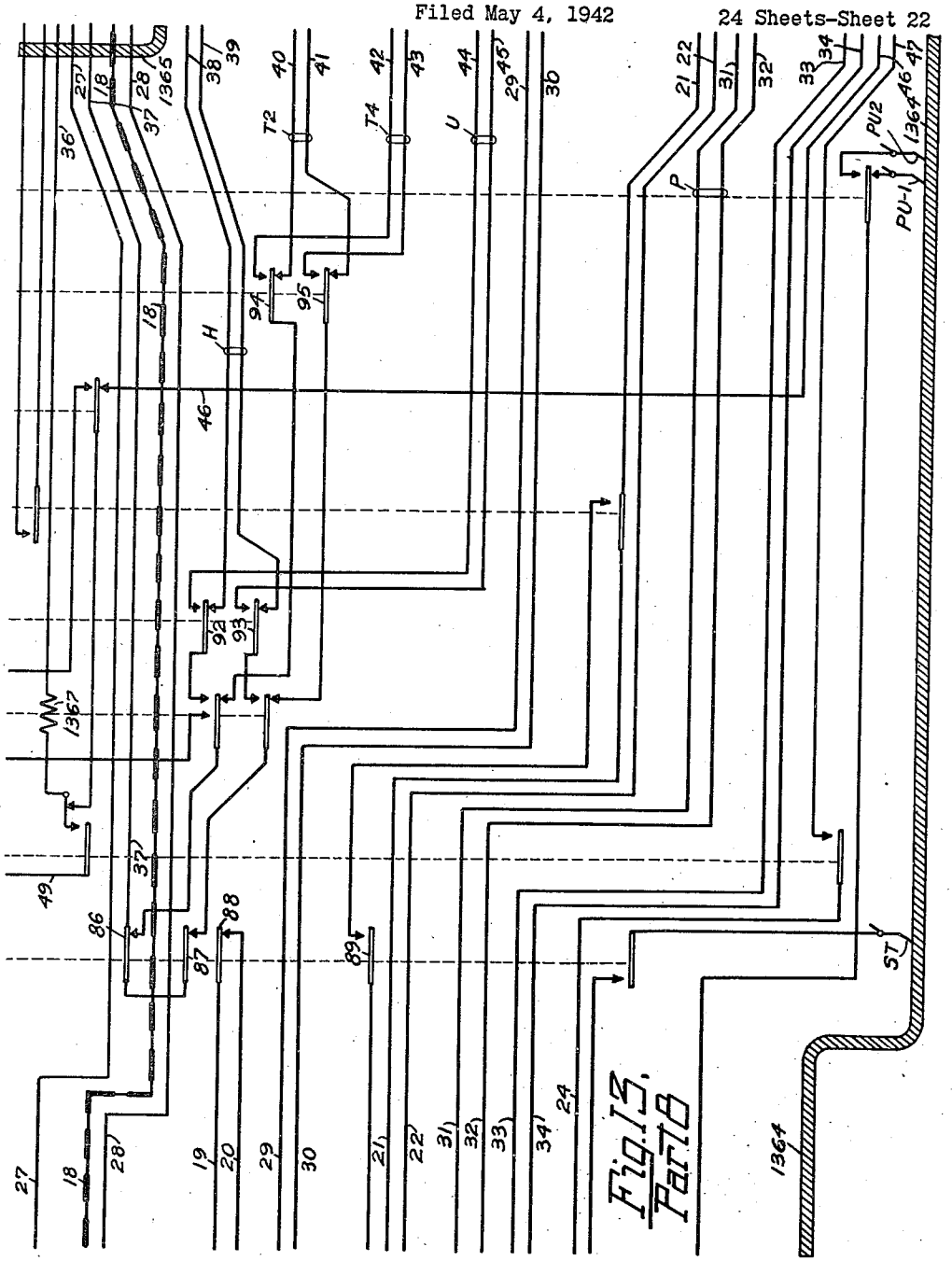

Fig. 13, Part B

Inventor:
Pier Bakker
By C. P. Sofer
Atty.

Sept. 23, 1947. P. BAKKER 2,427,650

MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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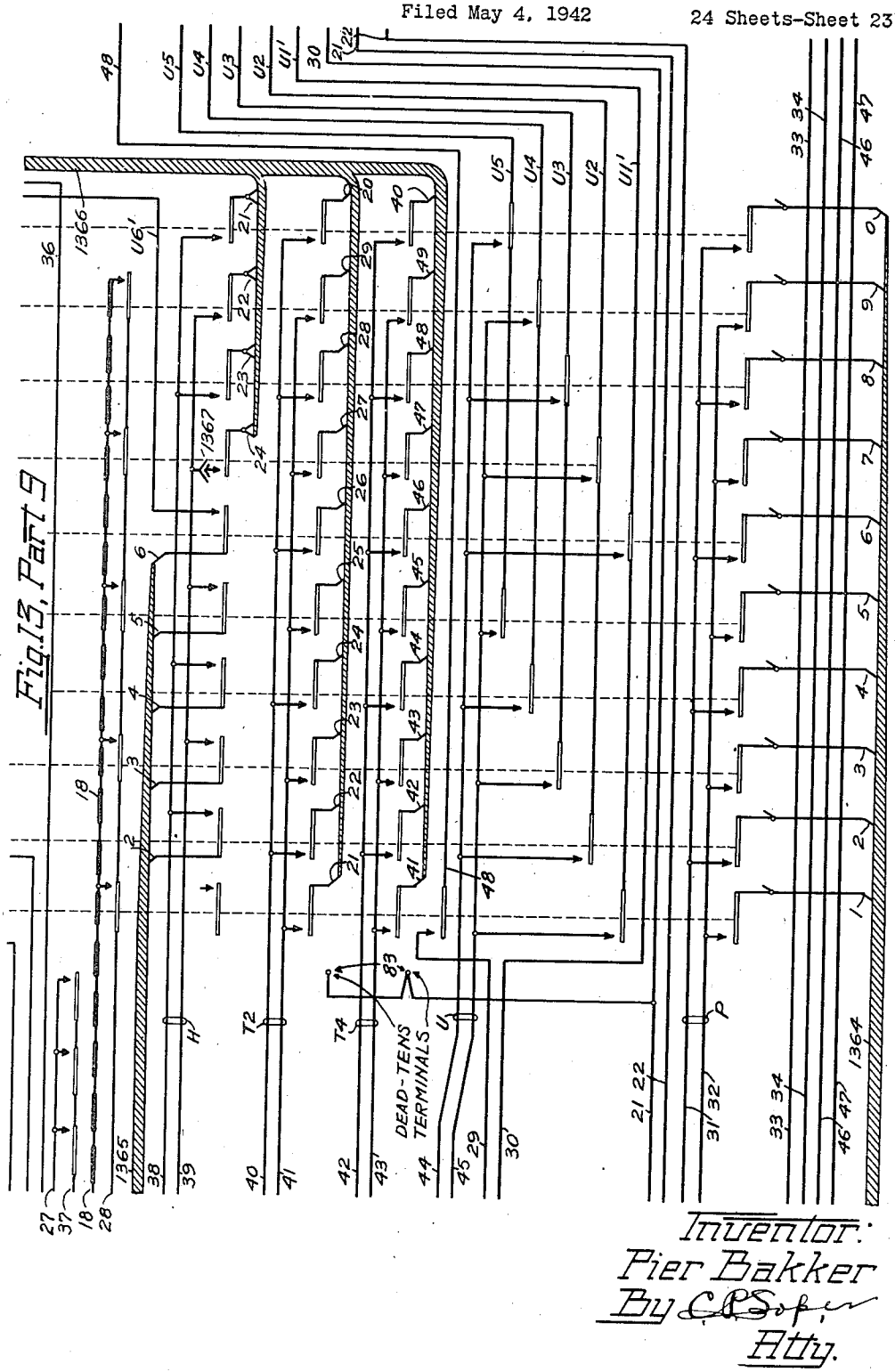

Fig. 13, Part 9

Inventor:
Pier Bakker
By C. P. Sopin
Atty.

Sept. 23, 1947. P. BAKKER 2,427,650

MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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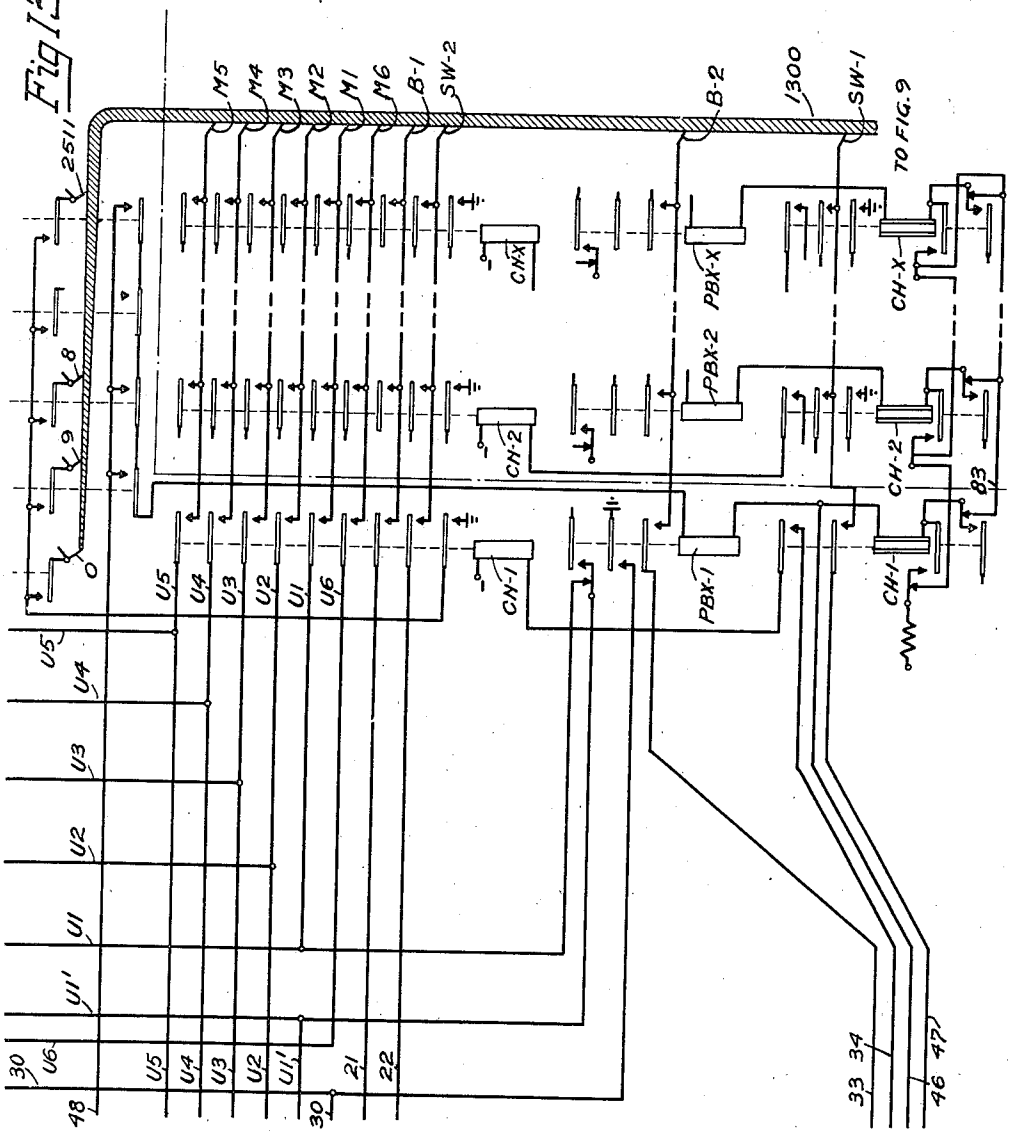
Fig 13, Part 10



Inventor:
Pier Bakker
By C. P. Safer
Atty.

Patented Sept. 23, 1947 2,427,650

UNITED STATES PATENT OFFICE

2,427,650

MULTIEXCHANGE COMMUNITY AUTOMATIC TELEPHONE SYSTEM

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

Application May 4, 1942, Serial No. 441,641

8 Claims. (Cl. 179—27)

1

This invention relates to multi-exchange community automatic telephone systems. Its main object is the production of a new and improved multi-office community automatic telephone exchange system capable of giving more efficiently and satisfactorily the services ordinarily found necessary in such systems.

General Description

The term community automatic telephone system as used herein refers to an automatic telephone system arranged to provide telephone service in a small community, usually a town or village and its environs. A network of such exchanges may be provided by interconnecting two or more of them by trunk lines to enable subscribers of any such exchange to call those of the other exchanges.

Many problems are encountered in connection with community automatic exchanges which are not commonly met with in the larger automatic exchanges provided in cities. For example, the lines interconnecting a community automatic exchange with another exchange are usually so small in number that their efficient use requires each of them to be equipped for two-way operation, and to be equipped to furnish toll as well as local service. Moreover, the number of lines served by such an exchange is ordinarily so small (from a few dozen to two hundred, for example), and the offered traffic is consequently so small, that the efficient use of the connecting links requires that each of them be arranged to handle all classes of calls, including local subscriber-to-subscriber calls, interexchange subscriber-to-subscriber calls, originated and received toll calls, calls to single-party and multi-party lines, reverting calls, calls from pay-station lines, and calls to a P. B. X (private branch exchange).

The invention is disclosed as embodied in a multi-exchange network of community automatic exchanges, including at least two community automatic exchanges interconnected with each other by two-way trunk lines, one of the community automatic exchanges (termed the tandem exchange) being interconnected by two-way trunk lines with each of two manual exchanges.

The invention is further illustrated as applied to a switching arrangement wherein the connections are set up in a community automatic exchange through the medium of any one of a number of finder-connector links, each such link including relay switching mechanism comprising a finder having access to all the lines of the exchange, and other relay switching mechanism

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comprising a connector having access to all the lines of the exchange.

The disclosed system includes the following features:

1. The finders and connectors have a full capacity of two hundred line multiples, each such multiple comprising three conductors, commonly referred to as tip, ring, and sleeve conductors. Each line multiple is provided with a line circuit for controlling the operation of the finders.

2. Connections involving interexchange trunk lines are made through the finder-connector links by assigning certain of the line multiples to such trunk lines instead of to subscriber lines. The full capacity of an exchange in the illustrated example is therefore two hundred lines of all kinds, including subscriber lines and trunk lines. Connections incoming from any subscriber line or trunk line are made through the finder portion of the calling line multiple, while connections to any subscribed line or trunk line are made through the connector portion of the called line multiple.

3. In the illustrated example, the two hundred line multiples comprise two hundreds groups. The first hundreds group comprises line multiples #211 to #200, while the second hundreds group comprises line multiples #411 to #400. The first hundreds group is commonly called by the hundreds digit 2, but is also reached when the hundreds digit 3 is called, while the second hundreds group is commonly called by the hundreds digit 4, but is also reached when the hundreds digit 5 is called. When a party line is being called, the hundreds digit used to obtain access to the concerned hundreds group of line multiples determines whether the call is for a first group of ten stations on the called party line or is for a second group of ten stations thereon. The party digit, which follows the tens and units digits in the number, then selects one of the ten stations in the selected group, enabling any party line to have as many as twenty stations connected thereto.

4. Each connector is so arranged that it makes connection with an idle one of a called group of interexchange trunk lines responsive to the dialing of a single digit assigned to such group. The basic wiring of the connectors is such that the initial digits 0, 9, 8, and 7 are associated respectively with the tens subgroups 1, 2, 3, and 4 in the first hundreds group of line multiples. This arrangement has the special advantage that connectors with the same basic wiring can be installed in small community automatic ex-

changes, where only a small number of line multiples are initially installed, as well as in larger community automatic exchanges, where all line multiples may be initially installed; for, when only a small number of line multiples are initially installed, such line multiples are those in the first few tens subgroups of the first hundreds group of line multiples.

5. Each connector is arranged to switch through (disconnect its bridges and connect its incoming tip, ring, and sleeve conductors respectively with the corresponding conductors of the called multiple) when an interexchange trunk-line group is called. In order to avoid the necessity of providing each connector with individual arrangements for hunting over the trunk lines of a called group for an idle one, each trunk-line group is provided with an allotter, and arrangements are associated with the allotter for marking the identity of the next idle trunk line of a group to be taken for use by a connector. Any connector involved in calling a trunk-line group makes connection with the marked idle trunk line. Arrangements are further provided for giving calling connectors access to the allotters, only one at a time, in the event that two or more calls are being made contemporaneously to the trunk-line groups.

6. In the illustrated example, each of the community automatic exchanges is arranged to be normally unattended. For this purpose, each of the line circuits is provided with circuit arrangements operating to lock the associated line out of normal service at any time when a connection with such line is broken during the existence of a grounded or bridged condition on the associated line. Such lockout condition is maintained until the associated line is subsequently returned to normal, or noncalling, condition. None of the common finder-connector links can be taken for use by a line during the time its individual line circuit is in lockout condition.

7. Each connector is provided with a release-timer arrangement operable to clear out the connector and the associated finder within two to four minutes following the taking of the link for use, provided the complete number has not been dialed during this time, or the called subscriber has not answered. This same timer arrangement operates to clear out any finder-connector link within two to four minutes after the called subscriber has replaced his receiver, provided the receiver is still unreplaced on the calling line. The lockout line circuits cooperate with the release-timer arrangement of the connectors to maintain the finder-connector links free for the handling of current calls by locking out of service the lines in inactive, unnormal condition when connection therewith is broken by the clearing out of a finder or connector.

8. Overloading of the finder-connector links by prolonged local conversations thereover is avoided by releasing any local connection over which conversation has been proceeding for from six to eight minutes, for example, which result is accomplished by additional release-timer arrangements associated with each connector. The concerned lines do not thereupon come into the finders as calling lines because the concerned line circuits are brought into lockout condition as above mentioned responsive to the connection being cleared out, and so remain until the concerned lines are returned to normal condition, as by the replacement of the receivers thereon.

9. Each connector is a combined toll and local

connector normally conditioned for giving toll service (with the conversation-timing arrangement ineffective, and with a busy-verification arrangement effective), and has a detector relay associated with its sleeve conductor and operable thereover following the last digit to change the connector over to local operation unless the call being handled is from one of the manual exchanges.

10. Each connector is arranged to reverse the current flow over its incoming tip and ring conductors when the called subscriber answers, so as to give answered supervision to a calling manual-exchange or P. B. X operator, as well as to require a calling post-payment pay-station subscriber to deposit a coin before conversing.

11. Each manual-to-automatic trunk line is provided with a repeater in the automatic exchange, interposed between the two-conductor interexchange portion of the trunk line and the associated three-conductor switchboard multiple. Each such repeater is arranged to identify any call incoming therethrough as a manual-exchange call, by applying an identifying ground potential to the sleeve conductor of the associated multiple. A special feature of this arrangement is that such grounding of the sleeve conductor by the repeater is rendered initially responsive to the grounding of the sleeve conductor of the multiple by a seized connector, whereby the cutoff relay of the associated line circuit is not prematurely operated to disconnect the line relay before the required finder operation has occurred.

12. On calls incoming to the automatic exchange from a manual exchange, the manual-to-automatic repeater is arranged to repeat supervision (answering, recall, and disconnect) from the called line to the manual exchange.

13. Each of the said manual-to-automatic repeaters is arranged, when seized in the automatic exchange, to apply a holding ground potential to the associated sleeve lead to hold the preceding portion of the connection under the control of the calling line. The repeater is further so arranged that, from the time the operator answers until she disconnects, the maintenance of holding ground potential on the sleeve lead associated with the repeater is removed from under the control of the calling line, enabling the calling subscriber to transmit recall signals to the operator by hook-switch operation without causing the connection to be released, such signals being relayed by the repeater.

14. Each of the manual-to-automatic repeaters is so arranged that, when it is employed as an outgoing repeater on a manual-to-manual call through the tandem automatic exchange, it relays supervision from the called manual exchange back to the incoming manual-to-automatic repeater, whereby such incoming repeater operates to repeat supervision to the calling manual-exchange operator.

15. When the manual exchange is called from any of the automatic lines, the concerned called manual-to-automatic repeater does not reverse battery to the calling line, whereby calling automatic pay-station subscribers may converse with the operator without depositing a coin. Whether or not a manual-to-automatic repeater reverses battery when the manual exchange operator answers a call from or through the automatic exchange is controlled by a detector relay in the repeater. This detector relay determines whether or not ground potential is being received by the repeater over the sleeve conductor, as it is

only in case the call is from the other manual exchange.

16. Each manual-to-automatic repeater is arranged to momentarily couple the associated sleeve conductor inductively with the associated talking conductors when the operator answers a call extended to her switchboard from the automatic exchange, whereby the operator is able to hear and identify any class-tone signal which may be applied to the sleeve conductor of the currently calling line.

17. In order to enable calls to be made between the automatic exchanges with the same operational effect as though the called line were one terminating in the calling exchange, each of the two-way trunk lines interconnecting the tandem automatic exchange with a terminating automatic exchange is provided at each end with a two-way repeater.

18. On a call from the tandem exchange to a terminating exchange, the repeater in the tandem exchange momentarily unbalances the current flow in the interexchange trunk line following the dialing of each digit in the number of the terminating-exchange line, provided the call is from a manual exchange. This operation is controlled by a detector relay in the repeater, connected in the incoming sleeve lead.

19. A differential detector relay in the repeater in the terminating exchange responds to the above unbalancing operation, if it occurs, to condition such repeater to extend ground potential ahead over the sleeve conductor to reproduce in the terminating exchange the grounded-sleeve condition produced in the tandem exchange by a call from a manual exchange.

20. The repeater in the terminating exchange relays supervision to the repeater in the tandem exchange, which in turn relays it to the calling line.

21. On calls from the terminating exchange, to or through the tandem exchange, the repeater in the tandem exchange places ground potential on the associated sleeve lead, whereby, in case the call is for one of the manual exchanges, the manual-to-automatic repeater is conditioned to send back reverse-battery supervision when the manual operator answers. Such reverse-battery supervision is relayed back by the repeater in the tandem exchange to the repeater in the terminating exchange, and is there used to cause class tone, if present on the sleeve lead, to be momentarily transmitted to the talking circuit to inform the operator of the classification of the calling line.

22. The reverse-battery supervision received by the repeater in the tandem exchange pursuant to the above class-tone application, is not relayed back to the calling line, as is done when answered supervision is received at such repeater when a subscriber line is called, whereby pay-station subscribers of the terminating exchange do not have to deposit a coin before conversing with the operator. The relaying back of answered supervision by the repeater in the terminating exchange is controlled by a digit counter, and is thereby prevented when only a single digit required to reach a manual exchange has been dialed after seizure of the terminating-to-tandem repeater.

23. The reverse-battery supervision received by the repeater in the terminating exchange pursuant to class-tone identification also conditions the latter repeater for the holding of the connection in the terminating exchange until it is cleared out in the called manual exchange, permitting hookswitch signals and disconnect supervision to be transmitted from the calling terminating-exchange line, through the tandem exchange, to the called manual exchange.

24. On the interexchange calls from the terminating exchange, the ground potential sent ahead over the sleeve conductor by the repeater in the tandem exchange for the purpose above noted is temporarily removed during (and for a short time following) the dialing of each digit, whereby such ground potential is absent when the connector tests for it by its detector relay, immediately following the receipt of the final digit in the number. The normal changeover of the connector from toll operation to local operation is thus not interfered with.

The drawings

The accompanying drawings, comprising Figs. 1 to 16, show a sufficient amount of equipment in a telephone system embodying the features of the invention to enable the invention to be understood:

Fig. 1 shows the paths taken by the trunk lines interconnecting exchanges of the system;

Fig. 2 is a diagram showing the scheme of the arrangement in the exchanges of Fig. 1;

Figs. 3 to 13 are drawings showing the circuit arrangements of the apparatus of Fig. 2;

Fig. 14 shows the intended arrangement of the sheets on which the three parts of Fig. 2 are drawn;

Fig. 15 shows the intended arrangement of the sheets on which Figs. 3 to 10 are drawn; and

Fig. 16 shows the intended arrangement of the sheets on which Figs. 1 and 11 to 13 are drawn.

The system

As shown in Fig. 1, the system includes a pair of manual exchanges A and B and a pair of automatic exchanges C and D. The exchanges C and D are community automatic exchanges, each arranged to serve a separate community.

As indicated in Fig. 1, the community automatic exchanges C and D are interconnected by a group of two-way trunk lines. The digit 6 placed within the circle adjacent the line representing the group of two-way trunk lines is intended to indicate that there are six such trunk lines in the illustrated example. "#8" adjacent exchange C indicates that the C to D interexchange trunk-line group is reached in exchange C by the dialing of the digit 8, while "#0" adjacent exchange D indicates that the C to D interexchange trunk-line group is reached in exchange D in the illustrated example responsive to the dialing of the digit 0.

Similarly, it is indicated that there are seven two-way trunk lines interconnecting exchanges A and C, reached in exchange C responsive to the dialing of the digit 0, and that there are five two-way trunk lines interconnecting exchanges B and C, reached in the exchange C responsive to the dialing of the digit 9.

The arrangement illustrated in Fig. 1 is further intended to indicate that an operator at exchange A can extend connection to exchange B through the tandem automatic exchange C by taking an A-to-C trunk line for use and dialing the digit 9, while an operator at exchange B can similarly extend connection to exchange A by taking a B-to-C trunk line for use and dialing the digit 0. Fig. 1 is further intended to indicate

that a subscriber of the terminating exchange D can reach manual exchange A by dialing the digits 0 and 0 and can reach the manual exchange B by dialing the digits 0 and 9.

Referring now to Fig. 2, comprising parts 1 to 3, the manual exchanges A and B of Fig. 1 are indicated by rectangles in the upper left-hand corner of part 1; the tandem community automatic exchange C is represented by the rectangle covering a portion of part 1 and a portion of part 2; and the terminating community automatic exchange D is represented by the rectangle in part 3 of Fig. 2.

Manual exchange A

The equipment in exchange A includes the jack J1, illustrative of the jacks through which the subscriber lines of exchange A are reached; the jack J2, illustrative of the jacks through which toll lines connected with exchange A are reached; the cord circuit CC1, and the jacks J3 to J5 which are three of the seven jacks representing the manual-exchange terminals of the seven associated interexchange trunk lines, of which trunk lines A—T1, A—T2, and A—T7 are indicated in Fig. 2.

The equipment in the manual exchange A further includes a trunk circuit interposed between each of the two-way interexchange trunk lines and the corresponding switchboard jack. The trunk circuits for the indicated trunk lines are respectively A—TC1, A—TC2, and A—TC7.

Manual exchange B

Similarly, the equipment in exchange B includes the subscriber-line jack J6, cord circuit CC2, trunk jacks J7 to J9, and trunk circuits B—TC1, B—TC2, and B—TC5.

Tandem automatic exchange C

As previously noted each of the community automatic exchanges includes finder-connector links each having a full capacity of two hundred line multiples. Finders F1, F2, and FX are indicated in exchange C, linked respectively to connectors C1, C2, and CX by the links L1, L2, and LX. The "X" designation with respect to the last link is used because the number of links required is indefinite, in that it depends on the traffic requirements of any specific installation.

The line multiples are divided into groups of ten multiples to the group, the tens groups being represented respectively by the twenty lines extending horizontally below the rectangles indicating the finders and connectors. These twenty horizontal lines thus indicate the full number of two hundred line multiples.

The tens subgroups of line multiples are sometimes referred to as "levels." Using this expression, each of the finders and connectors has twenty levels of contacts (ten sets of contacts to a level) and each of the short heavy horizontal lines below a finder or connector represents a separate one of such levels of contacts. In the relay type of switching mechanism herein illustrated, each such level is represented by a separate gang relay carrying ten sets of contacts. Certain of these gang relays are shown in Fig. 11 for the finder F1 and in Fig. 13, part 5, for the connector C1.

The upper set of levels of the finders and connectors comprises the first hundreds group and this hundreds group is reached as previously noted when either of the hundreds digits 2 and 3 is dialed. The lower set of levels comprises the second hundreds group, which, as previously noted, is reached when either of the hundreds digits 4 and 5 is dialed. The ten levels in each hundreds group have the tens digits 1 to 9 and 0 assigned respectively thereto, as is indicated below the finder F1 and below the connector C1.

Each of the line multiples has a line circuit connected thereto. The line circuits LC—211, LC—212, and LC—217, for example, are connected respectively with line multiples #211, #212, and #217, being line multiples 1, 2, and 7 in the first level of the uppermost hundreds group of the finders and connectors. Line circuit LC—211 is shown in the circuit drawings in the upper right-hand portion of Fig. 8. Other of the line circuits indicated in Fig. 2, part 2, are shown in Figs. 3, 5, and 10, being line circuits LC—221, LC—231, LC—251, LC—202, LC—203, and LC—411. All of these line circuits are identical, as will be noted, and each of them has a pair of individual "mark" conductors (a tens conductor and a units conductor). These mark conductors are indicated schematically in Fig. 2 by the short lines extending to the left from the bottom of the rectangles indicative of the line circuits. As indicated by the bracket and by the line extending therefrom to the distributor DR, such mark conductors extend to the distributor, and control the distributor so as to cause the currently allotted finder to be set on the individual multiple associated with the currently calling line.

The uppermost or 0 level of the "2" hundreds group of line multiples (the upper one in Fig. 2) in exchange C has line circuits LC—01 to LC—00 associated respectively with the ten multiples thereof, of which line circuits LC—201 to LC—203 are shown. The first multiple in this tens group is illustrated as serving the twenty-party line #201;301. That is, the same line is reached responsive to the calling of either 201 or 301. When fully equipped, this party line has ten substations #2011 to #2010 and ten substations #3011 to #3010, at total of twenty substations. For convenience of illustration, only the first, second, and last substation in each tens group on the twenty-party line are shown.

Line #202, associated with the correspondingly numbered line multiple and with line circuit LC—202, is illustrated as a four-party line, such as may be used for residential party-line service within the town or village. The directory numbers of the substations on four-party line #202 may be #2021 to #2024.

Line multiple #203, associated with line circuit LC—203, is illlustrated as serving pay-station line #203, having pay station #2031 thereon (the party digit 1 being added to the line designation of each individual line to make the directory numbers uniform in the number of contained digits).

The other line multiples of the above tens group may be arranged to serve either party lines or individual lines, and any station may or may not be a pay station, as desired. The same is true of the line multiples in the other tens groups.

The "5" level in the "2" hundreds group is illustrated as associated with ten P. B. X lines #251 to #250, extending to P. B. X #2511. The concerned multiples are associated respectively with line circuits such as LC—251, LC—252, and LC—250.

As will be hereinafter described, the arrangement is such that the first P. B. X line #251 is taken for use, if idle, when the P. B. X directory number 2511 is called. If the first line is busy, the first idle one of the subsequent lines is taken for use and the call is completed thereover, the

connection being denied and the busy signal returned only in case all P. B. X lines are in use. On the other hand, if the number of any line in the P. B. X group other than that of the first line is called, connection is completed to the particular line called, if it is idle, but the connection is denied and a busy signal is returned if that line is busy.

It is to be noted that the levels 1, 2, and 3 of the "2" hundreds group in addition to the respective level designations, have the designations (0), (9), and (8) respectively applied thereto below the connectors. This is intended to indicate that, when the digit in parenthesis is called as a first digit, the connector in use operates as a single-digit connector to make connection with the first idle interexchange trunk line served by the level to which the dialed single-digit number is assigned. For example, it was pointed out in connection with Fig. 1 that the dialing of the single-digit number 0 in exchange C results in the extension of connection from exchange C to exchange A over an idle one of the seven two-way interexchange trunk lines between exchanges A and C. These seven trunk lines are served by the first seven line multiples in the first level of the "2" hundreds group in Fig. 2, these multiples having associated therewith line circuits such as LC—211, LC—212, and LC—217. The illustrated ones (A—T1, A—T2, and A—T7) of these seven trunk lines extend in exchange C respectively to the repeaters 0R—1, 0R2, and 0R—7. The switchboard side of such of the repeaters 0R—1 to 0R—7 is connected respectively with the multiples associated with line circuits LC—211 to LC—217.

Similarly, the dialing of the digit 9 in exchange C causes the connector in use to extend connection by way of an idle one of the first five multiples in the second level of the "2" hundreds group, through one or another of the repeaters such as 9R—1 to 9R—5, and over a trunk line such as B—T1 to B—T5, to exchange B.

The dialing of the digit 8 in exchange C results in connection being extended by the connector in use through an idle one of the first six multiples in the third level of the "2" hundreds group, through one or another of the repeaters such as 8R—1 to 8R—6, and over one of the trunk lines C—T1 to C—T6, to exchange D.

One of the lines associated with the "4" hundreds group of line multiples is shown. This is the twenty-party line #411; 511, associated with line circuit LC—411 and the correspondingly numbered line multiple. This line may have ten substations #4111 to #4110 thereon indexed by the calling of the hundreds digit 4, and ten other substations #5111 to #5110 thereon indexed by the calling of the hundreds digit 5.

Terminating automatic exchange D

The arrangement of finder connector links, line multiples, and line circuits in exchange D is similar to that above described in exchange C. Connectors C1' to CX' are illustrated as linked respectively by links L1' to LX' with the finders F1' to FX', such finders being controlled by the distributor DR' under the control of the line circuits, such as LC—201', for example.

As is indicated by the designation (0) applied to the first level of the "2" hundreds group in exchange D, such level is used, when the single-digit number 0 is dialed, to give access to the interexchange trunk lines C—T1 to C—T6, by way of the repeaters R1 to R6, the first six line multiples in this level being used for this purpose.

With respect to each of the exchanges C and D, it will be understood that in any level assigned to interexchange trunk lines, any line multiple not required for the interexchange trunk line group may be used for a subscriber line and called by the regular directory number assigned according to the position occupied by the concerned multiple. This is illustrated by line #217 of exchange D, serving individual-line substation #2171, connected to the seventh line multiple in the same tens subgroup serving the six interexchange trunk lines C—T1 to C—T6.

The other illustrated subscriber lines of exchange D are the twenty-party line 201; 301, and the pay-station line #202.

The circuit drawings

The circuit drawings shown in Figs. 3 to 13 will now be described generally. Fig. 3 shows the location of the trunk circuit B—TC1 in exchange B (a duplicate of trunk circuit A—TC1, Fig. 7) interposed between the jack J1 and the interexchange trunk line B—T1. Fig. 3 also shows the location of the repeater 9R—1 in exchange C (a duplicate of the repeater 0R—1, Fig. 8) interposed between the interexchange trunk line B—T1 and the line circuit LC—221, with its associated line multiple #221.

Fig. 4 shows the circuit location of the trunk allotters TA—8 and TA—9, associated respectively with the interexchange trunk groups reached responsive to the dialing of the single digit #8 and #9. Each of these allotters may be similar to the trunk allotter TA—O (Fig. 9).

Fig. 5 shows the automatic-to-automatic repeater 8R—1 in exchange C, interposed between the line circuit LC—231 with its associated line multiple #231, and the interexchange trunk line C—T1.

Fig. 6 shows the automatic-to-automatic repeater R1 in exchange D, interposed between the interexchange trunk line C—T1 and the line circuit LC—211' with its associated line multiple #211.

Fig. 7 shows the trunk circuit A—TC1 in manual exchange A interposed between the jack J3 and the interexchange trunk line A—T1. Fig. 7 shows also a portion of cord circuit C1, the calling device (or "dial") CD, and the dial key K.

Fig. 8 shows the manual-to-automatic repeater 0R—1 in the tandem exchange C interposed between the interexchange trunk line A—T1 and line circuit LC—211 with its associated line multiple #211.

Fig. 9 shows the P. B. X line allotter LA associated with the ten P. B. X lines interconnecting the tandem exchange and P. B. X #2511, Fig. 10. Fig. 9 shows also the trunk allotter TA—O associated with the repeaters serving the interexchange trunk lines interconnecting tandem exchange C and manual exchange A, including the repeater 0R—1 (Fig. 8).

Figs. 4 and 9 together show the cable 1300 (leading thereto from Fig. 13, part 10) which interconnects the connectors of the tandem exchange with the allotters PA—8 and PA—9 of Fig. 4, and LA and PA—0 of Fig. 9. Each of these allotters is provided with a connecting relay such as 953, a busy relay such as 954, and an overflow meter such as 956.

Fig. 10 shows a rectangle indicative of the P. B. X #2511, together with three of the ten P. B. X lines; line circuit LC—251, connected with

the corresponding line multiple #251; the four-party party line #202 and line circuit LC—202, connected with the associated line multiple #202; pay station #2031 and associated line #203, together with line circuit LC—203, connected with the associated line multiple #203; and the twenty-party party line bearing line numbers 411 and 511, and associated with line circuit LC—411, connected to line multiple #411.

Fig. 11 shows the finder F1, linked with the connector C1 of Fig. 13 by the tip, ring, sleeve, and hold conductors T, R, S, and H of link L1.

The finder F1 includes five units relays U1F to U5F, units switching relay U6F, and twenty tens relays of which relays T21F to T26F, and T20F of the first or "2" hundreds group are shown, together with tens relays T41F and T40F, being the first and tenth tens relays of the second or "4" hundreds group. Each tens relay, by its illustrated ten groups of contact sets (thirty pairs), represents a separate one of the levels referred to hereinbefore in connection with Fig. 2. The line-multiple side of the tens-relay contacts, are attached to conductors in tens cables, such as the illustrated cables CA—21 to CA—26, CA—20, CA—41, and CA—40. Through these cables, whose conductors comprise the line multiples referred to, the said tens-relay contacts are connected respectively in multiple with the corresponding contacts of the tens relays of all the other finders and all of the connectors.

Fig. 12 shows a rectangle indicative of the distributor DR, to which the tens and units mark wires from all of the line circuits of the exchange extend, and which selects an idle finder when a call is received and positions that finder on the line multiple of the calling line by operating a tens and a units relay thereof. The distributor has a separate connecting relay such as 1200 for each of the finders.

Fig. 13 shows the connector C1, linked with the finder F1 by the four-conductor link L1. Connector C1 includes control relays 1301 to 1342, units relays U1C to U5C, and units-switching relay U6C, together with twenty tens relays. Of the tens relays, relays T21C to T26C and T20C associated with the first or "2" hundreds group are shown, along with relays T41C to T40C associated with the second or "4" hundreds group. The twenty line-multiple cables (of which CA—21 to CA—26, CA—20, CA—41, and CA—40 are shown) associated respectively with the tens relays of the finders and connectors (Fig. 11 and Fig. 13, part 5) are assumed to extend upwardly from Fig. 13 to the respective line circuits and connected lines.

Fig. 13, part 10, shows relays CN—1, PBX—1, and CH—1 in the first connector, C1; similar relays CA—2, PBX—2, and CH—2 which are in the second connector, and relays CN—X, PBX—X, and CH—X, in the last connector. These relays have to do with the extension of calls to the interexchange trunk line groups and the P. B. X group, which extension is controlled over conductors in the cable 1300 which extend from Fig. 13, part 10, to Fig. 9.

Fig. 13, part 1, shows the two-minute timer T which controls the timed release of connection as will hereinafter appear.

Fig. 13, part 7, shows the code ringing device 1363 including control cams A to C and code cams 1 to 0.

Detailed Description

The system to which the invention is applied having been described generally, a detailed description of the operation of the apparatus shown will now be given. For this purpose, the setting up of a local connection within tandem exchange C will first be described.

A. Local call in tandem exchange C from a pay-station line to a four-party line

Let it be assumed now that a subscriber at pay station #2031, Fig. 10, desires to converse with a subscriber on party line #202, Fig. 10, the subscriber at party-line substation #2024, for example.

A1. Marking the calling-line location

When the receiver 1024 at the calling pay stations is removed, hookswitch contacts 1030 close, connecting the receiver 1024 in circuit with the lower winding of induction coil 1021, through the illustrated condenser, and closing a direct-current bridge across the conductors of line #203, including the upper winding of induction coil 1021, the 90-ohm operating coil of the polarized magnet 1022 (in parallel with the 90-ohm shunt resistor 1023, which may be removed when the pay-station line has a high resistance), contacts of hookswitch 1030, transmitter 1026, and the impulse contacts of the calling device 1031.

When the conductors of calling line #203 are thus bridged, line relay 1009 of line circuit LC—203 operates, through contacts of cutoff relay 1007, placing the line circuit in calling condition, by grounding the associated tens and units mark conductors T and U, through contacts of lockout relay 1008.

A2. Selecting and operating an idle finder

It is to be observed that each of the line circuits illustrated in the drawings having individual T and U mark conductors, as have all the other line circuits. As indicated in Fig. 2, these conductors may all be carried over to the distributor DR, whereat they may be connected to the several T and U terminals, shown below the distributor. The grounding of a set of T and U conductors associated with any specific line circuit causes the usual control relays of the distributor DR (not shown) to operate to condition the distributor for setting a finder on the three-conductor line multiple associated with the calling line. The distributor DR thereupon takes an idle finder for use, the finder F1 (Fig. 11) for example. The finder F1 is indicated as idle to the distributor DR when test conductor 1201, normally connected to the associated hold conductor H of the link L1, is ungrounded. The finder F1 is taken for use by the operation of connecting relay 1200 over conductor 1203. Upon operating, relay 1200 connects up the twenty conductors associated with the twenty tens relays, some of which are omitted for ease of illustration, and it connects up the six conductors associated respectively with the units relays U1F to U5F and units-switching relay U6F.

In the present assumed example, the calling line circuit being LC—203, Fig. 10, the calling line multiple #203 is a multiple in the first or "2" hundreds group; it lies in the "0" level in that hundreds group, and it is line multiple 3 in the level. Accordingly, the marked condition of the T and U conductors of line circuit LC—203 causes the distributor DR, through the contacts of the operated connecting relay 1200 to operate the "0" tens relay T20F (Fig. 11) associated with the "2" hundreds group. The finder is thus conditioned to make connection with any one of the lines in the level containing the calling line.

Additionally, the distributor DR, through contacts of relay 1200, operates the third units relay U3F, thereby completing connection, through contacts of relay T20F, with the tip, ring, and sleeve conductors respectively of the calling line multiple #203.

A3. Preparing the associated connector for operation

The tip, ring, and sleeve conductors T, R, and S shown at the left of line circuit LC—203 are thereby extended, by way of conductors in cable CA—20, through contacts of relays T20F and U3F (Fig. 11), and through contacts of the unoperated relay U6F, to conductors T, R, and S respectively of the link L1 between the finder F1 of Fig. 11 and the connector C1 of Fig. 13. When this occurs, line relays 1305 and 1306 operate in series with each other over the calling line, being connected to the tip and ring conductors T and R of the link L1 through contacts of relays 1304 and 1301, such windings being now in multiple respectively with the lower and upper windings of line relay 1009.

Upon operating, each of the relays 1305 and 1306 closes an operating circuit for release relay 1307, to ground through contacts of relay 1301. At its inner lower contacts, release relay 1307 applies ground potential from normally grounded conductor 81 to local conductor 18, an extension of conductor H of the link L1.

The described application of ground potential to hold conductor H of the link L1 results in the closing of a locking circuit thereover for the winding of the operated units relay U3F, and in the closing of a locking circuit, through resistor 1100, for the winding of the operated tens relay T20F.

A4. Advancing the distributor

The ground potential on said hold conductor H is extended, through contacts of the operated connecting relay 1200 to the kick-off conductor 1202 of the distributor DR, causing the distributor to clear out from the link L1, and to restore relay 1200, in the usual manner. When this occurs, the initial circuits of the now-operated relays T20F and U3F are opened, but these relays remain operated in their above-mentioned locking circuits to the now grounded conductor H of the link L1. On restoring relay 1200 applies ground potential from the associated conductor H to test conductor 1201, causing the finder-connector link to test busy to the distributor DR until the connection now under consideration has been cleared out.

In the connector C1, at the upper armature of relay 1307, ground potential is applied to local conductor 5, a local extension of sleeve conductor S of the link L1. This ground potential is obtained over two paths. One path is from ground, through the upper winding of detector relay 1308, to the front contact of the upper armature of release relay 1307. The upper winding of detector relay 1308 is effectively shunted for the time being by ground potential applied to conductor 5 over the second path: from ground, through normally closed contacts of the switching and busy relays 1319 and 1320, and over conductor 15, to the said front contact of relay 1307.

A5. Clearing the calling line circuit

As the result of the above application of ground potential to local conductor 5, sleeve conductor S of the link L1 becomes grounded, thereby extending ground potential, through contacts of the operated relays U3F and T20F of the finder F1, to the sleeve conductor of line multiple #203, being the line multiple of the calling pay-station line #203, Fig. 10. When this occurs, cutoff relay 1007 operates over the associated grounded sleeve conductor S in series with lockout relay 1008. Upon operating, relay 1007 disconnects and restores line relay 1009 thus clearing the line circuit for the dialing of the desired number. Lockout relay 1008 upon operating makes certain circuit preparations which are ineffective at this time because of the now-restored condition of line relay 1009.

A further result of the above-mentioned application of ground potential to local conductor 5, at the front contact of the upper armature of release relay 1307, is the closing of a circuit for sleeve relay 1309, from ground on conductor 5, through contacts of reverting-call relay 1310, and contacts 64. Sleeve relay 1309 accordingly operates. At its middle lower armature (Fig. 13, part 6), relay 1309 connects release-timer relay 1303 to pickup conductor P1 of the common timer T, thereby starting the "permanent-timing" operation to be described hereinafter. At its lower contacts, sleeve relay 1309 grounds start conductor 1356 so as to start the timer T into operation.

At its inner lower contacts, relay 1309 connects ground supply conductor 81 to local conductor 17. Local conductors 17 and 18 are maintained grounded by relays 1309 and 1307, respectively, in addition to which conductors 17 and 18 are joined together through contacts of reverting-call relay 1310 and through contacts of busy relay 1320. For most purposes, therefore, during the operation of the connector, conductors 17 and 18 may be considered as one conductor held grounded both by release relay 1307 and by sleeve relay 1309.

Sleeve relay 1309, at its inner upper armature, disconnects the common all-finders-busy conductor AFB from its normal connection to ground in connector C1, leaving this conductor grounded at such of the connectors as remain idle. The distributor DR may be arranged to remain quiescent under a calling condition of one or more lines when all of the associated links are in use.

At the front contact of its inner upper armature, sleeve relay 1309 prepares an impulse circuit over conductors 11 and 25 in series for the counting relays in Fig. 13, part 4.

At its upper contacts, sleeve relay 1309 joins conductor 2 to counting-relay locking conductor 1, thereby grounding conductor 1 from ground on the grounded local conductor 17.

A6. Transmitting the dial-tone signal

The above grounding of conductor 1 by sleeve relay 1309 results in the closing of a circuit, through the inner upper contacts of relays 1327 and 1323, for the upper winding of dial-tone relay 1324. Relay 1324 thereupon operates to complete the preparation of the connector C1 for the receipt of the first or hundreds digit in the desired number, the operated relays of the connector now being 1305 to 1307, 1309, and 1324.

Dial-tone relay 1324, at its upper contacts, connects the common dial-tone lead DT, through contacts of code ring relay 1317, contacts 75 of busy-verification relay 1311, and small-capacity condenser 1358 to the associated tip talking conductor. As a result of this connection, a dial-tone signal is transmitted back through the operated finder F1 to the calling pay station #2031 (Fig. 10) to inform the calling subscriber there-

at that he may now dial the digits (2, 0, 2, and 4) in the desired number.

Each time the calling device (or "dial") CD' at pay station #2031 is operated in accordance with a digit of the desired number (constituting a forward movement of the dial thereof, not shown, to the desired digit position and the usual spring-driven return movement of such dial to generate the selected number of impulses), off-normal spring 1032 is permitted to move to the left to engage its associated shunt contacts, thereby shunting the receiver 1024 and the transmitter 1026, so as to avoid the production of clicks in the ear of the calling subscriber and to improve the dialing circuit.

A7. Dialing the hundreds digit (2)

When the hundreds digit 2 is dialed, a series of two impulses (circuit interruptions) is produced at springs 1031. When this occurs, the ground-connected line relay 1306 in the connector C1 is momentarily restored twice. It is immaterial whether or not the battery-connected line relay 1305 follows the received impulses, which it may not when the line insulation is faulty. Assuming that relay 1305 follows the impulses, the circuit of release relay 1307 is interrupted twice momentarily by relays 1305 and 1306, but relay 1307, being slow-releasing, remains operated, having a copper sleeve surrounding its core, as indicated by the double vertical lines.

Each time it restores, line relay 1306 delivers an impulse to series relay 1321, so called because it operates responsive to the first impulse of the series and, being slow-restoring, remains operated throughout the series. The first impulse delivered to series relay 1321 is by way of the following circuit path: from ground by way of armature 65 (of switch-through relay 1301) and its back contact, contacts of the momentarily restored line relay 1306, inner upper armature of sleeve relay 1309 and its front contact, conductor 11, back contacts of busy and switching relays 1320 and 1319, conductor 25, back contacts of driver relays 1332 to 1330, conductor 26, and through the winding of series relay 1321, to battery.

At its upper armature, series relay 1321 shunts resistor 1360 around battery-connected line relay 1305 to improve the dialing circuit for line relay 1306. At its inner lower armature, series relay 1321 disconnects grounded conductor 17 from conductor 27 and transfers it to the winding of series auxiliary relay 1326 thereby operating the latter relay.

Series auxiliary relay 1326, upon operating responsive to the operation of series relay 1321, prepares at its lower contacts a locking circuit for the #1 counting relay 1333, and it makes certain other circuit changes which are of no effect at this time.

The impulses delivered over conductor 25 to series relay 1321 by line relay 1306 are also passed over conductor 25 to the counting relays of Fig. 13, part 4. Resistor 1359 its connected between battery and conductor 25 to reduce any tendency to sparking at the back contacts of line relay 1306.

The first impulse delivered over conductor 25 passes through contacts of driver relays 1332 to 1330 to the #1 counting relay 1333. Relay 1333 thereupon operates and prepares an operating circuit for the #2 counting relay at its upper contacts, while at its contacts 96 it completes a locking circuit for itself in series with the first driver relay 1330. Driver relay 1330 does not operate immediately in this locking circuit for it is supplied with ground potential at both terminals until the impulse is terminated.

When line relay 1306 reoperates at the end of its first momentary restoration of the series and thereby removes ground potential from impulse conductor 25, it opens the initial circuit of slow-acting series relay 1321 and also opens the initial circuit of the #1 counting relay 1333. Relay 1321 remains operated because it is a slow-restoring relay, and relay 1333 remains operated in the following locking circuit: from ground on the now-grounded conductor 1, through the inner upper contacts of the second driver relay 1331, the winding of the first driver relay 1330, locking contacts 96 of counting relay 1333, inner lower contacts of the operated series auxiliary relay 1326, and through the winding of counting relay 1333, to battery. Relay 1333 remains operated, and relay 1330 now operates over the above-traced locking circuit.

At its lower contacts, relay 1330 joins conductors 27 and 37 for a purpose to appear hereinafter; at its inner upper contacts, it disconnects the third driver relay 1332 from locking conductor 1; at its middle upper armature it disconnects impulse conductor 25 from the now-operated and locked #1 counting relay 1333, and prepares an operating circuit over conductor *a* for the second counting relay 1334; while at its upper contacts driver relay 1330 disconnects impulse conductor 25 from conductor 26, thereby including resistor 1361 in circuit with series relay 1321. The arrangement is such that relay 1321 receives a strong impulse over a direct circuit path, excluding resistor 1361, to operate it initially, but is energized thereafter by reduced current through resistor 1361 as the succeeding impulses arrive, whereby slow-restoring relay 1321 operates promptly upon the receipt of the first impulse of the series, and restores rather promptly following the termination of the last impulse in the series.

When the second and last momentary impulse in the series comprising the hundreds digit 2 is received over conductor 25, this impulse is delivered, through back contacts of the unoperated driver relays 1331 and 1332, and through the middle upper armature and front contact of the operated driver relay 1330, to conductor *a*, whence it is delivered, through the upper contacts of the operated #1 counting relay 1333, to the #2 counting relay 1334. Counting relay 1334 thereupon operates and locks itself in series with the second driver relay 1331 to the grounded counting-relay-locking conductor 1, relay 1331 remaining unoperated for the time being as noted in connection with relay 1330.

When the second and final impulse in the hundreds digit 2 is terminated, the initial circuit of counting relay 1334 is thereby opened, whereupon relay 1331 operates in the locking circuit of relay 1334. At its middle upper armature, relay 1331 transfers impulse conductor 25 from conductor *a* to conductor *b*, while, at its inner upper armature, it open-circuits and restores the first driver relay 1330, along with the #1 counting relay 1333 which was previously locked in circuit therewith. Each driver relay has a spark-quenching resistor associated therewith, as shown.

Counting relay 1333 and driver relay 1330 have been operated and restored as described, and counting relay 1334 is held operated in its locking

circuit in series with the now-operated driver relay 1331.

A8. The counting-relay arrangement

The counting-relay circuit herein disclosed is the well-known arrangement for counting up to ten impulses in a series. The three driver relays (1330 to 1332) operate successively in regular rotation as the impulses of a series arrive. When a received series contains the full number (ten) of impulses, the first counting relay 1333 is operated as previously noted through normally closed contacts of all three driver relays, while the second, fifth, and eighth counting relays are operated over conductor *a*, through contacts of the driver relay 1330 and with relays 1331 and 1332 in restored condition; the third, sixth, and ninth counting relays are operated over conductor *b*, through the front contact of the middle upper armature of relay 1331, relays 1330 and 1332 being in restored condition at such times; and the fourth, seventh, and tenth counting relays are operated over conductor *c*, through the front contact of the middle upper armature of relay 1332, relays 1330 and 1331 being in restored condition at such times. The arrangement is such that any of the three driver relays 1330 to 1332 on operating open-circuits and restores the previously operated driver relay along with the counting relay last operated and locked in series therewith. The counting relays are thus operated and restored progressively, the action being wave-like. Generally speaking, therefore, only one counting relay at a time is in effective operated condition, but there is a slight overlap, following the operation of a new counting relay, before the newly received impulse is terminated, and the preceding counting relay is restored by the operation of the concerned driver relay. Because of this slight overlap in time, when two adjacent counting relays may be operated, separate hundreds-digit relay-operating conductors 38 and 39 are provided, and are connected to alternate contacts in the hundreds levels of contacts of the counting relays. Hundreds conductors 38 and 39 are arranged to be separated from each other by the disclosed circuit arrangements after the hundreds digit operation has been carried out, thereby preventing a relay locked as a result of the hundreds digit from effecting another hundreds-digit relay when the counting relays operate responsive to the succeeding digits in the number. For a similar purpose, separate conductors 40 and 41 are associated with alternate counting-relay contacts in the tens level thereof associated with the "2" hundreds group; separate conductors 42 and 43 are associated with the "4" hundreds group; separate conductors 44 and 45 are associated with alternate contacts in the units level of counting-relay contacts; and separate party conductors 31 and 32 are connected to alternate contacts in the party level of counting-relay contacts to avoid the momentary joining together (during a dialing operation) of adjacent ones of the common code conductors in cable 1314.

A9. The hundreds selection

Slow-restoring series relay 1321 restores shortly following the receipt of the second and last impulse in the hundreds digit 2. When it does so, it open-circuits and restores series auxiliary relay 1326 at the front contact of its inner lower armature. At the back contact of the inner lower armature of series relay 1321, ground potential (from the grounded local conductor 17) is transmitted over conductor 27, and through contacts of any operated one of the driver relays 1330 to 1332 (in this case driver relay 1331), conductor 37, armatures 86 and 87 of transfer-auxiliary relay 1322 and their back contacts, middle lower and lower armatures of dial-tone relay 1324 and their front contacts, and armatures 92 and 93 and their back contacts, to the hundreds operating conductors 38 and 39 connected respectively to alternate ones of the contacts in the hundreds level of counting-relay contacts. At this time, only the second counting relay 1334 is in operated condition. As a result, the only circuit closed through the hundreds level of counting relay contacts at this time is: from ground potential on conductor 38, through the hundreds contacts of counting relay 1334, and over conductor 2 in cable 1365, to battery through the lower winding of hundreds-transfer relay 1327. Hundreds transfer relay 1327 thereupon operates.

At its inner upper contacts, relay 1327 open-circuits the upper winding of dial-tone relay 1324, but dial-tone relay 1324 does not restore as a result of this, for it is held operated in a locking circuit including its lower winding and the left-hand front contact of its now-grounded middle lower armature.

At its middle upper armature, hundreds-transfer relay 1327 prepares a circuit for locking series-auxiliary relay 1326 on the next operation thereof.

At its upper armature, relay 1327 grounds branch locking conductor 49, by connecting it with the grounded conductor 17, thereby closing a locking circuit, through back contacts of relays 1328 and 1329, for the lower winding of hundreds-transfer relay 1327.

A10. Preparing for the receipt of the tens digit

At the normally closed contacts controlled by the upper armature of hundreds-transfer relay 1327, the grounded conductor 17 is disconnected from conductor 2, thereby depriving counting-relay-locking conductor 1 of ground potential. When this occurs, the counting and driver relays in Fig. 13, part 4, clear out, the operated ones of these relays (1331 and 1334) restoring. The restoration of relay 1334 disconnects conductor 2 of cable 1365 from its source of ground potential by way of hundreds conductor 38, but hundreds-transfer relay 1327 remains operated over its above-noted locking circuit including conductor 49. The restoration of driver relay 1331 also disconnects conductors 27 and 37 from each other thereby depriving conductor 37 (and consequently hundreds conductors 38 and 39) of ground potential. The locking circuit of dial-tone relay 1324 (including the lower winding thereof) is thereby opened, whereupon dial-tone relay 1324 restores. Upon restoring, dial-tone relay 1324 opens the dial-tone signaling circuit at its upper contacts, while at its middle lower armature and its lower armature, it disconnects the hundreds conductors 38 and 39 and substitutes the tens conductors 40 and 41 of the "2" hundreds group, hundreds-selection relay 1328 not having been operated.

A11. Dialing the tens digit (0)

When the tens digit 0 in the desired number is dialed, line relay 1306 is thereby restored ten times momentarily to deliver a series of ten impulses over conductor 11 to conductor 25, and thence to the counting relays of Fig. 13, part 4. Series relay 1321 is operated as before and re-

mains operated throughout the series of impulses. Series-auxiliary relay 1326 again responds to the operation of relay 1321. At this time, it connects conductor 2 (and consequently the counting-relay locking conductor 1) to ground on conductor 17 at its upper contacts, through the upper contacts of units transfer relay 1323.

With hundreds transfer relay 1327 having been operated and locked as described, and with dial-tone relay 1324 now in restored condition, series auxiliary relay 1326 closes a locking circuit for itself at the front contact of its inner upper armature as follows: from ground on conductor 17, through the back contact of the inner upper armature of tens-transfer relay 1325 and the said armature, middle upper contacts of hundreds-transfer relay 1327, inner upper armature of relay 1326 and its front contact, inner lower contacts of the restored dial-tone relay 1324, and thence to battery through the winding of series auxiliary relay 1326.

A12. The tens selection

The counting relays 1333 to 1342 operate successively as previously noted, the operation being accompanied and controlled by the successive operation, in a recurring cycle, of the driver relays 1330 to 1332. Upon the delivery of the tenth and final impulse of the series (which occurs with the #9 counting relay 1341 operated, and all the preceding counting relays restored, and with driver relay 1332 operated and driver relays 1330 and 1331 restored, the #0 counting relay 1342 operates and locks itself in series with the driver relay 1330 to the locking conductor 1. Consequently, when the tenth and final impulse in the series is terminated, opening the initial circuit of counting relay 1342, this counting relay remains operated, and driver relay 1330 operates, in a locking circuit including the inner lower contacts of relay 1342, the winding of relay 1330, and conductor 1.

When driver relay 1330 operates, it open-circuits and restores driver relay 1332 along with the #9 counting relay 1341. The only counting and driver relays now in operated condition are driver relay 1330 and counting relay 1342.

When series relay 1321 restores at the end of the tens digit, it opens the initial circuit of relay 1326, but relay 1326 remains operated for the time being over its previously described locking circuit. Relay 1321 also applies ground to conductor 27, extending ground through contacts of driver relay 1330, over conductor 37, armatures 86 and 87 and their back contacts, the middle lower and lower armatures of the restored dial-tone relay 1324 and their back contacts, and armatures 94 and 95 and their back contacts, to the tens conductor 40 and 41 associated with the "2" group of line multiples. With the #0 counting relay 1342 in operated condition, the ground potential on conductor 40 extends, through contacts of relay 1342, and over conductor 20 in cable 1366, to the tenth tens relay T20C, in the "2" hundreds group.

Tens relay T20C now operates, and connects the ten line multiples represented by the thirty conductors in cable CA—20 respectively to the ten sets of units conductors controlled by units relays U1C to U5C and units switching relay U6C. Relay T20C also prepares a locking circuit for itself by connecting its winding with the associated locking conductor 36, thereby extending ground potential over locking conductor 36, through resistor 1367, normally closed contacts controlled by the inner lower armature of units-transfer relay 1323, lower armature of the operated hundreds-transfer relay 1327 and its front contact, to the free terminal of the winding of tens-transfer relay 1325. Tens transfer relay 1325 thereupon operates. At armatures 92 and 93, it connects the units conductors 44 and 45 to the now-open front contacts of the restored dial-tone relay 1324. At its middle upper armature, relay 1325 closes a locking circuit for itself to the grounded conductor 17, thereby locking the tens relay T20C operated through the current-reducing resistor 1367.

A13. Preparing for the receipt of the units digit

At its inner upper armature, tens-transfer relay 1325 breaks the locking circuit of series-auxiliary relay 1326 and prepares a new operating circuit for dial-tone relay 1324. When this occurs, series-auxiliary relay 1326 restores and ungrounds the counting-relay locking conductor 1 at its upper contacts, thereby again clearing out the counting chain.

Dial-tone relay 1324 is now reoperated in a circuit from ground on conductor 17, through the back contact of the inner upper armature of relay 1326 and said armature, middle upper contacts of the operated hundreds-transfer relay 1327, inner upper armature of tens-transfer relay 1325 and its right-hand front contact, the inner upper armature of units-transfer relay 1323 and its back contact, to the upper winding of dial-tone relay 1324. At the left-hand front contact of its middle lower armature, relay 1324 again prepares a locking circuit for its lower winding, while at the right-hand front contact of its middle lower armature and at the front contact of its lower armature, it again makes connection with armatures 92 and 93, this time preparatory to the exercising of units control over units conductors 44 and 45, at the end of the units digit.

A14. Dialing the units digit (2)

When the units digit 2 is dialed, two momentary impulses are delivered by line relay 1306 over conductors 11 and 25 to the counting relays of Fig. 13, part 4, causing the #2 counting relay 1334 to operate and lock. Series relay 1321 responds again at the beginning of the first impulse of the series and again operates series-auxiliary relay 1326. At its upper contacts, relay 1326 again extends ground potential to counting-relay-locking conductor 1 to enable the counting operation to proceed. With relays 1324, 1325, and 1327 in operated condition, series-auxiliary relay 1326 is again locked operated, this time over a circuit path from ground on conductor 17, through contacts 90 of relay 1324, left-hand front contact of the inner upper armature of relay 1325 and said armature, middle upper contacts of relay 1327, inner upper armature and front contact of relay 1326, inner lower contacts of relay 1325, and through the winding of relay 1326, to battery.

A15. The units selection

When series relay 1321 restores at the end of the impulse series constituting the units digit 2, and reapplies ground potential to conductor 27, conductor 37 consequently becomes grounded (through contacts of the then operated driver relay 1331), extending ground potential through contacts 86 and 87, the middle lower and lower armatures of the reoperated dial-tone relay 1324 and their front contacts, and armatures 92 and 93 and their front contacts, to the units conduc-

tors 44 and 45 associated with the units level of contacts of the counting relays.

With the #2 counting relay 1334 now operated, the ground potential on conductor 44 is extended, by way of units conductor U2, to the #2 units relay U2C (Fig. 13, part 5). Relay U2C now operates to complete the extension of the tip, ring, and sleeve conductors of the out links OL, through contacts of the operated tens relay T20C to the conductors in cable CA—20 constituting the line multiple #202, being the multiple of the desired called line.

The conductors of the out link OL are open at this time in the connector; the tip and ring conductors are open at contacts 84 and 85 of switching relay 1319, and the sleeve conductor is open at the front contact of the lower armature of series relay 1321.

When the units relay U2C is operated by ground potential on conductor U2 as previously described, it prepares a locking circuit for itself and closes an operating circuit at its lower armature for units-transfer relay 1323. This circuit includes back contacts of units relays U3C to U5C, and conductor 35. Units-transfer relay 1323 now closes a locking circuit for itself and completes the prepared locking circuit of units relay U2C by connecting the grounded conductor 17 to conductor 35 at its upper armature and front contact. As its inner upper armature, units-transfer relay 1323 open-circuits the upper winding of dial-tone relay 1324, and prepares a circuit for auxiliary-transfer relay 1322, through contacts of dial-tone relay 1324, but dial-tone relay 1324 remains operated temporarily in its previously described locking circuit including its lower winding.

A16. Preparing for the receipt of the party digit

At its inner lower armature, units-transfer relay 1323 transfers the tens-relay locking conductor 36 from its previous connection to ground on conductor 17 (through the lower armature and front contact of relay 1327 and the upper contacts of units-transfer relay 1325) to a new connection with conductor 17, by way of conductor 49 and the upper armature and front contact of hundreds-transfer relay 1327. At the back contact of its upper armature, units-transfer relay 1323 disconnects ground from conductor 2, and consequently from the counting-relay-locking conductor 1, thereby restoring the operated driver relay 1331 and the operated counting relay 1334. The initial circuit of units relay U2C is thus broken, but relay U2C remains operated over its above-described locking circuit. Upon the separation of conductors 27 and 37 at the lower contacts of driver relay 1331, the locking circuit of dial-tone relay 1324 is broken. Dial-tone relay 1324 thereupon restores and disconnects conductors 44 and 45 from each other and from conductor 37, at the same time opening another point in the previously existing locking circuit of its lower winding. At armature 90, dial-tone relay 1324 opens the currently existing locking circuit of series-auxiliary relay 1326, whereupon relay 1326 again restores.

Upon restoring at this time, relay 1326, at its inner upper armature and back contact, completes a circuit for the upper winding of auxiliary-transfer relay 1322, as follows: from ground on conductor 17, through the back contact and inner upper armature of relay 1326, middle upper contacts of relay 1327, inner upper armature and right-hand front contact of relay 1325, inner upper armature and front contact of units-transfer relay 1323, contacts 91 of the restored dial-tone relay, conductor 9, contacts of supervisory relay 1304, conductor 10, and through the upper winding of auxiliary relay 1322, to battery. Relay 1322 thereupon operates, and locks itself to conductor 17 at its inner upper contacts, over a circuit path including conductors 9 and 10 and contacts of relay 1304; and at armatures 86 and 87, it disconnects conductor 37 from each of the tens conductors 40 and 41 to which such conductor was connected upon the last-described restoration of dial-tone relay 1324 so as to avoid the possibility of any further and unintended tens-relay operation during the dialing of the party digit which is to follow.

A17. Dialing the party digit (4)

When the party digit 4 is dialed, the four impulses constituting such digit are delivered to the counting relays with results as hereinbefore described. When the last impulse has been delivered and terminated, the #4 counting relay 1336 is in operated condition with all the other counting relays in restored condition, and driver relay 1330 is operated in the locking of counting relay 1336, driver relays 1331 and 1332 being in restored condition.

At the beginning of the delivery of the party-digit series of impulses, series relay 1321 again operates and brings about the operation of series auxiliary relay 1326. Upon operating, relay 1326 extends ground potential to the counting-relay locking conductor 1 as above to enable the counting operation to proceed. At this time, the ground potential is extended to conductor 1 from conductor 17, through the inner upper contacts of the operated relay 1322, conductor 9, contacts of relay 1304, conductor 10, middle upper contacts of relay 1322, upper contacts of relay 1326, conductor 2, and the upper contacts of relay 1309 to conductor 1. Series-auxiliary relay 1326 locks itself at this time over the following circuit path: from ground on conductor 17, through the inner upper contacts of relay 1322, contacts 91, front contact and inner upper armature of relay 1323, right-hand front contact and inner upper armature of relay 1325, middle upper contacts of relay 1327, inner upper armature and front contact of relay 1326, inner lower contacts of relays 1324 and 1325 in parallel, and thence to battery through the winding of relay 1326.

A18. Testing the called line

During the receipt of the party digit of the number, the called line is tested to determine whether or not it is in idle condition. This test is made by test relay 1318, through its upper or test winding.

When series relay 1321 responds at the beginning of the receipt of the series of party-digit impulses, at its lower armature and front contact, it extends ground over conductor 23, contacts of release relay 1307, and conductor 22, to the lower terminal of the upper winding of test relay 1318. The other terminal of this winding is connected to the sleeve conductor S of the out link OL and this sleeve conductor is now connected to the sleeve conductor of the line multiple #202 of the called line, as previously explained (through contacts of relays U6C, U2C, and T20C. If called line #202 is idle, there is a battery potential on the sleeve conductor of the called multiple #202, by way of the windings of cutoff and lockout relays 1004 and 1005 of line circuit LC—202 (Fig. 10), with the result that

relays 1005, 1004, and 1318 all operate in series with each other.

A18a. The called line is busy

If the called line is idle and test relay 1318 is consequently operated in the explained manner, busy relay 1320 is prevented from operating at the end of the party digit because its then-prepared circuit is opened at the lower contacts of test relay 1318. Let it be assumed, however, that the called line is busy, in which case the called sleeve conductor is grounded, and relay 1318 fails to operate. In this event, when slow-restoring series relay 1321 restores at the end of the party digit, it terminates the testing operation by removing the testing ground connection from the sleeve conductor of the called multiple.

With relay 1322 operated and locked; with relay 1326 having been reoperated and locked; and with test relay 1318 having failed to operate; when relay 1321 restores, it completes a circuit at its lower contacts, from ground on conductor 17, through the lower contacts of test relay 1318, contacts 89 of auxiliary relay 1322, the lower contacts of the series-auxiliary relay 1326, conductor 21, and thence to battery through the winding of busy relay 1320. Busy relay 1320 thereupon operates.

At its inner upper armature, busy relay 1320 opens the counting-relay impulse circuit by disconnecting conductor 11 from conductor 25, whereby the setting of the counting relays cannot be disturbed, nor can series relay 1321 be subsequently operated, by any further dialing.

A18a(1). Conditioning the connector for operation as a local connector

At the back contact of its inner lower armature, busy relay 1320 removes ground potential from conductor 15, thereby removing the shunt previously existing around the upper or test winding of detector relay 1308, thereby placing such upper winding effectively in series with the sleeve lead S of the link L1 to enable it to be determined whether or not the connector is to act as a toll connector, or is to be conditioned to act as a local connector.

In the present example, the connector C1 is to act as a local connector, for the call is not from a manual exchange, and the sleeve conductor of the multiple of the calling line is consequently not now grounded outside of the connector. The upper winding of detector relay 1309 is, therefore, energized over the sleeve lead of the calling line in series with cutoff and lockout relays 1007 and 1008 of line circuit LC—203. Detector relay 1308 now operates and locks itself to conductor 17 at its lower contacts; shunts its upper winding at its inner upper contacts; at the back contact of its middle upper armature, it disconnects the lower winding of busy-verification relay 1311 to remove such relay from under the control of the calling, non-manual line; and at its inner lower contacts it connects up the common lead P2 pursuant to conversation timing.

A18a(2). Transmitting the busy signal

As a further result of its described operation, busy relay 1320, at its upper contacts, connects the common busy-tone lead BT to the upper incoming talking conductor, through contacts of relays 1317 and 1311 and condenser 1358, whereby a busy-tone signal is transmitted back to the calling substation to inform the calling subscriber that the desired line is busy.

The calling subscriber is now expected to replace his receiver to permit the switching apparatus involved in the attempted connection to clear out.

A18b. The called line is idle

Let it be assumed now that the desired line is idle when called. Under this condition, with series relay 1321 energized during the dialing of the party digit, test relay 1318 is energized over the sleeve conductor of the called multiple as previously explained. When it operates, test relay 1318 locks itself to conductor 5, a local extension of the now grounded incoming sleeve conductor of the link L1; it by-passes its upper winding at its inner upper contacts by applying ground potential directly to the sleeve conductor of the called multiple; and at its lower armature, it opens a point in the circuit of busy relay 1320 and prepares a circuit for switching relay 1319.

A18b(1). Conditioning the connector for operation as a local connector

When series relay 1321 now restores at the end of the party digit, switching relay 1319 is operated in a circuit from the grounded conductor 17, through the lower contacts of series relay 1321, and the lower armature and front contact of the operated test relay 1318. Upon operating, switching relay 1319, at its inner upper armature, opens the dialing circuit over conductor 25 to prevent a further response of series relay 1321 and a change in the setting of the counting relays in case the calling subscriber should dial a further digit. At its inner lower contacts, switching relay 1319 removes ground potential from conductor 15 thereby permitting detector relay 1308 to operate as hereinbefore described to change the connector over from toll operation to local operation, which at this time consists principally in the closing of the lower contacts of relay 1308 to connect up the common conductor P2 to release-timer relay 1302, for the purpose of conversation timing, to be described hereinafter.

At its armatures 84 and 85, switching relay 1319 closes points in the ringing circuit and prepares the talking circuit; at its lower contacts, it connects up pickup relay 1316, preparatory to a starting of the ringing operation in accordance with the code assigned to the called party-line substation, while at its armature 97 it applies ground potential, through the lower contacts of auxiliary-transfer relay 1322, to the start conductor ST in cable 1364, thereby starting the code generator 1363 into operation in any desired manner.

A19. The code-ringing arrangement

Code generator 1363 is illustrated as comprising a number of cams on a common shaft arranged to be rotated in a clockwise direction. Cam A is arranged to control the application of locking ground potential to the common conductor 1362; cams B and C are arranged to control the momentary application of ground potential to pickup leads PU—1 and PU—2; and cams 1 to 9 and 0 are code generating cams, each arranged to generate a separate one of ten ringing codes. Additionally, each cam 1 to 0 is arranged to generate a preliminary impulse ahead of its code, and circuit arrangements are provided for causing the preliminary impulse to be effective, or not, depending upon whether or not pickup lead PU—2 is substituted for lead PU—1. The second pickup lead is used only when the alternative hundreds digit is employed in calling a line in one or the other of the hundreds groups. In the

present example, the normally assigned hundreds digit has been called, as a consequence of which relay 1329 has not been operated, and pickup lead PU—1 remains connected. Therefore, no pickup impulse is received in the connector C1 to start the ringing operation until after the preliminary code impulse has been transmitted by cams 1 to 0, whereby only the regular code of the selected one of these cams is effective.

A20. Transmitting the selected ringing code

When lead PU—1 is next grounded, by cam B of device 1363, a circuit is closed through the lower contacts of relay 1329, contacts controlled by the lower armature of pick-up relay 1316, and the lower contacts of relays 1319 and 1313, for pickup relay 1316. Upon operating, relay 1316 locks itself at its lower armature to the common locking lead 1362, normally grounded at the contacts of cam A, at the same time disconnecting itself from pickup lead PU—1.

At its inner armature, pickup relay 1316 joins party conductors 31 and 32 together and connects them to the winding of code-ring relay 1317. As a result, the code generated by the selected code cam of device 1363 is transmitted to the winding of code ring relay 1317 over the following circuit: from ground, through the contacts controlled by code cam 4 of the device 1363, conductor 4 in cable 1364, the lower contacts of the operated #4 counting relay 1336, party conductor 31, contacts of pickup relay 1316, and thence to battery through the winding of code-ring relay 1317. Relay 1317 accordingly follows the impulses generated by the selected code cam and imparts a corresponding code of ringing current to the called line at its upper armature. This upper armature disconnects the tip conductor of the called line from ground and transfers it to the common generator lead 80, whereby ringing current from this lead is transmitted over the tip conductor to the called line through the upper contacts of relays 1314, 1313, and 1319. A return path for ringing current is provided over the ring conductor of the called line and associated multiple through contacts 85 of relay 1319, armature 77 and its back contact, contacts of relay 1314, the winding of ring-trip relay 1315, and through the exchange battery, to ground.

The ringers at all of the substations on the called four-party line #202 (Fig. 10) are thereby operated in accordance with the selected #4 code.

Ring-trip relay 1315, being of the indicated retarded construction (a conducting sleeve surrounding the core beneath the winding and a conducting collar over the core between the end of the winding and the armature proper of the relay), is non-responsive to alternating current, and the flow of direct current over the circuit above traced is prevented by the condensers in circuit respectively with the ringers on the called line.

At its inner upper armature, code-ring relay 1317 transmits the ringing code back to the calling line, through contacts 75 and current-limiting condenser 1358, giving a mild ring-back signal in the receiver at the calling substation.

At the end of the first code period, the illustrated notch in cam A of device 1363 permits the associated contacts to open momentarily, thereby momentarily removing ground potential from locking conductor 1362, whereupon pick-up relay 1316 restores and disconnects code-ring relay 1317 as well as transferring its own winding back from locking conductor 1362 to pickup lead PU—1. As a result of this arrangement, all code ringing operations are started under conditions above explained in connection with the starting of the first code-ringing operation.

A21. The answering operation

When the subscriber at called substation #2024 (Fig. 10) on called line # 202 answers, by removing his receiver (not shown), the resulting closure of the usual direct-current bridge across the conductors of the called line permits ring-trip relay 1315 to operate. The return circuit of relay 1315 to ground includes the common ringing lead 80 and the exchange generator if the receiver is removed during an application of ringing current, while it is directly to ground through the upper contacts of relay 1317 if the receiver is removed during a silent period.

Upon operating, relay 1315 operates ring-cut-off relay 1313 over conductors 18 and 31. At its inner lower contacts, relay 1313 locks itself to the grounded conductor 17 so as to maintain its circuit intact after relay 1315 has been disconnected and has restored; it disconnects pick-up relay 1316 at its lower contacts, whereupon pickup relay 1316 restores, if operated at the moment when answering occurs, and disconnects code-ring relay 1317; at armatures 78 and 79, relay 1313 makes certain circuit changes which have no particular effect on the type of call being considered; and at armatures 76 and 77, it disconnects the tip and ring conductors of the called line from the ringing circuit and completes the talking circuit. When this occurs, ring-trip relay 1315 restores, and back-bridge relay 1312 operates over the called line.

Supervisory relay 1304 now operates over conductor 16, through contacts of relay 1312. At its inner upper contacts, supervisory relay 1304 separates conductors 9 and 10, thereby open-circuiting relay 1322 and depriving counting-relay-locking conductor 1 of ground potential. The operated driver and counting relays of Fig. 13, part 4, clear out immediately, and the slow-restoring auxiliary-transfer relay 1322 falls back a moment later. When it does so, it opens a further point in its previously established locking circuit at its inner upper contacts.

At its inner lower, middle lower, and lower armatures, relay 1304 makes certain circuit changes having to do with changing over from "permanent" timing to conversation timing, to be hereinafter explained.

A22. Giving answered supervision

At armatures 71 and 72, supervisory relay 1304 reverses the connections between the incoming tip and ring conductors and the windings of line relays 1305 and 1306, thereby reversing the current flow in the calling line, which is pay station #203 (Fig. 10) in the present example.

A23. Disabling the calling pay-station instrument

At the calling pay station #2031, Fig. 10, when the current flow is reversed in the calling line, incident to the call having been answered as previously described, the polarity of the 90-ohm series coil of the polarized pay-station magnet 1022 is thereby reversed. When this occurs, the polarized armature of the pay-station magnet is operated in the usual manner to cause (A) contacts 1029 and (C) contacts 1027 to close. The (C) contacts connect up the 3,000-ohm shunt winding of the coil, but without any particular

effect so long as the hookswitch contacts 1030 are closed. Contacts 1029 place a direct shunt around transmitter 1026 to render such transmitter inoperative, and it places the 8-ohm resistor 1025 in shunt of the receiver 1024 to reduce the efficiency of the receiver sufficiently that it cannot be used as a transmitter, while leaving the receiver sufficiently operative to enable the calling pay-station subscriber to hear that the call has been answered.

A24. Coin deposit to render pay-station instrument again operative

The calling pay-station subscriber is now expected to drop a coin in the usual coin mechanism (not shown). When he does so, the (A) contacts 1029 are thereby again opened, and the (B) contacts 1028 are thereby closed to shunt the series 90-ohm coil of magnet 1022, leaving the 3,000-ohm shunt coil connected across the line through the C contacts 1027.

Upon the opening of the (A) contacts 1029, the transmitter 1026 is again unshunted and rendered operative, and the partial shunt is removed from around the receiver 1024.

The two subscribers may now converse with each other as desired.

A25. Disconnect supervision

Let it be assumed now that the called subscriber at substation #2024 is the first to replace his receiver when the conversation is terminated. When this occurs, the resulting restoration of back-bridge relay 1312 permits supervisory relay 1304 to restore. Relay 1304 again changes over from conversation timing to "permanent" timing, with results to be pointed out hereinafter. At armatures 71 and 72, it reverses the current flow in the calling line back to normal direction. This is of no particular effect at the calling pay station #2031 (Fig. 10) because the 90-ohm series winding has been shunted out at contacts 1028, and the 3,000-ohm shunt winding is of practically no effect as long as the hookswitch contacts 1030 are closed.

A26. Restoring the pay-station instrument to normal condition

When the receiver is subsequently replaced at the calling pay station #2031, the opening of hookswitch contacts 1030 leaves the associated line bridged only through the upper winding of induction coil 1021, the 3,000-ohm shunt winding of polarized magnet 1022, (C) contacts 1027, transmitter 1026, and calling-device contacts 1031. The 3,000-ohm shunt winding of magnet 1022 is thereupon effectively energized to restore any operated ones of the associated contacts 1027 to 1029 to their illustrated normal condition, whereupon contacts 1027 open the restoring-magnet circuit.

A27. Clearing out the connection

In the connector C1, Fig. 13, line relays 1305 and 1306 now restore and open the circuit of release relay 1307. Release relay 1307 restores after a slight interval. When it does so, it removes ground potential from conductor 5, a local extension of the incoming sleeve conductor S of link L1, whereupon sleeve relay 1309 restores, along with test relay 1318 and switching relay 1319. With relays 1307 and 1309 restored, the previously grounded local conductors 17 and 18 are both ungrounded, whereupon the locked-up relays 1308, 1313, 1323, 1325 to 1327, U2C, and T20C restore. The connector of Fig. 13 is thus returned to normal condition.

In the finder F, the previously operated tens and units relays T20F and U3F are unlocked and restored when conductor H of the link L1 becomes ungrounded as a result of the ungrounding of the local extension thereof (conductor 18) in the associated connector. Test conductor 1201 associated with finder F1 also becomes ungrounded to terminate the indicated busy condition of the finder in the distributor DR.

The clearing out of the connection ungrounds the sleeve conductors of the calling and called multiples, whereupon cutoff and lockout relays 1007 and 1008 of the line circuit LC—203 and 1004 and 1005 of the line circuit LC—202 restore, returning such line circuits to their illustrated normal condition.

B. "Permanent" timing at the connectors

As previously mentioned, arrangements are associated with each finder-connector link for clearing out any connection established thereto within two to four minutes, provided the complete number has not been dialed and the called subscriber has answered during this interval. Such arrangements in the connector C1 are controlled by release-timer relay 1303, in conjunction with the common two-minute timer T, as will be described.

It may be pointed out that a somewhat common cause of the failure of a call to be completed and answered within a reasonable time, following the taking of a link circuit for use responsive to an indicated calling condition on a line, is trouble on the line or at a substation thereon, such as the accidental upsetting of a desk telephone instrument, a shorted condition of a line, or a grounded condition of one of the conductors of the line. Such a condition is often referred to as a "permanent" condition to distinguish it from the ordinary calling condition, in which the call goes through as intended.

B1. Starting the timer

When the finder F1 operates as hereinbefore described to extend a calling line to the connector C1, line relays 1305 and 1306 of the connector C1 operate over the calling line, followed by the described operation in succession of release and sleeve relays 1307 and 1309. At its lower contacts, sleeve relay 1309 grounds common start conductor 1356 so as to start the timer T into operation. The arrangement in the timer T is such that cams 1351 to 1355 are slowly rotated in unison to make a complete revolution in about two minutes.

B2. Placing the connector under control of the timer

At its middle lower contacts, relay 1309 prepares a circuit for release-timer relay 1303 over pickup conductor P1, thereby placing the connector under the control of the timer.

Keeping in mind that the device T is common to all of the finder-connector links in the exchange and may be in operation at any given time because of the grounding of start conductor 1356 at any other link, it will be seen that the cams of the timer may be in any position whatever at the time sleeve relay 1309 operates to connect up conductor P1. Conductor P1, for example, may have been momentarily grounded just previously, by the passage of the illustrated notch in cam 1304 under the associated contact

spring, in which case conductor P1 will not again be grounded for approximately two minutes. On the other hand, the timer T may be about to ground conductor P1 momentarily when sleeve relay 1309 operates.

B3. Starting the two-minute time period

At the end of a preliminary time period which cannot exceed the two-minute interval required for a complete cycle of operations of the timer T, pickup conductor P1 is momentarily grounded by the action of cam 1304, thereby closing a circuit through contacts of relays 1304, 1303, 1309, and 1304, for release-timer relay 1303. Release-timer relay 1303 thereupon operates and locks itself to ground at armature 70, through contacts of relays 1309 and 1304. At armature 69, hold conductor H1 is substituted for the ground connection normally applied to conductor 81. Nothing occurs immediately as a result of this transfer, because conductor H1 is maintained grounded normally, being ungrounded momentarily only once during each cycle of operations of the timer T. By noting the relative position of the notches on cams 1354 and 1352, it will be seen that the notch on cam 1352 has passed beyond the associated contact spring when conductor P1 is grounded to cause relay 1303 to energize. Hold conductor H1, therefore, remains grounded for approximately the full two-minute period after relay 1303 is operated as described.

If, during this interval the number is dialed; the call is answered; and supervisory relay 1304 consequently operates, the locked release-timer relay 1303 is restored by the opening of its circuit at the inner lower contacts of supervisory relay 1304 (conductors 19 and 20 being separated at such time at contacts 88 of auxiliary-transfer relay 1322), and release-timer relay 1303 again applies ground potential directly to conductor 81 at the normally closed contacts controlled by armature 69, without the release of the connection having been forced.

Assume that, for some reason, a complete number has not been dialed, or the call has not been answered, during the two-minute time period. In this event supervisory relay 1304 has not operated; release-timer relay 1303 has not restored; and conductor 81 is still dependent on the common hold lead H1 for its ground supply. Then, when the notch in cam 1352 comes under the associated contact spring, at the end of the two-minute interval following the operation of relay 1303, ground potential is removed from conductor H1, and consequently ground potential from conductor 81.

B4. Forced release at the end of the two-minute period

Upon the above removal of ground potential from conductor 81, ground potential is consequently removed from conductors 17 and 18. The removal of ground potential from these conductors causes any relays in the connector C1, which derive holding current therefrom, to restore. At the same time, hold conductor H of the link L1 is deprived of current causing the finder F1 to clear out, disconnecting the link L1 from the calling line. Line relays 1305 and 1306 consequently restore, followed by the restoration of release relay 1307 to remove ground potential from conductor 5 and sleeve conductor S of link L1, with the result that sleeve relay 1309 restores. Sleeve relay 1309 unlocks and restores release-timer relay 1303 at its middle lower contacts, thus completing the clearing out of the finder-connector link.

B5. Locking out the "permanent" line

Assume that the calling line involved in the connection just described as having been cleared out by "permanent" timer action is the pay-station line #203 (Fig. 10) whose associated line circuit is LC—203. The consequent ungrounding of the sleeve lead of the calling multiple open-circuits the operated relays 1007 and 1008. Cut-off relay 1007 thereupon restores and reconnects line relay 1006. Before the slow-restoring lockout relay 1008 has had time to restore, line relay 1009 reoperates over the associated line (still in calling condition). With relay 1008 in operated condition, the inner contacts of line relay 1009 close a locking circuit for lockout relay 1008. The lower contacts of relay 1009 extend ground, through the lower armature and front contact of lockout relay 1008, to the associated alarm conductor A, to which any desired form of alarm signal (usually a delayed signal) may be connected. The alarm conductor A may be common to all of the line circuits of the exchange.

With lockout relay 1008 operated, no ground potential is extended to the associated T and U marking conductors, and no finder is therefore started. The locking ground potential applied to the junction of the windings of relays 1007 and 1008 appears on sleeve conductor S to guard the associated line from being seized as a called line.

When the "permanent" condition of line #203 is cleared, line relay 1009 restores permitting lockout relay 1008 to restore shortly, returning the associated line circuit LC—203 to its illustrated normal condition.

C. Conversation timing

Conversation timing, when effected, is performed in the connector C1 by release-timer relays 1302 and 1303 under the control of the common timer T, pickup leads P1 and P2, and hold leads H1 and H2 being used for this purpose. The performance of conversation timing is dependant upon the connector being conditioned to act as a local connector by the hereinbefore described operation of detector relay 1308 following the dialing of the last digit.

C1. Preparing for conversation timing

When detector relay 1308 operates, it connects up common pickup lead P2 preparatory to an operation of release-timer relay 1302 pursuant to conversation timing. This preparatory operation occurs at the same time that the called line is seized and is of no effect if the call is not answered, for in that case relay 1303 at its inner contacts invariably prevents relay 1302 from operating over lead P2.

Until the ringing operation has been performed as hereinbefore described and the called subscriber has answered and caused back-bridge relay 1312 to operate supervisory relay 1304, the "permanent" timing arrangement involving leads H1 and P1 and relay 1303 continued uninterrupted. If relay 1303 is operated over lead P1 before supervisory relay 1304 operates, it prevents, at its inner contacts, the operation of relay 1303 over lead P2 until relay 1304 has operated to restore relay 1303. This is invariably true because the grounding of lead P2 follows closely the grounding of lead P1 with a separation of less than a second, for example, during which time the connector cannot be taken for use and the complete number dialed up.

C2. Changing over from "permanent" timing to conversation timing

When the call is answered, and supervisory relay 1304 operates, auxiliary transfer relay 1322 is in operated condition as hereinbefore pointed out with the result that conductors 19 and 20 are separated at the inner lower contacts of supervisory relay 1304, disconnecting and restoring release-timer relay 1303 if it has been operated. Relay 1302 is thereby placed under the control of the common-timer lead P2. It will be recalled that supervisory relay 1304 at its inner upper contacts unlocks and restores auxiliary transfer relay 1322. At contacts 88, relay 1322 rejoins conductors 19 and 20 to prepare for a reoperation of relay 1302 pursuant to conversation timing. Relay 1322 is slow-restoring to give time for relay 1303 to restore and open its locking circuit at contacts 70 before conductors 19 and 20 are rejoined.

Pickup lead P1 is disconnected at the middle lower contacts of supervisory relay 1304 to prevent a reoperation of relay 1303 thereover for the time being.

C3. Starting the first full two-minute period

At the end of a variable interval of time (not exceeding two minutes) following the beginning of the conversation period, as indicated by the described operation of supervisory relay 1304 and the restoration (if operated) of release-timer relay 1303, common lead P2 is momentarily grounded by cam 1355, closing a circuit through contacts of the operated detector relay 1308, and through contacts of the restored release-timer relay 1303 for release-timer relay 1302. Relay 1302 thereupon operates and locks itself to conductor 17, through armature 68 and its back contact, at the same time disconnecting itself from the common conductor P2. At armature 67, relay 1302 prepares a new circuit for operating relay 1303 over lead P1.

C4. Starting the second two-minute period

Substantially two minutes after the described operation of relay 1302, lead P1 is again momentarily grounded thereby completing a circuit through contacts 67, normally closed contacts controlled by armature 70, middle lower contacts of sleeve relay 1309, conductor 20, contacts 88 of the now-restored auxiliary-transfer relay 1322, and conductor 19, for release-timer relay 1303. At armature 70, relay 1303 closes a locking circuit for itself independent of lead P1 and contacts 67 of relay 1302, and disconnects itself from lead P1. Relays 1303 and 1302 both now being in operated condition, armatures 69 and 66 maintain ground supply conductor 81 grounded. At armature 68, relay 1303 transfers the locking circuit of release-timer relay 1302 from the grounded conductor 17 to the normally grounded common hold conductor H2.

C5. Starting the third two-minute period

About two minutes later, lead H2 becomes momentarily ungrounded thereby unlocking and restoring relay 1302. Upon restoring, relay 1302, at its lower contacts, prepares a warning-pulse circuit over conductor 21, while at armature 66 and associated contacts, it transfers ground-supply conductor 81 to the normally grounded hold lead H1. Lead H1, being arranged to be ungrounded momentarily just ahead of the momentary ungrounding of the lead H2, accordingly remains grounded for substantially two minutes following the described restoration of relay 1302.

C6. Warning the conversing subscribers

Providing the conversation still continues, a warning pulse is delivered about a minute later over common conductor WP to warn the conversing subscribers that the connection is about to be released. This warning pulse is transmitted from conductor WP, through the lower contacts of the restored release-timer relay 1302, lower contacts of the operated release-timer relay 1303, lower contacts of supervisory relay 1304, and conductor 21, to busy relay 1320. Busy relay 1320 is operated for the duration (several seconds, for example) of this warning pulse. At its upper contacts, it applies a busy-tone signal from the common lead BT, through contacts 75 and condenser 1358, to the tip talking conductor. The conversing subscribers are thereby warned that the connection will be automatically cleared out about a minute later if conversation is still in progress at that time.

C7. Forced release at the end of the third two-minute period

Assuming that the conversation is not voluntarily terminated, the next time the timer T reaches its H1 position and momentarily ungrounds hold conductor H1 (approximately two minutes after the described restoration of relay 1302, and approximately six minutes after the described operation of relay 1302 over common lead P2), ground-supply conductor 81 is ungrounded because armature 69 of relay 1303 is in operated condition and armature 66 of relay 1302 is in restored condition. Ground potential is thereby removed from conductors 17 and 18, causing the connector C1 and the finder F1 to clear out as previously described. Each of the concerned line circuits is automatically locked out as described hereinbefore in connection with the line circuit LC—202 (Fig. 10). Such operation occurs within six to eight minutes after the called subscriber answers.

D. Timing following conversation

"Permanent" timing is accomplished following a conversation provided the calling subscriber does not replace his receiver to cause the connection to be cleared out in the normal manner following the termination of the conversation and the replacing of the receiver at the called substation.

If the calling subscriber replaces his receiver at the conclusion of a conversation, the established connection is thereupon cleared out whether the receiver has been replaced at the called substation or not, the line circuit associated with the called line being brought into lockout condition upon the clearing out of the connection if the called subscriber has not replaced his receiver.

Let it be assumed now that the calling subscriber, in a call through connector C1, Fig. 13, fails to replace his receiver after the conversation has terminated, but that the calling subscriber replaces his receiver after conversation and before the connection is cleared out by the conversation-timing arrangement hereinbefore described. Under this condition, back-bridge relay 1312 restores and permits supervisory relay 1304 to restore, as before described.

The effect upon the timing operation of the restoration of supervisory relay 1304 depends upon at what period in the conversation-timing

operation such restoration of supervisory relay 1304 occurs. If it occurs in the preliminary interval before release-timer relay 1302 has operated as hereinbefore described to start the first full two-minute period in the conversation-timing operation, the consequent reconnection of release-timer relay 1303 at the middle lower contacts of supervisory relay 1304 starts a "permanent" timing operation as hereinbefore described, in which relay 1303 is next operated over lead P1 to begin a two-minute interval, at the end of which lead H1 becomes ungrounded and the connection is thereby cleared out.

On the other hand, if the restoration of supervisory relay 1304 occurs at any time after release-timer relay 1302 has operated as hereinbefore described to begin the first full two-minute period in the conversation-timing operation, the restoration of supervisory relay 1304 has no effect upon the conversation-timing operation, other than to open the warning-pulse circuit to busy relay 1320. Therefore, if the calling subscriber fails to replace his receiver under these conditions, the conversation-timing operation proceeds to its described conclusion, and the forced release of the connection occurs approximately six minutes from the time of operation of release-timer relay 1302.

E. Absorbing the initial digit 1

The connectors are arranged to absorb the initial digit 1, because the dialing of the initial digit 1 is often inadvertently simulated at a calling substation during the act of removing the receiver, as by the bumping of the hookswitch after its contacts have been allowed to close. This may occur after a finder has operated to find the calling line and the associated connector has been prepared for operation. Such bumping of the hookswitch sometimes momentarily opens the contacts. Such an operation is termed a preliminary impulse, for it often produces the effect in the connector of the dialing of the digit 1. As a result, the initial digit 1 has not been assigned in the disclosed system, each of the connectors being arranged to absorb such digit when received, whereby the inadvertent transmission of a preliminary impulse during the act of removing the receiver does not prevent the calling subscriber from obtaining the number which he subsequently dials.

Referring now to the connector C1 (Fig. 13), it will be recalled that the locking circuit of the #1 counting relay 1333 includes contacts 96 and the inner lower contacts of series auxiliary relay 1326. When any digit of a number is dialed, series auxiliary relay 1326 responds to the operation of slow-restoring series relay 1321 by preparing a locking circuit for the #1 counting relay 1333 at its lower contacts. When the initial digit dialed is any digit other than 1, one or more additional counting relays is operated and the #1 counting relay 1333 is restored thereby. Series-auxiliary relay 1326 invariably restores at the end of the initial digit of the number, as hereinbefore described. Upon so doing, it open-circuits and restores the #1 counting relay 1333 at its lower contacts, if this relay has not been otherwise restored. The associated driver relay 1330 is thereby unlocked and restored, returning the relays of the counting chain to their illustrated normal condition. Such counting relays, therefore, operate in response to the following digit and treat such digit as the initial digit of the number, no interdigit transfer operation having taken place.

It will be recalled further that series-auxiliary relay 1326 is invariably locked operated temporarily following the dialing of any digit subsequent to an assigned initial digit, wherefore, counting relay 1333 is not unlocked at the inner lower contacts of relay 1326 if such subsequent digit is the digit 1.

F. Handling units digits having a value greater than 5

The disclosed units-relay arrangement of the connectors is such that five units relays and a units-switching relay are employed to make any desired one of ten units selections. Such relays in the connector C1 are shown in Fig. 13, part 5, being the units relays U1C to U5C and units-switching relay U6C. Relays U1C to U5C respond respectively to units digits 1 to 5. These same relays also respond respectively to the units digits 6 to 0, but the units-switching relay U6C responds to any digit having a value greater than 5.

The dual operation of relays U1C to U5C is secured by connecting each of the conductors U1' and U2 to U5 (Fig. 13, part 9) to two counting-relay armatures, as illustrated.

The bringing about of the operation of units-switching relay U6C when the units digit has a value greater than 5 is accomplished over conductor 6 of cable 1365, through contacts of the #6 counting relay 1338, and over conductor U6'. Conductor 6 in cable 1365 is energized by ground potential (through contacts of dial-tone relay 1324 and the middle upper contacts of tens-transfer relay 1325) only in the period including the dialing of the units digit. During this period, if the units digit has a value greater than 5, counting relay 1338 operates to close a circuit over conductor U6' for units-switching relay U6C. Relay U6C thereupon operates and locks itself to conductor 17. At the same time, it disconnects the out link OL from the upper group of contact sets of relays U1C to U5C and transfers the out link to the inner upper group of contact sets of relays U1C to U5C. The subsequent operation of one of the relays U1C to U5C therefore makes connection with one or another of the lines 6 to 0 in the selected tens group.

G. Unequipped tens groups

It will be recalled that the operation of tens-transfer relay 1325 following the dialing of the tens digit in the desired number is dependent upon one of the tens relays T21C to T40C (Fig. 13, part 5) having operated and prepared a locking circuit for itself at its inner lower contacts. When an exchange is installed with less than the maximum number (twenty) of tens relays, tens-transfer relay 1325 is not operated when the designation of an unequipped tens group is inadvertently dialed; the counting chain is not restored; and the normal progressive operation of the transfer relays is halted, preventing the giving of a busy signal in the normal way, as when an unequipped line multiple is called and test relay 1318 is unable to operate. Special provisions are, therefore, desirable for giving a calling subscriber a busy signal in this event.

The special provisions referred to consist merely in the provision of a pair of terminals 83 (Fig. 13, part 9) connected to the busy-relay conductor 21 and associated with the contact levels of the counting relays through which relays T21C to

T40C are operated. If any tens relay is not equipped in a given installation, the corresponding conductor in cable 1366 is left open and the associated armature on the concerned one of the counting relays 1333 to 1342 is connected to the associated terminal 83. Under this condition, when the armature in question is energized at the end of the dialing of the tens digit, ground potential is thereby extended to the connected terminal 83, and thence over conductor 21 to busy relay 1320. Busy relay 1320 thereupon operates and disconnects conductor 11 from conductor 25 to prevent the current setting of the counting relays from being disturbed by any further dialing that may occur. At its upper contacts, busy relay 1320 applies busy-tone current to the calling line to inform the calling subscriber that the attempted connection cannot be completed.

H. Bridged and divided ringing

The connectors are so arranged that either bridged or divided ringing may be used on any party line. On individual lines and on party lines having only a small number of party substations thereon, it is desirable to employ bridged ringing, as no ground connection need then be employed at the substation. On the other hand, when many party substations are connected to the same party line, it is desirable that the so-called divided-ringing system be used. Among other reasons, divided ringing on heavily loaded party lines lessens the number of ringers connected to each of the talking conductors and thereby causes less distortion of dial impulses than is experienced when all of the ringers on a heavily loaded party line are bridged across the two conductors thereof. By dividing the ground-connected ringers between the two conductors of the line, the line is better balanced against foreign disturbances than if all the ringers were connected between one line conductor and ground so as to leave the other line conductor free for controlling the impulse-delivering line relay of a connector, line relay 1306 of the connector C1.

Upon referring to the twenty-party line #411; 511 (Fig. 10), it is to be noted that the odd-numbered substations such as #4111 and #5111) have their ringers connected between the ring conductor of the line and ground, while the even-numbered substations on the party line have their ringers connected between the tip conductor of the line and ground. On the other hand, the ringer at the individual line substation #2031 is a bridged ringer, and the same is true for the ringers at the substations on the four-party line #202. Accordingly, each connector must be arranged to apply ringing current so as to operate the ringers on lines equipped for bridged ringing as well as to operate the ringers on lines equipped for divided ringing. The way in which this is accomplished will now be pointed out.

Code-ring relay 1317, as previously described, connects ringing current to one of the talking conductors of the called line (at its upper armature) each time it operates during the ringing operation, ring-trip relay 1315 being connected to the other conductor of the called line to actuate ring-cutoff relay 1313 when the called subscriber answers, either during an application of ringing current or during a silent period. Normally, the ringing current applied from the common ringing lead 80 through the upper armature of code-ring relay 1317 passes out through the upper contacts of reverse-ring relay 1314, through the back contact of armature 76 and the said armature, and through contacts 84 to the tip conductor of the called line, while a return path for ringing current is provided from the ring conductor of the called line, to battery and ground, through ringing trip relay 1315, which is connected to the ring conductor of the called line, through the back contact of the inner armature of reverse-ring relay 1314 and the said armature, back contact of armature 77 and the said armature, and contacts 85 of switching relay 1319. When a call is made to a divided-ringing party line and the station called is one having its ringer connected between the tip conductor and ground, the above described connections suffice for the ringing current returns through ground to the ringing generator, rather than over the ring conductor of the called line and through ring-trip relay 1315. Ring-trip relay 1315, however, is operated over the called line when the latter is bridged upon the removal of the receiver thereon.

When an even-numbered substation on a divided party line is being called, the ringer is connected to the ring side of the line, making it necessary that ringing current be applied to the ring side of the called line in order to signal the called substation. In this event, reverse-ring relay 1314 is operated as will be subsequently explained to reverse the connections between the ringing lead and ring-trip relay 1315 on the one hand, and the tip and ring conductors of the called line on the other hand. The ringing current is thus sent out over the ring conductor of the called line, and ring-trip relay 1315 is operated over the tip conductor of the called line when the call is answered. This arrangement does not affect a line on which the ringers are bridged, for it is immaterial in the case of a bridged ringer which of the two conductors of the line is the source of ringing current and which is the return path through ring-trip relay 1315.

On a call to an odd-numbered substation on any party line, the party digit dialed is an odd-party digit and consequently an odd-numbered counting relay in Fig. 13, part 4, is in operated and locked condition at the end of the dialing of the final digit in the number. Conductors 18 and 28 are, therefore, joined together. Consequently, when switch relay 1319 operates, ground potential on conductor 18 is transmitted over conductor 28 and through contacts 96 to operate reverse-ring relay 1314, which remains operated until the connection is cleared out. Ringing current is, therefore, transmitted in this case over the ring side of the called line instead of over the tip side of the called line. On the other hand, if the party digit dialed is an even digit, conductors 18 and 28 are not joined by the counting relay in operated condition at the end of the party digit, with the result that reverse-ring relay 1314 does not operate, and ringing current is sent out over the tip side of the called line.

I. Twenty-party signaling in the "2" hundreds group

It has been described hereinbefore that hundreds-transfer relay 1327 is energized over conductor 2 in cable 1365 and through its lower winding when the hundreds digit 2 is dialed in which case the lower winding of relay 1327 is locked energized to conductor 17 (through the front contact and upper armature of relay 1327, and through closed contacts of the unoperated relays 1328 and 1329). Relay 1329 is not operated under this condition. Accordingly, pickup conductor PU—1 remains connected up at the lower

armature of relay 1329 as previously described with the result that the first or preliminary-ring impulse has been transmitted by each of the code cams 1 to 0 of the device 1363 before pick-up relay 1316 operates to connect code-ring relay 1317 to the one of the code conductors 1 to 0 in cable 1364 selected by the subsequently dialed party digit. Therefore, any selected one of the ten codes assigned to the first tens group of party stations on a twenty-party line in the "2" hundreds group is sent out during the ringing operation. One such group of ten substations on a twenty-party line may be substations #2011 to #2010 (Fig. 2, part 2) on line #201;301.

When the call is for one of the party substations in the second group of ten on the twenty-party line (such as for one of the substations including #3011 to #3010 on line #201;301, Fig. 2, part 2), the hundreds digit dialed is the digit 3. In this event, the #3 counting relay 1335 is the one locked in operated condition at the end of the dialing of the hundreds digit, and a circuit is accordingly closed over conductor 3 in cable 1365 for the lower winding of group-selection relay 1329, in multiple with the upper winding of hundreds-transfer relay 1327. Relay 1329 closes its upper contacts, but without effect, for conductor 5 in cable 1365 is not energized at this time. At its inner lower armature, relay 1329 prepares a locking circuit for its lower winding and for the upper winding of relay 1327. This locking circuit is completed at the upper contacts of relay 1327; from ground on conductor 17, through the upper contacts of relay 1327, over conductor 49, inner lower armature and back contact of relay 1328, inner lower armature and front contact of relay 1329, and thence to battery through the lower winding of relay 1329, and through the upper winding of relay 1327.

Hundreds-transfer relay 1327 performs transfer operations with results described hereinbefore.

At its lower armature, relay 1329 substitutes pickup conductor PU—2 for conductor PU—1. As a result, when the complete number has been dialed and the ringing operation is started, pick-up relay 1316 is operated earlier in each ringing cycle than when conductor PU—1 is used. Specifically, it is operated from the contacts of cam C of device 1363 and over conductor PU—2 to connect up code-ring relay 1317 before the preliminary ringing impulse has been transmitted by the selected one of the associated code cams 1 to 0. The consequence is that whichever one of the ten codes has been selected is preceded by a distinguishing preliminary application of ringing current, thus designating to the subscribers on the called twenty-party line that one of the substations in the second tens group is being called.

J. Calls to the "4" hundreds group

When the first digit dialed is the hundreds digit 4, the #4 counting relay 1336 is locked operated at the end of the digit. Under this condition, when hundreds conductors 38 and 39 are grounded at the end of the hundreds digit, the ground potential on conductor 38 is extended over conductor 4 in cable 1365 to operate group-selection relay 1328. When relay 1328 operates, the ground potential on conductor 4 of cable 1365 is extended through the upper contacts of relay 1328 to conductor 49, and thence through the inner lower armature and front contact of relay 1328, to the upper winding of relay 1327. Relay 1327 thereupon operates. Upon so doing, it connects 49 with the grounded conductor 17, thereby closing a self-locking circuit for relay 1328 through the upper contacts of the latter relay, and closing a locking circuit for the upper winding of relay 1327 through the inner lower armature of relay 1328 and its front contact.

At armatures 94 and 95, relay 1328 disconnects tens conductors 40 and 41 associated with the "2" hundreds group and substitutes tens conductors 42 and 43 associated with the "4" hundreds group.

Under this condition, when the counting relays have been reset in accordance with the tens digit in the desired number, conductors 42 and 43 become grounded in place of conductors 40 and 41, and one or another of conductors 41 to 40 in cable 1366 becomes energized through the associated contacts of the then operated one of the counting relays. Accordingly, one of the tens relays (such as T41C to T40C) associated with the "4" hundreds group is energized, and connection is completed to the desired line in the desired tens group of the "4" hundreds group upon the dialing of the remaining digits in the desired number.

J1. Twenty-party signaling in the "4" hundreds group

When a call is extended to a line in the "4" hundreds group by the calling of a number containing the hundreds digit 4 as above discussed, group-selection relay 1329 is not energized and pickup lead PU—1 associated with the code-ringing apparatus 1363 is effective during the ensuing ringing operation. Consequently, when a twenty-party line, such as #411;511 (Fig. 2, part 2, and Fig. 10), is called in a number containing the hundreds digit 4, the resulting ringing operation sends out one of the ten codes to signal one of the ten party substations #4111 to #4110 thereon, the preliminary application of ringing current being omitted in this case.

When such a party line is called by a number containing the hundreds digit 5 as the first digit thereof, conductor 5 in cable 1365 is energized at the end of the hundreds digit, thereby closing a circuit for the upper winding of relay 1329. At its upper contacts, relay 1329 extends the energized conductor 5 in cable 1365 to the winding of relay 1328, energizing the latter relay. The ground potential on conductor 5 in cable 1365 is thereupon extended through the upper contacts of relays 1329 and 1328 to conductor 49, energizing the upper winding of hundreds relay 1327, through the lower armature and front contact of relay 1328. Relay 1327 thereupon connects conductor 49 to the grounded conductor 17 to close a locking circuit for itself through the inner lower armature and front contact of relay 1328; closing a locking circuit for relay 1328 through the upper contacts of the latter relay; and closing a locking circuit for the upper winding of relay 1329 through the upper contacts of relays 1328 and 1329. Hundreds-transfer relay 1327 carries out its hereinbefore described transfer operations; relay 1328 disconnects the tens conductors 40 and 41 and substitutes tens conductors 42 and 43 associated with the "4" hundreds group; and relay 1329 disconnects pickup conductor PU—1 and substitutes pickup conductor PU—2. Accordingly, when the complete number has been called and the ringing operation ensues, each ringing operation is started sufficiently earlier that a preliminary application of ringing current is made preceding the selected

code, thereby signaling the selected one of substations such as #5111 to #5110 (Fig. 10) on the called party line.

K. Reverting calls

Calls from a party-line substation to another substation on the same party line are termed reverting calls. The way in which such calls are handled will now be described.

Let it be assumed that the party-line subscriber at substation #2021 (Fig. 10) on four-party line #202 desires to converse with another subscriber on the same line, the subscriber at substation #2024, for example.

When the receiver (not shown) is removed at calling substation #2021, line relay 1006 of line circuit LC—202 thereupon operates to ground the associated T and U marking conductors whereby an idle finder is caused to make connection with the associated line multiple #202.

It may be assumed that the finder F1 (Fig. 11) is idle at this time and is taken for use by the distributor DR through the operation of relay 1200 as hereinbeforedescribed. Tens and units relays T20F and U2F in the finder F1 are now operated from the distributor DR in accordance with the designation of the calling line to make connection with the calling multiple #202. When this occurs, the connector C1 of Fig. 13 is prepared for operation in the manner hereinbefore described responsive to the energization of its line relays 1305 and 1306. When this has occurred, the sleeve conductor S of the calling line multiple #202 becomes grounded, whereupon relays 1004 and 1005 operate and line relay 1006 restores.

Responsive to the dialing of the number (2024) of the desired substation on the calling line, operations as previously described occur in the connector C1 of Fig. 13 with the result that the conductors of the out link OL are connected to the line multiple of the called (and calling) line #202 through the operation of relays T20C and U2C as hereinbefore described.

The dialing of the final digit, the party digit 4, results in the counting relays of Fig. 13, part 4, being finally reset in accordance with the called substation on the called party line. The testing operation occurring as described during the dialing of the party digit results in the inability of test relay 1318 to operate because the called multiple is the same as the calling multiple and the sleeve conductor thereof is consequently grounded. Busy relay 1320 is accordingly operated when series relay 1321 restores at the end of the dialing of the final digit, applying a busy-tone signal at its upper contacts of the calling line.

K1. Conditioning connector for operation as a local connector

Upon the operation of busy relay 1320, detector relay 1308 operates as previously described to condition the connector for operation as a local connector rather than as a toll connector. One result of the operation of detector relay 1308 at this time is the disconnection of conductor 14 from conductor 13 to render busy-verification relay 1311 ineffective, and the connection of conductor 14 to the sleeve conductor S of the out link OL to enable reverting-call relay 1310 to operate when the calling subscriber replaces his receiver. The closing of the upper contacts of the detector relay 1308 further prepares a circuit, through the middle upper contacts of busy relay 1320, for reverting-call relay 1310.

Party-line subscribers are preferably instructed to replace the receiver when the busy-tone signal is heard upon the dialing of the number of another substation on the same party line.

When the calling subscriber at substation #2021 (Fig. 10) replaces his receiver responsive to the busy-tone signal returned to the calling line as above described, operations occur in the connector C1 to cause the finder F1 to be restored and the connector C1 to seize the called (and calling) line to signal the called substation thereon, as well now be described.

K2. Making the reverting-call test

When line relays 1305 and 1306 restore (when the receiver is replaced), they open the circuit of slow-acting release relay 1307, but relay 1307 remains operated for a moment. Line relay 1306 extends ground potential, through contacts of the operated sleeve relay 1309, over conductor 11, through the inner upper armature and front contact of the operated busy relay 1320, conductor 14, and the middle upper armature and front contact of detector relay 1308, to the sleeve conductor S of the out link OL, thereby applying ground potential at a new point to the multiple of the called (and calling) line, out link OL having been connected with such multiple through the relays of Fig. 13, part 5, as previously described.

A moment later, release relay 1307 restores. At its inner lower contacts, it disconnects local conductor 18 from ground-supply conductor 81, thereby ungrounding conductor 18 (and consequently hold conductor H of the link L1) except for the connection between conductor 18 and the grounded conductor 17 through contacts of reverting-call relay 1310. Conductor 17, it will be recalled, is maintained grounded, from ground-supply conductor 81, at the inner lower contacts of sleeve relay 1309 as long as the latter relay remains operated.

At its upper armature, release relay 1307 removes the ground potential previously applied through the front contact of the said armature to conductor 5, a local extension of sleeve conductor S of the link L1. Ordinarily, sleeve relay 1309 (which derives its operating current from conductor 5) restores at this point and permits the connection to clear out by ungrounding conductor 17 and consequently conductor 18. In the present example, however, this does not occur because of the ground connection made as previously described to the sleeve conductor S of the out link OL through contacts of the operated relays 1320 and 1308. This ground potential is extended through the connecting relays of the operated connector to the concerned line multiple #202, and from this line multiple it extends through the connecting relays of the operated finder F1 to the sleeve conductor S of the link L1, to which conductor 5 is connected. Ground potential reaches conductor 5 at this time only because the finder F1 and the connector C1 have both been set on the same line multiple, which occurs only during a reverting call.

The ground potential reaching conductor 5 of the connector C1 through the operated connector and the operated finder, by way of the sleeve conductor of the concerned line multiple, is effective to hold sleeve relay 1309 operated for the time being (through the inner upper armature and back contact of relay 1310 and contacts 64). Conductors 17 and 18 are consequently held grounded for the time being to maintain finder F1 and the connector C1 operated.

K3. Operating reverting-call relay 1310

With ground potential thus maintained on local conductor 5 of the connector C1, the described restoration of release relay 1307 closes a circuit through the upper armature and back contact of relay 1307, upper contacts of detector relay 1308, conductor 3, contacts of the operated busy relay 1320, and conductor 4, for reverting-call relay 1310. Reverting-call relay 1310 now operates.

K4. Clearing out finder F1

At its lower armature, reverting-call relay 1310 locks itself to conductor 17 (grounded through the inner lower contacts of sleeve relay 1309); at its upper contacts, it makes a new ground connection to local conductor 5, through the upper contacts of the operated relay 1308 and of the restored relay 1307; and at the normally closed contacts controlled by its lower armature, it disconnects conductor 18 from conductor 17, thereby depriving conductor 18 of ground potential, release relay 1307 having been restored as described and busy relay 1320 being in operated condition. When this occurs, conductor H of the link L1 becomes consequently ungrounded, thereby unlocking and restoring the operated relays (U2F and T20F) of the finder F1. The incoming conductors of the connector C1 are thus cleared from the concerned line multiple to enable ringing current to be transmitted thereover from the connector without affecting line relays 1305 and 1306. Local conductor 5 is maintained grounded thereafter through the above described substitute ground connection, closed at the upper contacts of relay 1310.

At the back contact of the inner upper armature of reverting-call relay 1310, one point in the circuit of sleeve relay 1309 is opened, but sleeve relay 1309 remains operated over conductors 5 and 7, which are joined together at this time at the upper contacts of auxiliary relay 1322, locked operated to conductor 17 over conductors 9 and 10.

K5. Seizing the called line and ringing

At its upper armature and front contact, reverting-call relay 1310 causes the connected line to be seized by closing a circuit from the grounded conductor 5 over conductor 6 for the lower winding of test relay 1318. Upon operating, relay 1318 makes a new ground connection to the sleeve conductor of the out link OL at its inner upper contacts; it locks itself to conductor 5 at its upper contacts; and at its lower armature and front contact, it closes an operating circuit for switching relay 1319, from ground on conductor 17.

Switching relay 1319 now operates to seize the tip and ring conductors at contacts 84 and 85, while at its lower contacts it connects up pickup relay 1316 to initiate the hereinbefore described party-line ringing operation.

K6. Reguarding the finder-connector link

A further result of the operation of test relay 1318 is the open-circuiting of busy relay 1320 at its lower contacts. Slow-restoring busy relay 1320 falls back after a slight interval and opens the busy-tone connection at its upper contacts; at its inner upper armature, it disconnects conductor 14 thereby opening the initial circuit path over which ground was applied to the sleeve conductor of out link OL, but a substitute path has been closed as described at the inner upper contacts of relay 1318.

At its middle lower armature and back contact, busy relay 1320 again joins conductors 17 and 18 together, thereby regrounding conductor 18 and consequently the hold conductor H in link L1, whereby ground potential (which was momentarily removed from the said conductor H to allow the finder F1 to clear out) is again extended, through contacts of connecting relay 1200, to test conductor 1201 to mark the finder F1 as busy to the distributor DR.

The ringing code now transmitted to the line involved in the reverting call, party line #202, Fig. 10, operates the ringers at all the substations on the line, whereby the calling subscriber at substation #2021 is informed that the called subscriber at substation #2024 is being signaled.

K7. Clearing out the connection when the reverting call is answered

When the called subscriber removes his receiver to answer the reverting call, ring-trip relay 1315 in the connector C1 operates as previously described, thereby operating the ring-cutoff relay 1313 from ground potential on the regrounded conductor 18. The operation of ring-cutoff relay 1313 is followed by the operation of back-bridge relay 1312, followed in turn by the operation of supervisory relay 1304.

At its inner upper contacts, supervisory relay 1304 separates conductors 9 and 10, to clear out the counting relays of Fig. 13, part 4, and to unlock and restore auxiliary-transfer relay 1322. At its upper contacts, relay 1322 separates conductors 5 and 7 (reverting-call relay 1310 being in operated condition), whereupon sleeve relay 1309 restores, disconnecting ground supply conductor 81 from conductor 17. Thereupon, conductors 17, 18, and 5, together with the sleeve and hold conductors of the link L1 become ungrounded, being all joined together and previously deriving ground potential solely through the inner lower contacts of sleeve relay 1309, from ground-supply conductor 81. All of the operated relays of the connector C1 thereupon clear out returning the connector to its illustrated normal condition.

K8. The reverting-call line circuit is locked out

In the line circuit LC—202, Fig. 10, the operated cutoff and lockout relays 1004 and 1005 are open-circuited by the consequent removal of ground potential from the associated sleeve conductor S when the connector C1 clears out. Being slow-restoring, lockout relay 1005 does not restore immediately. Cutoff relay 1004 immediately restores and reconnects line relay 1006, whereupon line relay 1006 operates and closes a locking circuit for relay 1005, through the inner contacts of the two relays. Ground potential is applied to the associated common alarm conductor A through the lower armatures of relays 1006 and 1005. As previously stated, alarm conductor A may lead to common alarm equipment. This alarm equipment may be arranged to sound an alarm only after the conductor has been grounded for an extended period of time, half an hour for example, whereby an alarm is not sounded as a result of the carrying on of a reverting-call conversation of ordinary length, but an alarm may be sounded eventually (to attract the attention of an attendant, if present) when the alarm conductor A is continuously grounded as a

result of a locked-out trouble condition on a line, as previously discussed.

Upon noting the cessation of the operation of his ringer, the calling subscriber at substation #2021 may remove his receiver and converse with the subscriber at called substation #2024 as desired, transmitter current being supplied to the two substations through the windings of line relay 1006. The line circuit LC—202 is made busy (guarded against seizure by the connectors) by the ground potential applied to sleeve conductor S, through the inner armatures of the operated relays 1006 and 1005, and through the winding of cutoff relay 1004.

When the reverting-call conversation has been completed and the subscribers have replaced their receivers, line relay 1006 restores, followed by the restoration of lockout relay 1005 to return the line circuit LC—202 to its illustrated normal condition.

Reverting calls may be made on any of the other party lines in the manner described. The only difference to be noted is that, when the concerned party line is one employing divided ringing, the calling subscriber does not hear the reverting-call ringing operation if the called station in the reverting call is one having its ringer connected to the opposite conductor of the line. For example, when the subscriber at substation #4111 on the twenty-party line #411;511 (Fig. 10) makes a reverting call to substation #5110, the ringing current is sent back over the tip conductor of the line to signal the called substation, whereas the ringer at the calling substation is connected to the ring conductor of the line and is therefore not operated. Under such a condition, the calling subscriber is expected to wait a reasonable time after replacing his receiver to permit the ringing operation to take place, after which he removes his receiver to converse with the called subscriber if the latter has answered.

The reverting-call apparatus may also be used by any subscriber or by a service man at any substation (either an individual-line substation or a party-line substation) to check the operativeness of the ringer thereat. For this purpose, the subscriber removes the receiver and dials his own directory number, replacing his receiver when he hears the busy signal, whereupon the hereinbefore described reverting-call operation occurs and ringing current is sent back to the calling line to operate the ringer at the calling substation. The ringing operation is terminated and the concerned connector is cleared out when the calling subscriber again removes his receiver.

L. P. B. X calls

The handling of calls to private branch exchanges will now be described. For this purpose, it may be assumed that a subscriber at pay station #2031 (Fig. 10) desires to converse with someone at the private branch exchange, #2511 (Fig. 10). It is assumed by way of illustration that ten lines are provided between exchange C and the private branch exchange. The directory numbers of these lines are 2511, 2521, and so forth, to 2501.

When the receiver is removed at the calling pay station #2031 (Fig. 10), line circuit LC—203 operates as previously described to cause a connection to be made to the associated line multiple L. M. #203 as described hereinbefore. It may be assumed that the finder F1 (Fig. 11) is idle and is caused to operate as previously described to extend connection to the connector C1. When this occurs, cutoff and lockout relays 1007 and 1008 of the line circuit LC—203 operate over the associated sleeve conductor to disconnect and restore line relay 1009 as described hereinbefore.

The connector C1 is prepared for operation as previously described, by the operation of line relays 1305 and 1306, release relay 1307, sleeve relay 1309 and dial-tone relay 1324, dial tone being applied to the calling line through the upper contacts of relay 1324.

L1. Dialing the hundreds digit (2)

When the hundreds digit (2) in the desired number is dialed, series and series-auxiliary relays 1321 and 1326 operate as previously described during the transmission of impulses by line relay 1306 to the counting-relay equipment of Fig. 13, part 4.

Driver relay 1331 and counting relay 1334 are in energized condition at the end of the transmission of the impulse series. Then, when series relay 1331 restores at the end of the series of impulses, it restores series-auxiliary relay 1326, and its operates hundreds-transfer relay 1327, through contacts of counting relay 1334 and over conductor 2 of cable 1365. Relay 1327 locks itself as previously described; restores dial-tone relay 1324; and clears out the counting and driver relays preparatory to their operation in response to the tens digit in the desired number.

L2. Dialing the tens digit (5)

When the tens digit (5) is dialed, series and series-auxiliary relays 1321 and 1326 operate as above, relay 1326 locking itself at this time through contacts of the operated hundreds-transfer relay 1327 to provide locking potential, through its upper contacts, for the counting and driver relays.

At the end of the series of five tens impulses, counting relay 1337 is in operated condition, locked in series with driver relay 1331.

When series relay 1321 restores at the end of the tens digit, it closes the following circuit for the fifth tens relay T25C in the "2" hundreds group: from ground on conductor 17, through the inner lower armature and back contact of relay 1321, conductor 27, contacts of driver relay 1331, conductor 37, contacts 87, lower armature and back contact of the restored dial-tone relay 1324, armature 95 and its back contact, tens conductor 41, contacts of counting relay 1337, conductor 25 of cable 1336, and through the winding of relay T25C, to battery. Upon operating, relay T25C connects up the ten associated line multiples represented by cable CA—5. At its inner lower contacts, it closes a circuit over conductor 36, through resistor 1367, contacts of relay 1323, and the lower armature and front contact of relay 1327, for tens-transfer relay 1325. Relay 1325 thereupon locks itself and relay T25C operated at its middle upper contacts.

As previously described, relay 1325 unlocks and restores series-auxiliary relay 1326 at its inner upper armature, and relay 1326, on restoring, reoperates dial-tone relay 1324 in preparation for the units digit. The counting and driver relays of Fig. 13, part 4, are cleared out responsive to the restoration of relay 1326.

L3. Dialing the units digit (1)

When the impulses constituting the units digit (1) are received, series-auxiliary relay 1326 is again operated by series relay 1321. At this time, relay 1326 locks itself as previously described,

through armature 90 of the reoperated dial-tone relay 1324, preparing the counting-relay locking circuit at its upper contacts. At the end of the units digit (1), counting relay 1333 is in energized condition, locked in series with driver relay 1330.

When series relay 1321 falls back at the end of the units digit, and grounds units conductors 44 and 45 as previously described, the ground potential on conductor 45 is extended, through contacts of the operated #1 counting relay 1333, conductor U1', contacts of relay P. B. X—1, and conductor U1 to the first units relay, U1C. Relay U1C thereupon operates and connects the tip, ring, and sleeve conductors T, R, and S of the out link OL (through contacts of relay T25C) respectively with the corresponding conductors in line multiple #251, being the switchboard multiple of the first line of the called P. B. X group. At its lower contacts, relay U1C prepares a locking circuit for itself, extending ground potential, through the lower contacts of the unoperated relays U2C to U5C, to conductor 35, to units-transfer relay 1323. Relay 1323 thereupon operates with results as previously described, including the closing of a locking circuit for itself and relay U1C at the front contact of its upper armature. The locking circuit of relay U1C includes conductors U1' and U1 in series, normally joined by contacts of relay PBX—1.

As previously described, the counting and driver relays clear out responsive to the operation of units-transfer relay 1323; dial-tone relay 1324 is again restored; series-auxiliary relay 1326 is again unlocked and restored; and auxiliary-transfer relay 1323 is energized by its upper winding, and locks over conductors 17, 9, and 10.

L4. Dialing the party digit (1)

When the final (party) digit (1) is dialed, series relay 1321 and auxiliary-series relay 1326 again operate, and series-auxiliary relay 1326 locks itself over a circuit path including closed contacts 91 of dial-tone relay 1324 and the inner upper contacts of the locked auxiliary-transfer relay 1322.

Counting relay 1333 is operated responsive to the single impulse in the final digit and locks itself in circuit with driver relay 1330.

During the dialing of the final digit (the tip, ring, and sleeve conductors of the out link OL having been connected to the multiple of the first line in the called P. B. X group), the first P. B. X line (#251, Fig. 10) is tested by the upper winding of test relay 1318. For this purpose, the lower armature of series relay 1321 extends ground, from conductor 17, over conductor 23, through contacts of release relay 1307, and over conductor 22, to the upper winding of test relay 1318.

L5. Seizing the first P. B. X line, when idle

The operations which now occur depend upon whether the first line of the P. B. X group is idle or busy. If this line is idle, test relay 1318 operates to prepare a circuit at its lower armature for switching relay 1319 with the result that the latter relay operates to seize the first line of the P. B. X group when series relay 1321 falls back at the end of the final digit, such seizure and resulting operations being as hereinbefore described.

L6. Operation when the first P. B. X line is busy

If the first line of the P. B. X group is busy, test relay 1318 is unable to operate and switching relay 1319 consequently fails to operate when relay 1321 restores. Under this condition (auxiliary-transfer relay 1322 having become operated and locked at the end of the units digit, and series-auxiliary relay 1326 having reoperated and locked at the beginning of the final or party digit), busy relay 1320 operates over its hereinbefore traced circuit (from ground on conductor 17, through the lower contacts of relays 1321 and 1318, contacts 89, lower contacts of relay 1326, and conductor 21). Upon operating, busy relay 1321 applies busy tone to the calling line at its upper contacts and performs other operations hereinbefore described (including the opening of the impulse circuit at its inner upper armature and the rendering effective of the upper, or test, winding of detector relay 1308).

L6a. Seizing the common control leads

In the call under consideration, a P. B. X call number (2511) having been dialed, and tens relay T25C having been operated to close its lower contacts (Fig. 13, part 10), a circuit is now closed at the lower contacts of busy relay 1320 for relays P. B. X—1 and CH—1 in series as follows: from ground on conductor 17, through the upper armature and front contact of units-transfer relay 1323, units-relay-locking conductor 35, through the lower contacts of units relays U5C to U1C (relay U1C being in operated condition), the lower contacts of relay U6C, conductor 30, contacts 78, lower contacts of busy relay 1320, conductor 29, contacts of the operated counting relay 1333, conductor 48, lower contacts of relay T25C, the winding of relay P. B. X—1, the winding of relay CH—1, chain-end conductor 83 (common to the CH relays of all the connectors), chain contacts of relay CH—X, similar contacts of other CH relays, and thence through the chain contacts of relays CH—2, and CH—1 to the exchange battery.

Relays P. B. X—1 and CH—1 operate in series over the above-traced circuit. Relay CH—1 connects conductor SW—1 of cable 1300 to local conductor 47; prepares a circuit for connecting relay CN—1; at its inner lower armature, it locks itself to the originating end of the chain circuit, at the same time opening the chain to the succeeding CH relays; and at the normally closed contacts controlled by its lower armature, it disconnects its winding from the chain-end conductor 83, completely depriving the remaining relays of the chain of current for the time being. The marking conductors and other common conductors in cable 1300 are thus taken for the exclusive use of the connector C1, the other connectors being locked out from such conductors.

At its inner contacts, relay P. B. X—1 connects conductor B—2 of cable 1300 to local conductor 33, at its middle armature, it closes a locking circuit for itself and for relay CH—1 by applying ground potential directly to conductor 30 over a circuit path which includes conductor 35 and the lower contacts of the operated units relay U1C; and at the normally closed contacts controlled by its upper armature, relay P. B. X—1 disconnects conductor U1' from conductor U1, thereby open-circuiting and restoring relay U1C. At its upper group of contact sets, relay U1C disconnects the out link OL from the multiple of the first line of the called P. B. X, while at its lower contacts, it opens a point in the initial circuit of relays P. B. X—1 and CH—1, leaving these relays operated in the above-noted locking cir-

cuit, including the middle contacts of relay P. B. X—1 and conductor 30.

Connecting relay CN—1 is now operated to place the setting of the units relays U1C to U5C, and units-switching relay U6C under the control of the common marking conductors M1 to M6 in cable 1300, being operated over the following circuit: from ground on conductor 5, through the inner upper armature and back contact of reverting-call relay 1310, contacts 64, conductor 8, middle upper contacts of test relay 1318, conductor 34, contacts of relay CH—1, and through the winding of relay CN—1, to battery. Upon operating, relay CN—1 connects up the local conductors U1 to U6, 21, and 22, respectively to conductors M1 to M6, B—1, and SW—2 of cable 1300.

L6b. Seizing line allotter LA, Fig. 9

At its inner armature, relay CN—1 applies ground potential, through the middle lower contacts of the operated tens relay T25C, to conductor 2511 in cable 1300, extending to connecting relay 951 of the P. B. X line allotter LA (Fig. 9). Connecting relay 951 thereupon operates, but the effect of its operation depends upon the busy or idle condition of the associated P. B. X lines, as indicated by the operated or unoperated condition of relays 901 to 910 and also upon whether or not busy relay 952 is in operated condition, as it is when all of the relays 901 to 910 are in operated condition.

Relays 901 to 910 are connected respectively to conductors 961 to 970 in cable CA—1000, connected in turn to the sleeve leads of the line multiples of the lines 251 to 250 assigned to P. B. X #2511. Accordingly, when any one of these lines is in use and the associated sleeve lead is therefore grounded, the corresponding one of the relays 901 to 910 is in operated condition, being operated over its corresponding conductor in cable CA—1000. The relays 901 to 910 are preferably each of comparatively high resistance, whereby a cutoff relay such as 1001 is not operated in series therewith when the associated line is locked out of service and ground potential is applied to the junction of the windings of the cutoff and lockout relays, as hereinbefore described in connection with line circuit LC—203.

L6b(1). All P. B. X lines busy

Let it be assumed now that all lines of the called P. B. X are in use when the call being described is made. In this event, all of the relays 901 to 910 are in operated condition, and a chain circuit has been closed through the contacts of relays 901 to 910 and through the inner upper armature and back contact of connecting relay 951 for busy relay 952. Busy relay 952 has operated, and at its middle upper armature has closed a locking circuit for itself independent of the inner upper armature and back contact of relay 951; at its upper armature, relay 955 has disconnected conductor SW—2 of cable 1300, and substituted the cumulative counting device or meter 955; and at its inner contacts it has partially connected up busy lead B—2 in cable 1300. Under this condition, when connecting relay 951 is operated, at its upper contacts, it closes a circuit through the operated upper armature of the busy relay 952 for the meter or counting device 955, whereupon such device is operated to record the loss of a call for P. B. X 2511. At its inner upper armature (now grounded through contacts of relays 901 to 910 in series), connecting relay 951 applies ground potential, through the inner contacts of busy relay 952, to lead B—2 in cable 1300, thereby closing a circuit through contacts of relay P. B. X—1 (Fig. 13, part 10), and over conductor 33 for ring-cutoff relay 1313. Relay 1313 thereupon operates to lock itself at its inner lower contacts, while at its contacts 78 it opens the described locking circuit over conductor 30 for relays P. B. X—1 and CH—1 in series, whereupon relays P. B. X—1, CH—1, and CN—1 clear out, freeing the common leads in cable 1300 and reclosing the chain associated with the CH relays. Busy relay 1320 remains operated to maintain the busy-tone lead BT connected through condenser 1358 to the calling line to inform the calling subscriber by the continued busy signal that all of the lines leading to the called P. B. X are in use.

L6b(2). All P. B. X lines not busy

Let it be assumed now that one or more of the lines of the P. B. X is idle when the connection is attempted as previously described, the first line of the group being busy as hereinbefore assumed. In this event, group-busy relay 952 is not in operated condition when connecting relay 951 operates as described. It may be assumed that the first five lines of the P. B. X are busy and that the sixth line is idle. In this event, relays 901 to 905 are in operated condition, while relay 906 is in restored condition.

With relays 901 to 905 in operated condition, ground potential is maintained on conductor 936 to bring about the operation of the units switching relay in the connector in use. With relays 901 to 905 in operated condition and relay 906 in restored condition, ground potential is present on local conductor 931.

When connecting relay 951 now operates, marking conductors M1 and M6 in cable 1300 are grounded from conductors 931 and 936. The ground potential on marking conductor M6 of cable 1300 closes a circuit, through contacts of the operated relay CN—1, and over conductor U6, for the lower winding of units-switching relay U6C. Relay U6C thereupon operates to prepare a new locking circuit for relay U1C at its lower armature and front contact; at its inner armature and front contact, relay U6C locks itself to the grounded conductor 17; and at its upper group of armatures, it disconnects the conductors of the out link OL from the upper group of contact sets of relays U1C to U5C, and transfers them to the inner upper group of contact sets of these relays.

The above placing of ground potential on marking conductor M1 of cable 1300 closes an operating circuit, through contacts of relay CN—1, and over conductor U1, for units relay U1C. Relay U1C, at its lower contacts, locks itself to conductor 35, through the lower contacts of relays U5C to U2C, its own lower contacts, and the lower armature and front contact of relay U1C. At its inner upper group of contact sets, relay U6C being operated, relay U1C connects the conductors of the out link OL, through contacts of the operated connecting relay T25C, respectively to the conductors of the sixth one of the ten line multiples represented by cable CA—25, being the one associated with the idle sixth line of the P. B. X group.

In the line allotter LA (Fig. 9), with busy relay 952 not in operated condition, the upper contacts of the operated connecting relay 951 apply ground potential to switching conductor SW—2 of cable 1300, closing a circuit, through contacts

of connecting relay CN—1, and over local conductor 22, for the upper winding of test relay 1318. This circuit is completed to battery over the sleeve lead of out link OL and the sleeve lead of the multiple to which connection has been extended, the battery potential being obtained through the windings of the cutoff and lockout relays similar to 1501 and 1002 of line circuit LC—251 (Fig. 10). The concerned cutoff relay thereupon operates to clear the called line for ringing and talking purposes, and relay 906 (being highly inductive and stiffly adjusted) operates after a slight interval to indicate in the allotter LA the busy condition of the line associated with such relay.

L6c. Freeing the common control leads and the allotter

In the connector C1 of Fig. 13, test relay 1318 operates immediately when its above described circuit is closed. At its upper contacts, it locks itself to the grounded conductor 5; at its middle upper contacts it open-circuits and restores connecting relay CN—1 before the marking can be changed in the allotter LA (Fig. 9); it shunts its test winding at its inner upper contacts; and at its lower armature and front contact, it closes a circuit for switching relay 1319, at the same time, open-circuiting and restoring busy relay 1320, previously operated over conductor 21, through contacts of relay 1326, contacts 89, and the lower contacts of relays 1318 and 1321. Busy relay 1320 accordingly restores after a slight interval. Upon doing so, it disconnects busy-tone lead BT at its upper contacts, thereby terminating the application of busy-signaling current to the called line. This operation is ordinarily effected in a very short time following the described operation of busy relay 1320, in less than a second, for example.

At its lower contacts, busy relay 1320 opens the locking circuit previously existing over conductors 29 and 30 for relays PBX—1 and CH—1; these relays restore, the common chain circuit being reclosed by slow-restoring relay CH—1.

In the allotter LA (Fig. 9), connecting relay 951 restores when conductor 2511 of cable 1309 is ungrounded by the restoration of relay CN—1, thus disassociating the allotter LA from the common conductors of cable 1300 and reconnecting busy relay 952.

L6d. Seizing the idle P. B. X line

Switching relay 1319 operates when its circuit is closed at the lower armature of test relay 1318; it makes connection with the tip and ring conductors of the called line at contacts 84 and 85; while at its lower contacts, it closes a point in the circuit of pickup relay 1316 to initiate the ringing operation in accordance with the selected #1 ringing code.

From this point, the operation proceeds as hereinbefore described; relay 1315 operates temporarily when the call is answered; ring-cutoff relay 1313 thereupon responds to open the ringing circuit and complete the talking circuit; back-bridge relay 1312 operates over the called line; and supervisory relay 1304 thereupon responds to reverse the current flow in the tip and ring conductors of the calling line, whereby the calling subscriber at pay station #2031 (Fig. 10) is required to deposit a coin before conversing. Following conversation, the established connection is cleared out as hereinbefore described.

With further reference to the showing of P. B. X #2511 in Fig. 10, each of the illustrated lines serving the P. B. X is shown as terminating at a separate substation, each such substation being indicated in the drawing by a circle. Ordinarily, the P. B. X lines terminate at a switchboard presided over by the P. B. X operator who has switching equipment enabling her to interconnect any one of the P. B. X lines with a desired local extension line, but the showing of the switching arrangements within the P. B. X has been omitted for the sake of simplicity.

L7. Other P. B. X calls

The arrangement of the connectors such as C1 is such that any one of the P. B. X lines other than the first may be called directly by its directory number without the connection being extended automatically to another idle line of the group if the specific called line is busy. This service is provided for by arranging that relay PBX—1 (Fig. 13, part 10) is called into play (along with relays CH—1 and CN—1) only when the units digit dialed in a P. B. X call is the units digit 1. The initial energization of relay PBX—1 (in series with relay CH—1) is made dependent on relay U1C having operated and locked itself over conductors U1 and U1' to thereby apply an energizing ground potential to conductor U1' and consequently to conductor 30. When any other line of the P. B. X is being called, a different units digit is dialed, and ground potential is consequently not applied to conductor 30 to enable relay PBX—1 to operate thereafter as a result of the operation of busy relay 1320.

In view of the arrangement just described, any line of the P. B. X other than the first may be assigned for what is termed night service. That is, when the P. B. X operator is not on duty, as at night, any line may be interconnected with a specific extension line in the P. B. X and such extension line may then be called by the regular directory number of the connected P. B. X line.

The illustrated P. B. X group may, of course, include any smaller number of lines than ten, two or three lines for example. When such is the case, the line allotter LA of Fig. 9 uses only as many of the relays 901 to 910 as required. The remaining relays are disconnected from the conductors of cable CA—1000. The conductor leading through contacts of connecting relay 951 to the winding of busy relay 952 is connected to the front contact of the last one of the relays 901 to 910 associated with a P. B. X line. The remaining lines in the same tens group are available for service to other subscribers.

L8. Other P. B. X groups

Without altering the basic wiring of the connectors, the P. B. X lines in any given installation may be assigned to any other tens groups in the "2" hundred, including tens groups 2, 3, and 4 therein, provided such tens group is not required for other service, such as the extension of calls to another exchange. For example, if it is desired that the P. B. X lines be reached from the fourth tens group of the "2" hundreds, instead of from the fifth tens group, conductor 2511 in cable 1300 is connected to the middle lower armature of tens relay T24C instead of to the corresponding armature of relay T25C, and conductor 48 is connected to the front contact of the lower armature of relay T24C instead of to the corresponding contact of relay T25C. The number assigned to the P. B. X then becomes #2411. In this event, cable CA—1000 associated

with the P. B. X line allotter LA extends to the tens group of lines including lines 241 to 240 instead of to lines 251 to 250 as illustrated, and the lines 241 to 240 are extended to the P. B. X instead of lines 251 to 250.

If a second P. B. X is required to be served, the lines which extend to such second P. B. X may be equipped with a line allotter similar to allotter LA (Fig. 9) and an additional conductor similar to 2511 may be provided in cable 1300 extending to the relay in the second allotter similar to connecting relay 951. This latter conductor is connected to the middle lower armature of the one of the tens relays T22C to T25C which serves the second P. B. X. As many as four P. B. X groups may be served in any exchange using the disclosed connectors provided only a single interexchange trunk group is required for handling calls outgoing from the exchange, as in the case of terminating exchange D (Fig. 1 and 2). Chain-seizure conductor 48 is in such case multipled of the front contact of the lower armature of each tens relay (T22C to T25C) serving a P. B. X group.

M. Calls from tandem exchange C to manual exchange A

The handling of calls from lines of tandem exchange C to manual exchange A will now be described. For this purpose, it may be assumed that a subscriber of exchange C, the subscriber at pay station #2031 for example, desires to converse with a subscriber at manual exchange A, or with a subscriber reached through such manual exchange A. To become connected with the manual exchange, the subscriber at substation A removes the receiver 1024 from switchhook 1030; waits for dial tone; and then dials the single digit 0 assigned to the manual exchange.

M1. Seizing an idle connector

Line relay 1009 operates as previously described to ground the associated tens and units-mark conductors T and U when the receiver is removed at pay station #2031. It may be assumed that the finder-connector link comprising the finder F1 of Fig. 11 and connector C1 of Fig. 13 is idle and is the one selected when the distributor DR of Fig. 12 responds as previously described. When the finder F1 is operated, the calling line is extended to the connector C1, whereupon line relays 1305 and 1306, release relay 1307, sleeve relay 1309, and dial-tone relay 1324 operate as before described. The cutoff and lockout relays of the calling line circuit operate over the sleeve conductor of the calling multiple and the distributor DR is cleared out in the usual manner.

M2. Dialing the single digit number 0

Upon hearing the dial-tone signal impressed from the common dial-tone lead DT at the upper contacts of the dial-tone lead 24, the calling subscriber dials the digit 0 comprising the number designation of manual exchange A. When this occurs, line relay 1306 transmits a series of ten impulses to the counting relays of Fig. 13, part 4, causing operations to occur as previously described. At the end of the digit, the #0 counting relay 1342 is in operated condition, locked in circuit with driver relay 1330, and the other counting and driving relays are in restored condition.

Slow-acting series relay 1321, having been operated as before described during the transmission of the series of impulses, restores at the end thereof to apply ground potential to hundreds conductors 38 and 39. The ground potential applied to conductor 39 is extended through contacts of the operated counting relay 1344 to conductor 21 in cable 1366, thereby operating tens relay T21C to connect up the associated tens group of line multiples, including the line multiples (#211 to #217) assigned to the trunk lines interconnecting tandem exchange C with manual office A.

M3. Seizing trunk allotter TA—0

At its lower contacts, relay T21C connects the now-grounded conductor 21 in cable 1366 to conductor 36, thereby closing a circuit over conductor 36, through resistor 1367, normally closed contacts controlled by the inner lower armature of units-transfer relay 1323, the lower armature and back contact of hundreds-transfer relay 1327 (relay 1327 not having been operated when the tens relay operates in a single-digit call), conductor 46, through the winding of chain relay CH—1, chain-end conductor 83, and thence to battery through the chain contacts. Relay CH—1 is operated over this circuit to lock itself into the chain circuit and to open the chain circuit to the other chain relays. At its inner upper armature, relay CH—1 connects up switching conductor SW—1 in cable 1300, while at its upper contacts, it closes a circuit as previously traced over conductor 34 for connecting relay CN—1. Connecting relay CN—1 thereupon operates to connect up conductors M1 to M6, B—1, and SW—2 of cable 1300. Additionally, relay CN—1 at its inner contacts applies ground potential, through the lower contacts of the operated tens relay T21C, to conductor 0 in cable 1300.

It is to be noted in this case that with hundreds-transfer relay 1327 not having been operated, the grounded conductor 17 remains connected to conductor 2, and consequently with counting-relay-locking conductor 1, so as to maintain the operated counting relay 1342 in operated condition.

In the trunk allotter TA—0 (Fig. 9) assigned to the trunk group interconnecting exchanges A and C, the described grounding of conductor 0 in cable 1300 results in the operation of connecting relay 953.

It may be assumed that allotter relays 911 to 917 are each locked in energized condition as illustrated because each of the seven trunks in the associated group is idle. Under this condition, conductor 941 is grounded at the contacts of relay 911, while conductors 942 to 946 are ungrounded. Additionally, group relay 921 is in restored condition as illustrated; likewise busy relay 954.

M4. Marking the location of the allotted idle trunk line

When connecting relay 953 operates under the assumed conditions, it grounds switching conductor SW—1 of cable 1300 through contacts of the unoperated group-busy relay 954. At the same time, marking conductor M1 becomes grounded by way of conductor 941 and the middle armature and front contact of relay 911.

Responsive to the grounding of conductor M1 in cable 1300, a circuit is closed through contacts of relay CN—1 and over conductor U1 for the #1 units relay U1C. Relay U1C thereupon operates. At its upper group of contact sets, relay U1C connects the tip, ring, and sleeve conductors of the out link OL respectively with the tip, ring, and

sleeve conductors of line multiple #211, through the upper group of contact sets of the operated tens relay T21C.

At its lower contacts, units relay U1C makes a connection from the now-grounded conductor U1, through contacts of the unoperated relay PBX—1, over conductor U1', the lower contacts of units relays U1C to U5C, and conductor 35, to the winding of units-transfer relay 1323. Units-transfer relay 1323 thereupon operates to close a locking circuit for itself at its upper armature and front contact, to the grounded conductor 17. The ground potential thus impressed on conductor 35 passes back over the traced circuit to conductor U1 to lock relay U1C in operated condition independent of the continued grounded condition of conductor M1 of cable 1300.

M5. Freeing trunk allotter TA—0

At its lower contacts, relay 1323 closes a circuit for switch-through relay 1301, from ground on the now-grounded conductor SW—1 of cable 1300, contacts of relay CH—1, conductor 47, lower contacts of relay 1323, and over conductor 24, to relay 1301. Relay 1301 thereupon operates and closes a self-locking circuit to ground on conductor S of link L1 from conductor 5, grounded at contacts of release relay 1307. At contacts 64, relay 1301 open-circuits and restores relay CN—1 to disconnect the marking conductor of cable CN—1 from the connector before the setting of the allotter TA—0 (Fig. 9) is changed by the trunk-line seizure now being effected. Relay 953 of the allotter consequently restores. Other results of the operation of relay 1301 will be described subsequently.

A further result of the operation of units-transfer relay 1323 is that, at its inner lower armature, it closes a circuit over conductors 36 and 49, through resistor 1357 for the upper winding of hundreds-transfer relay 1327, through contacts of relays 1328 and 1329, at the same time opening the previously traced circuit over conductor 34 for slow-restoring chain relay CH—1.

Hundreds-transfer relay 1327 now operates to ground conductor 49 at its upper contacts by connecting it to the grounded conductor 17, thereby closing a locking circuit for its own lower winding, and extending ground potential back over conductor 49, through the inner lower armature and front contact of units-transfer relay 1323, resistor 1367, and conductor 36, to lock tens relay T21C operated after the counting chain is cleared out, which it does responsive to the disconnection of ground potential from conductor 2 and consequently from conductor 1 at the normally closed contacts controlled by the upper armature of relay 1327.

M5a. Freeing the allotter-control chain

Shortly after the described operation of units-transfer relay 1323, and responsive thereto, slow-restoring chain relay CH—1 restores, freeing the associated allotter-control chain. The other connectors now have access to the chain, such access being delayed by the slow-restoring action of relay CH—1 to give time for switch-through relay 1301 to operate as above described, and for the concerned allotter TA—0 (Fig. 9) to reset itself after trunk-line seizure has taken place by the operation of relay 1301.

M6. Switching through to the allotted trunk line

When switch-through relay 1301 operates as described, it open-circuits and restores sleeve relay 1309 at contacts 64, whereby the counting chain is cleared out; at armature 65, it disconnects ground potential from the armatures of line relays 1305 and 1306 (thereby depriving slow-restoring release relay 1307 of current) and applies ground potential at an additional point to hold conductor H, through which the ground potential reaches the joined-together local conductors 18 and 17 to maintain both of these conductors grounded as long as switch-through relay 1301 is maintained operated. Being slow-restoring, release relay 1307 remains operated for a short interval, enabling holding current for switch-through relay 1301 to be obtained from the repeater now to be seized before relay 1307 restores.

At armatures 61 and 62 and their back contacts, relay 1301 disconnects the tip and ring conductors of link L1 from those extending to line relays 1305 and 1306, while at armatures 61 to 63 and their front contacts, it connects the incoming tip, ring, and sleeve conductors of link L1 directly to the corresponding conductors of out link OL. Relays U1C and T21C having been energized and locked as hereinbefore described, the tip, ring, and sleeve conductors of link L1 are extended through the contacts of these relays to the corresponding conductors of line multiple #211, extending by way of line circuit LC—211 (Fig. 8) to the manual-to-automatic repeater OR—1, associated with the interexchange trunk line AT—1. In the line circuit LC—211, sleeve relay 820 operates in series with the associated lockout relay 819 to disconnect line relay 818. The ground potential for operating relays 820 and 819 at this time is obtained from the incoming sleeve conductor S of connector C1 and its local extension 5, through the upper armature and front contacts of the still-operated slow-releasing relay 1307.

M7. Preparing seized repeater OR—1 for outgoing operation

In the seized repeater OR—1 (Fig. 8), the double-wound outgoing line relay 810 operates over the calling line, through the back contacts of armatures 823 and 824, right-hand windings of repeating coil 800, and contacts of outgoing supervisory relay 816. Upon operating, line relay 810 operates outgoing release relay 811 at its upper contacts. Outgoing release relay 811 operates auxiliary relay 812 at its middle lower contacts. Relay 812 applies ground potential to sleeve conductor S of line multiple #211 over the following circuit path: from ground, through the normally closed contacts controlled by the upper armature of release-timer relay 817, the low-resistance lower winding of detector relay 813, upper contacts of relay 812 and the back contact of the inner upper armature of relay 808 and the said armature, to the associated sleeve conductor S. This ground potential maintains relays 820 and 819 operated in line circuit LC—211; maintains relay 1301 operated in the connector C1; and maintains relays 1007 and 1008 operated in line circuit LC—202 (Fig. 10), associated with the calling line.

At its lower contacts, relay 812 separates the normally joined conductors 931, thereby unlocking and restoring the associated #1 relay 911 in trunk allotter TA—0, whereby the marked condition of the associated marking conductors 941 to 946 is suitably changed.

In the connector C1, line relays 1305 and 1306 restore immediately responsive to being discon-

nected at armatures 61 and 62. Release relay 1307 restores after a slight interval and breaks the ground connection previously made at the front contact of its upper armature to the associated local conductor 5 and the incoming sleeve conductor S, leaving the sleeve conductor of the established connection grounded only at the repeater OR—1 (Fig. 8). With sleeve relay 1309 and release relay 1307 restored, the joined-together conductors 18 and 17 are grounded only at the front contact of armature 65 of switch-through relay 1301.

The operated relays in the connector C1 are now switch-through relay 1301, units transfer relay 1323, hundreds-transfer relay 1327, units relay U1C, and tens relay T21C, and all of these relays are dependent, directly or indirectly, on the continued grounded condition of the now-extended incoming sleeve conductor S of the connector C1.

In the seized repeater OR—1 (Fig. 8), certain additional operations occur upon the described seizure thereof. These operations include, causing the operator to be signalled by a "splash" application of ringing current; preparing for giving a class-tone signal to the operator when she responds; and preparing to give the operator dark supervision, all of which operations will now be described.

At its inner lower contacts, release relay 811 closes a circuit for class-tone relay 814 through contacts of incoming line relay 804. Class-tone relay 814 operates the associated relay 815, completing the preparation for the giving of a momentary class tone. At its lower contacts, relay 814 applies ground potential to tone-start conductor 825 so as to insure that the tone-generating equipment of the exchange is in operation at this time.

At its upper contacts, relay 816 applies ringing current to the associated tip conductor, obtained through condenser 831, the upper armature and back contact of sleeve-control relay 809, and small-capacity condenser 830, from the common interrupted-generator lead 821. The calling subscriber hears the intermittently applied ringing tone and is thereby informed that the operator is being signalled.

At armatures 828 and 829, auxiliary relay 812 closes points in circuits having to do with the operation of release-timer relay 817, to be considered subsequently.

At armature 827 and its front contacts, auxiliary relay 812 prepares circuits for sleeve-control relay 809 and for outgoing supervisory relay 816, subject to becoming closed when the operator answers.

M8. Disconnecting the outgoing supervisory relay

When the release relay of the calling connector C1 (Fig. 13) falls back and removes ground potential at the connector from the extended sleeve conductor, the low-resistance lower winding of detector relay 813 thereupon becomes the sole supply of ground potential to the associated sleeve conductor, whereupon it operates as the result of current drawn by relays 819 and 820 of the line circuit LC—211, the corresponding relays of the line circuit associated with the calling line, and by switch-through relay 1301 of the connector. Upon operating, detector relay 813 disconnects outgoing supervisory relay 816 so as to prevent a current reversal over the calling line when the operator answers. At this point, it may be mentioned that when the call to the manual exchange is from an exchange other than the terminating exchange detector relay 813 is prevented from operating as will be discussed subsequently.

As a further result of its described operation, line relay 810 closes a circuit at its lower contacts for incoming supervisory relay 803. Relay 803 thereupon operates to reverse the connection between the associated trunk line conductors and the windings of the double wound incoming line relay 804 so as to prepare for giving dark supervision to the operator when she answers.

M9. Signaling the manual-exchange operator

Upon the described closing of the circuit of auxiliary relay 812 at the middle armature and front contact of outgoing release relay 811, a branch circuit is closed, through contacts of relay 802, for splash-ring relay 801. Relay 801 thereupon operates and closes a circuit at its lower contacts for the associated slow-operating relay 802.

At its inner upper and upper armatures, relay 801 applies ground potential and ringing current respectively to the ring and tip conductors of the trunk line A—T1, thereby projecting ringing current over this trunk line to signal the manual operator. A moment later, relay 802 operates and disconnects relay 801, at the same time closing a self-locking circuit independent of the contacts of relay 801. A moment later, slow-restoring relay 801 falls back and terminates the "splash" application of ringing current to the trunk line.

In trunk circuit A—TC1 (Fig. 7) in the called manual exchange A, line relay 704, whose upper winding is bridged across the conductors of the trunk line A—T1, through contacts of cutoff relay 703 in series with a condenser, operates responsive to the above described "splash" application of ringing current. Upon operating, line relay 704 closes a self-locking circuit through its lower winding, its own contacts, lower contacts of cutoff relay 703, and call lamp 706. Call lamp 706 becomes lighted in this circuit as a call signal, and line relay 704 remains operated in its locking circuit after the momentary ringing operation has been terminated.

M10. The operator answers

Upon noting the lighted condition of call lamp 706, the operator inserts the answering plug of an idle cord circuit (the illustrated plug of cord circuit CC1, for example) into the jack J3. When this occurs, jack spring contacts 707 are closed, thereby closing a direct-current bridge across the tip and ring conductors of the trunk line A—T1. This bridge may be traced from the tip trunk-line conductor, through the upper right-hand winding of repeating coil 700, jack contacts 707, the 40-ohm right-hand winding of polarized supervisory relay 702, and the lower right-hand winding of repeating coil 700, to the ring conductor of the trunk line. Supervisory relay 40 operates in this bridge circuit by current flow obtained over the trunk line through the windings of line relay 804. Its operation occurs at this time because incoming supervisory relay 803 has been operated as described to reverse the trunk-line conductors.

Supervisory relay 701 is operated responsive to the operation of relay 702. At its upper contacts, it lights busy lamp 705; at its middle contacts, it connects up the 30,000-ohm left-hand winding of polarized relay 702 for a purpose to be dis-

cussed subsequently; and at its inner contacts, it bridges the left-hand windings of repeating coil 700 across the tip and ring conductors of the jack J3 so as to extinguish the usual supervisory lamp in the cord circuit C1 to give the operator what is termed dark supervision.

Cutoff relay 703 operates over the sleeve conductor from battery potential supplied from the cord circuit. Upon operating, cutoff relay 703 extinguishes call lamp 706 and restores line relay 704 at its lower contacts; it disconnects the upper winding of line relay from in bridge of the trunk conductors; and at its upper contacts, it closes a parallel circuit for busy lamp 705.

M11. Placing extended connection under operator control

In the automatic exchange, incoming line relay 804 of the repeater OR—1 now operates over the conductors of the trunk line A—T1 responsive to the bridge established at contacts 707 of the jack J3, through the low-resistance right-hand winding of relay 702. Upon operating, relay 804 open-circuits the slow-releasing class-tone relay 814 and closes a circuit for incoming release relay 805. Relay 805, at its middle contacts, completes a locking circuit for auxiliary relay 812 through the inner lower armature and front contact of the latter relay, whereby relay 812 is henceforth held operated under the control of both of the release relays 805 and 811, enabling the connection to be held from the manual exchange.

M12. Answered supervision withheld to enable manual exchange to be called free

At its inner contacts, release relay 805 extends ground potential through the operated armature 827 to the front contacts thereof. The extension of ground potential to the right-hand front contact of armature 827 is of no effect at this time, for detector relay 813 has been operated as previously described to disconnect outgoing supervisory relay 816, whereby the current flow over the calling line is not now reversed and the calling pay-station subscriber (Fig. 10) is not required to deposit a coin before conversing.

The ground potential applied to the left-hand front contact of the operated armature 827 is extended through contacts of sleeve-control relay 809 to the winding of the such relay. Relay 809 operates to close a locking circuit for itself and to open its initial circuit. Its locking circuit is to ground, through the middle contacts of incoming release relay 805, and to ground through the inner lower contacts of auxiliary relay 812 and the middle contacts of outgoing release relay 811, whereby the sleeve-control relay remains operated as long as either of the release relays remains operated. Relay 809 is a dual-purpose relay, being used as a sleeve-control relay on calls originated in the manual exchange as will be subsequently described. In the present example, the call is originated in the automatic exchange and the function of relay 809 is to disconnect the interrupted-generator lead 821 and prepare for the transmission of a class-tone signal to the answering operator.

M13. Momentary class-tone signal

Slow-releasing class-tone relay 814 restores a short interval after its circuit is opened as above pointed out upon the operation of incoming line relay 804. Upon restoring, relay 814 open-circuits the associated relay 815 with the result that relay 815 restores a short interval later. During the interval required for relay 815 to restore after relay 814 restores, the upper winding of detector relay 813 is bridged across the talking conductors, through contacts of relays 814 and 815, condenser 831, and the upper armature and front contact of the now-operated sleeve-control relay 809. This bridge circuit is opened a moment later when class-tone relay 815 restores. During the time that it is established, the windings of detector relay 813 act as a transformer, the lower winding being the primary and the upper winding being the secondary. Class-tone current is applied to the sleeve lead S of line multiple #203 associated with calling pay-station line #203 (Fig. 10) from the common class-tone lead CT through the illustrated individual condenser. A portion of this class-tone current travels over the extended sleeve lead to ground through the lower winding of detector relay 813, thereby inducing a similar tone current in the upper winding of this relay, which tone is impressed across the talking conductors during the described momentary class-tone interval, thereby informing the calling operator that the calling line is a pay-station line. As previously noted, as many distinctively different class-tone sources as may be desired may be provided for classifying the subscriber lines. On all calls from the tandem exchange C to exchange A, any class tone applied to the sleeve lead of the calling line is momentarily applied to the talking circuit a moment after the operator responds.

M14. Recalling the class-tone signal

Let it be assumed now that the operator either failed to have her listening key thrown at the time she plugged in to answer or for some other reason desires to verify the class tone. Under this condition, she withdraws the plug of the cord circuit from the jack J3 and then reinserts the plug. Line and release relays 804 and 805 restore successively, but sleeve-control relay 809 is not restored because it is held operated through contacts of relays 812 and 811. Relays 814 and 815 operate successively responsive to the restoration of line relay 804.

When the plug is reinserted in the jack, line and release relays 804 and 805 reoperate, and the line relay 804 open-circuits class-tone relay 814. Relays 814 and 815 again restore successively, and the class-tone signal is again applied to the talking circuit in the interval required for relay 815 to restore after relay 814 restores.

The exchange-A operator may now converse with the calling pay-station subscriber over the established connection and she may further extend the connection if desired, or she may give the calling subscriber any requested information; ticket a requested toll connection; and the like.

If the connection is further extended by the manual operator, when the called subscriber answers, the operator may require the calling pay-station subscriber to deposit a coin or coins before permitting him to converse, the usual gong signals (not shown) being employed to notify the operator, through the action of the transmitter 1026, of the number and denomination of the deposited coins.

M15. Disconnect supervision and hookswitch recall signaling

Let it be assumed now that, when the conversation has been completed, the calling pay-sta-

tion subscriber replaces his receiver before the exchange-A operator withdraws the plug from the jack J3. Under this condition, the operator is given disconnect supervision as follows:

When the receiver is replaced on the calling line, line relay 810 restores followed a moment later by the restoration of release relay 811. Relay 812, however, remains operated through the middle contacts of incoming release relay 805 and the inner lower armature of relay 812 and its front contact, to maintain the associated sleeve conductor grounded at its upper contacts, whereby the connection in the automatic exchange remains intact. This provision enables the calling automatic-exchange subscriber to signal the operator by depressing his hookswitch momentarily one or more times as a recall signal.

The lower contacts of line relay 810 open-circuit incoming supervisory relay 803, whereupon supervisory relay 803 restores after a slight interval and reverses the connection between the windings of line relay 804 and the conductors of the associated trunk line back to the illustrated normal condition, whereupon the current flow in the trunk line is reversed to its normal direction. When this occurs, polarized relay 702 in the manual trunk circuit A—TC1 opens its contacts, thereby open-circuiting and restoring supervisory relay 701. At its inner contacts, relay 701 opens the direct-current bridge across the tip and ring conductors of the jack J3, thereby causing the usual supervisory lamp (not shown) in the cord circuit C to become lighted.

If the hookswitch at the calling substation has been depressed pursuant to a recall operation, it is again released after a slight interval, whereupon line and release relays 810 and 811 reoperate. Incoming supervisory relay 803 thereupon reoperates, whereupon polarized relay 702 again closes its contacts to reoperate supervisory relay 701. When relay 701 reoperates and closes its inner contacts, the above-mentioned supervisory lamp in the operator's cord circuit is extinguished.

M16. Maintaining trunk line guarded in manual exchange after operator disconnects

Let it be assumed now that, when the conversation has been terminated, the manual exchange operator disconnects before the calling subscriber in the automatic exchange has replaced his receiver. Under this condition, supervisory relays 702 and 701 are in operated condition in trunk circuit A—TC1 because incoming supervisory relay 803 in the automatic exchange is maintaining the current flow reversed over trunk line A—T1.

When the plug is withdrawn from the jack J3, cutoff relay 703 restores. At its upper contacts, it opens a point in the circuit of busy lamp 705, leaving this lamp lighted at the upper contacts of supervisory relay 701 to inform the operator of the continued busy condition of the associated trunk line.

When contacts 707 of the jack J3 open, the low-resistance direct-current bridge (including the right-hand 40-ohm winding of polarized relay 702, and the right-hand windings of repeating coil 700) is opened, leaving a high-resistance bridge closed across the trunk-line conductors. This high-resistance bridge may be traced from the tip conductor of the trunk line, through the upper right-hand repeating coil winding, middle contacts of the operated supervisory relay 701, the 30,000-ohm left-hand winding of relay 702, the 40-ohm right-hand winding of the relay, and the lower right-hand repeating-coil winding, to the ring conductor of the trunk line. The sensitive polarized relay 702 is able to remain operated in this high-resistance bridge circuit to maintain the circuit of supervisory relay 701 closed.

In the automatic exchange, incoming-line relay 804 of the repeater OR—1 restores when contacts 707 of the jack J3 open, as it is unable to remain operated through the high-resistance bridge now maintained across the trunk line conductors. Upon restoring, line relay 804 open-circuits and restores release relay 805, leaving auxiliary relay 812 operated only by release relay 811, held by line relay 810.

As long as the receiver remains unreplaced at the calling substation, the connection with the trunk line is held in its present condition, and the trunk line is unavailable for use by the manual exchange operator, which condition is indicated by the continued lighted condition of busy lamp 705, held lighted by the upper contacts of supervisory relay 701.

As will be discussed subsequently, this condition can continue for only a few minutes because of timing arrangements including release-timer relay 817.

M17. Clearing out the established connection

When the receiver is replaced at the calling substation under the present conditions, the resulting restoration of line relay 810 permits incoming supervisory relay 803 to restore, whereupon the current flow over the interexchange trunk line A—T1 is reversed back to normal direction. Polarized relay 702 thereupon opens its contacts, permitting supervisory relay 701 to restore. Supervisory relay 701 extinguishes busy lamp 705 at its upper contacts, while at its middle contacts it opens the high-resistance bridge.

A further result of the restoration of line relay 810 is that relays 811 and 812 restore successively. When relay 811 restores, it opens the holding circuit for relay 809, permitting relay 809 to restore.

At its upper contacts, relay 812 disconnects ground potential from the associated sleeve conductor, whereupon detector relay 813 restores. Relays 814 and 815 restore responsive to the restoration of relay 811, completing the clearing out of the repeater.

Upon the said ungrounding of the sleeve conductor, cutoff and lockout relays 820 and 819 of line circuit LC—211, the corresponding relays of the calling line circuit LC—203 (Fig. 10), and switch-through relay 1301 of the connector C1 (Fig. 13) restore.

In the connector C1 (Fig. 13) switch-through relay 1301, upon restoring, disconnects its winding from the sleeve conductor at its inner upper contacts, while, at armature 65, it removes ground potential from the associated hold conductor H of the link L1. This permits the finder F1 to clear out. By the same operation of relay 1301, ground potential is removed from conductors 17 and 18, wherepon all of the remaining operated relays of the connector C1 restore, completing the clearing out of the established connection.

N. Calls from manual exchange B to manual exchange A

The way in which the operator at manual exchange B extends a connection to manual exchange A (by way of the tandem automatic exchange C) will now be explained.

It may be assumed that the trunk line B—T1 is idle as indicated by the unlighted condition of

the busy lamp associated with the jack J1. Accordingly, the operator may take this trunk line for use by inserting the plug of a cord circuit into the jack J1. Operations thereupon occur in the trunk circuit B—TC1 to bridge the trunk line B—T1, thereby causing operations to occur in the manual-to-automatic repeater 9R—1 in exchange C to bridge the tip and ring conductors of the associated line multiple #221. The operations occurring during this call in the trunk circuit B—TC1 and in repeater 9R—1 are the same as those to be subsequently described in a connection with the similar trunk circuit and repeater shown in Figs. 7 and 8.

N1. Seizing an idle connector

Line relay 201 of line circuit LC—221 operates through the established bridge in repeater 9R—1 to ground the associated tens and units-mark conductors T and U to cause an idle finder to make connection with the now-calling line multiple #221. It may be assumed that this connection is made by the finder F1 (Fig. 11), associated with the connector C1 (Fig. 13). In this event, the connector C1 prepares itself for operation, including grounding sleeve conductor incoming thereto, whereupon cutoff and lockout relays 203 and 202 of the calling line circuit LC—221 operate. Line relay 201 is thereby disconnected and restored, terminating the calling condition of the line circuit.

As will be explained hereinafter in connection with the outgoing repeater OR—1, the above grounding of the sleeve conductor of the line multiple causes ground potential to be applied to such sleeve conductor in repeater 9R—1 and to distinguish the call as one coming from a manual exchange.

N2. Dialing the single-digit number 0

The operator at exchange B now dials the single-digit number *0* assigned to manual exchange A, using a key such as K (Fig. 7) and the calling device such as CD. When this occurs, the seized connector C1 (Fig. 13) operates as previously described to extend connection to an idle one of the trunk lines leading from exchange C to exchange A.

N3. Seizing repeater OR—1 and signaling the operator

It may be assumed that the trunk line associated with outgoing repeater OR—1 is allotted at this time, in which case the line multiple seized by the connector responsive to the dialing of the digit *0* is the line multiple #211 associated with line circuit LC—211 (Fig. 8). Operations as hereinbefore described occur in the repeater OR—1 to condition the repeater for operation and to apply ringing current momentarily through the action of splash-ring relays 801 and 802 to the conductors of trunk line A—T1 to signal the operator at exchange A by lighting call lamp 706.

The operations in the repeater OR—1 include the operation of relays 810, 811, 812, 814, 815, and 801 to 803. Ground potential is applied to the associated sleeve conductor at the upper contacts of auxiliary relay 812, through the lower winding of detector relay 813, but relay 813 does not operate at this time as its lower winding is maintained shunted by the ground connection made to the sleeve conductor of the established connection at the calling repeater 9R—1. As a result, outgoing supervisory relay 816 remains connected through the unopened contacts of relay 813.

When the operator at exchange A responds to the lighted condition of call lamp 706 by inserting the plug of an idle cord circuit in the jack J3, relays 702 and 701 operate as previously described, relay 701 closing its inner contacts to give the answering operator dark supervision.

N4. Giving answered supervision

In the repeater OR—1, line relay 804 now operates over trunk line A—T1 and brings about the previously described operation of incoming release relay 805 to lock auxiliary relay 812 operated. Additionally, sleeve control relay 809 operates as previously described to lock itself under the joint control of release relays 805 and 811, and class-tone relays 814 and 815 restore successively for the purpose hereinbefore explained.

At this time, the ground potential applied to armature 827 of relay 812 (through contacts of the operated relays 804 and 805) is extended through the right-hand front contact of armature 827, and through contacts of the unoperated detector relay 813, to the winding of outgoing supervisory relay 816. Relay 816 now operates. At its lower contacts, it locks itself operated independent of the contacts of detector relay 813, while at its upper pair of armatures and associated contacts, it reverses the connections between the windings of line relay 810 and the tip and ring conductors in the associated line multiple, thereby reversing the current flow back over the established connection to the calling repeater 9R—1. The repeater 9R—1 responds to this operation (in a manner to be explained subsequently in connection with the repeater OR—1) to relay answered supervision back over the trunk line B—T1 to the trunk circuit B—TC1 which thereupon operates to give answered supervision in the calling cord circuit in exchange B.

The operator at exchange A may now extend the connection as desired.

N5. Recalling the called operator

The circuit arrangement is such that the operator at exchagne B may recall the operator at exchange A by removing the cord circuit plug from the jack J1 and reinserting it, or she may remove the plug of the cord circuit in use and substitute the plug of another cord circuit if she finds the one in use to be defective.

As will hereinafter appear, when plug is removed from the jack J1, repeater 9R—1 responds to the the consequent control of the trunk circuit B—TC1 to unbridge the associated tip and ring conductors of the switchboard multiple and to remove the ground connection previously applied to the sleeve conductor thereof. When this occurs, the lower winding of detector relay 813 becomes the sole supply of ground potential to the sleeve conductor of the established connection, whereupon relay 813 operates and opens a point in the circuit of outgoing supervisory relay 816, but relay 816 remains operated to maintain the reversed condition of the associated tip and ring conductors. Line relay 810 restores responsive to the unbridging of the tip and ring conductors in the repeater 9R—1, restoring incoming supervisory relay 803, with the result that current flow in the interexchange conductors is reversed back to normal direction. Relay 702 thereupon opens its contacts, and relay 701 consequently restores to cause the supervisory lamp in the associated cord circuit to become lighted.

Release relay 811 retores at this time, but without harmful effect, as relay 812 is locked through contacts of relay 805.

When the same or another plug is subsequently reinserted into the jack J7 at exchange B, the resulting operation is that tip and ring conductors of line multiple #221 are again bridged in repeater 9R—1 and ground potential is again applied directly to the associated sleeve conductor. As a consequence, detector relay 813 again restores (being short-circuited) and line relay 810 reoperates, followed by the reoperation of relays 811 and 803.

Polarized relay 702 in trunk circuit A—TC1 now reoperates relay 701, thereby bringing about the extinguishment of the supervisory lamp in the associated cord circuit.

N6. Giving disconnect supervision to the calling operator

When the connection is to be taken down, it may be assumed that the operator at exchange A is the first to take down the connection. When this occurs, the removal of the plug from jack J3 and the consequent opening of the contacts 707 causes incoming-line relay 804 to restore, open-circuiting and restoring outgoing supervisory relay 816, release relay 805 also restoring. When relay 816 restores, the current flow in the talking conductors of the connection through the automatic exchange is reversed to normal direction, whereupon repeater 9R—1 relays disconnect supervision to trunk circuit D—TC1, which operates to relay it to the associated cord circuit by the lighting of the usual supervisory lamp therein.

N7. Clearing out the connection

Under the above conditions, when the operator at exchange B removes the plug from the jack J7 and the repeater 9R—1 consequently unbridges the associated talking conductors and ungrounds the sleeve conductor, the connection is cleared out responsive to operations to be now described.

Line relay 810 restores responsive to the unbridging of the associated tip and ring conductors at the repeater 9R—1, whereupon incoming supervisory relay 803 restores, followed by the restoration of relays 702 and 701 and the extinguishment of busy lamp 705.

Relay 811 restores after a slight interval. With incoming release relay 805 in restored condition, the restoration of relay 811 is followed immediately by the restoration of relay 812 to remove ground potential from the associated sleeve conductor, whereupon the operated relays in the concerned line circuits LC—211 and LC—221 restore and the connection through the finder F1 of Fig. 11 and the connector C1 of Fig. 13 is cleared out as hereinbefore described.

O. Calls from manual exchange A to manual exchange B

Let it be assumed now that the operator at exchange A desires to extend a connection (by way of tandem exchange C) to or through manual exchange B. It may be assumed that trunk line A—T1 is idle as indicated by the unlighted condition of busy lamp 705, and is the one used. When the plug of a cord circuit is inserted into the jack J3, cutoff relay 703 operates to disconnect line relay 704 and to light busy lamp 705. Contacts 707 of the jack J3 close a bridge across the tip and ring conductors of the associated trunk line through the 40-ohm right-hand winding of supervisory relay 702 and the right-hand windings of repeating coil 700. Polarized relay 702 is not operated at this time because the ensuing current flow is in the normal direction. As a consequence, supervisory relay 701 is not operated, wherefore the usual supervisory lamp in the calling end of the operator's cord circuit is lighted.

O1. Preparing repeater OR—1 for incoming operation

In the automatic exchange, line relay 804 now operates over the trunk line A—T1 through the right-hand winding of polarized relay 702. The operation of relay 804 is followed by the operation of incoming release relay 805 to extend ground potential to armature 827, but this is without effect at this time as auxiliary relay 812 remains unoperated.

At its middle contacts, relay 805 closes a circuit through the inner lower armature of relay 812 and its back contact for incoming transfer relay 808. Relay 808 thereupon operates to separate conductor 931 at its lower contacts to thereby restore allotter relay 911, if operated. At its inner lower contacts, relay 808 prepares a circuit for series relay 807; at its inner upper armature, it transfers the associated sleeve conductor of line multiple #211 from in association with the lower winding of detector relay 813 into connection with the winding of sleeve-control relay 809; and at armatures 822 and 823, it disconnects the associated terminals of the right-hand repeating-coil windings from the windings of line relay 810 and connects them to a low-resistance bridge to place the associated line circuit LC—211 in calling condition. This low-resistance bridge may be traced from the front contact of armature 822, through the upper contacts of line relay 804, the 500-ohm resistor 825, and the 40-ohm right-hand winding of polarized relay 806, to the front contact of armature 823. Polarized relay 806 does not operate at this time, because of the normal direction of the current flow therethrough.

O2. Seizing and preparing an idle connector

Line relay 818 operates responsive to the closing of the described bridge across the associated tip and ring conductors in the repeater OR—1, thereby energizing the associated tens and units marking conductors T and U to cause a finder to make connection with the associated line multiple #211. It may be assumed that this connection is made by the illustrated finder F1 (Fig. 11) associated with the connector C1 (Fig. 13), relay T2F and U1F in the finder operating for this purpose.

When the connection is made, the connector C1 is prepared for operation in the usual manner responsive to the energization of line relays 1305 and 1306 over the tip and ring conductors of the calling multiple #211, now bridged in the repeater OR—1.

When the sleeve conductor of the calling multiple becomes grounded (at the front contact of the upper armature of release relay 1307) incidental to the preparation of the connector C1 for operation, cutoff and lockout relays 820 and 819 of the line circuit LC—211 operate. Line relay 818 restores responsive to the operation of cutoff relay 820, terminating the calling condition of line circuit LC—211.

O3. Grounding the sleeve conductor to identify the manual-exchange call

A further result of the described grounding of the sleeve conductor in line multiple #211 is the closing of a circuit through the front contact of the inner upper armature of relay 808 for sleeve-control relay 809. Sleeve-control relay 809 now

operates and locks itself to ground at the middle lower contacts of the operated incoming release relay 805, thereby applying ground potential in the repeater OR—1 to the sleeve conductor of the associated line multiple #211 to identify the call as one being made from a manual exchange. This ground connection is through the middle contacts of relay 805, and through contacts of the operated relays 809 and 808 to the associated sleeve conductor. Dial tone from the connector C1 (Fig. 13) is now transmitted back over the calling multiple and through the windings of repeating coil 800 to the calling manual exchange, informing the calling operator that the switching apparatus is in readiness to respond to the dialing operation.

O4. Dialing the single-digit number 9

Upon hearing the dial tone, the operator may actuate the key K associated with the trunk line A—T1 thereby transferring the trunk-line conductors to the calling device CD.

Since the call is for exchange B, designated by the single-digit number 9, the operator may now actuate the calling device CD to transmit the digit 9 (nine momentary interruptions), after which she restores the key K.

Line relay 804 in repeater OR—1 is thereby restored momentarily nine times, the associated release relay 805 remaining operated because it is slow releasing. At its upper contacts, line relay 804 momentarily interrupts the previously described bridge across the tip and ring conductors of line multiple #211 nine times, thereby repeating the dialed digit 9 to the connector C1 (Fig. 13).

Upon each momentary restoration of line relay 804, a circuit is closed for series relay 807, through the inner lower contacts of incoming transfer relay 808, and through the lower contacts of incoming supervisory relay 803. Slow-releasing series relay 807 operates promptly in response to the first impulse of the series and remains operated throughout the series of impulses. Relay 807 shunts the 200-ohm resistor 826 around the 500-ohm resistor 825 and the 40-ohm right-hand winding of polarized relay 806 to improve the impulse-repeating circuit.

O5. Seizing trunk allotter TA—0

In the connector C1, the results following the dialing of the digit 9 are similar to the hereinbefore described results of the dialing of the digit 0, except that tens relay T22C is operated (over conductor 22 of cable 1366, from ground potential placed on hundreds conductor 39 at the end of the digit), in place of relay T21C. Consequently, when connecting relay CN—1 subsequently responds to the ensuing operation of chain relay CH—1 as hereinbefore described, conductor 9 of cable 1300 becomes grounded (through the lower contacts of relay T22C) in place of conductor 0 in the said cable. As a result, the trunk allotter called into play is the trunk allotter TA—9 of Fig. 4 rather than the trunk allotter TA—0 of Fig. 9. The trunk allotter TA—9 may be a duplicate of the trunk allotter TA—0. In has control pairs of conductors 411 to 415 extending therefrom and connected respectively with the repeaters (such as 9R—1) associated with the five trunk lines interconnecting exchanges B and C.

O6. Marking the location of the allotted idle trunk line

It may be assumed that the first of these trunk lines is idle and is allotted, in which case conductor 431 of the allotter TA—9 is in grounded condition (conductors 431 to 436 corresponding respectively to conductors 941 to 946 of the allotter TA—0). Under this condition, when connecting relay 443 operates (over conductor 9 in cable 1300), mark conductor M1 in cable 1300 becomes grounded upon being connected to the grounded mark conductor 431, and switching lead SW—1 is grounded at the upper contacts of relay 443 through the upper contacts of the unoperated busy relay 444.

In the connector C1, the described grounding of conductor M1 in cable 1300 results in the closure of a circuit through contacts of the operated relay CN—1 and over conductor U1 to operate units relay U1C to connect the conductors of the out link OL with line multiple #221, through the upper group of contact sets of the actuated tens relay T22C.

O7. Seizing the repeater OR—1 and signaling the operator

Other operations in the connector C1 now occur as described hereinbefore, culminating in the operation of switch-through relay 1301 as described to transfer the incoming tip, ring, and sleeve conductors of the connector C1 directly to the corresponding conductors of out link OL and therefore to the corresponding conductors of the called line multiple #221.

The resulting grounding of the sleeve lead of line multiple #221 brings about the operation of cutoff and lockout relays 303 and 302 of line circuit LC—221 (Fig. 3).

In the repeater 9R—1, the relays therein corresponding respectively to line relay 910, release relay 811, and auxiliary relay 812, operate pursuant to the preparation of the repeater for operation. Additionally, the relay in repeater 9R—1 corresponding to incoming supervisory relay 803 operates; the described splash ringing operation is accomplished by relays corresponding to relays 801 and 802; and the class-tone relays in the repeater 9R—1 corresponding to 814 and 815 operate in preparation for applying a class tone, if present on the extended sleeve conductor.

It is to be noted that the relay in repeater 9R—1 corresponding to detector relay 813 of the repeater OR—1 is not operated at this time because it is short-circuited by the ground potential placed on the sleeve conductor S of the calling multiple #211 through the inner upper armature and front contact of incoming transfer relay 808, lower armature of relay 809 and the middle armature of release relay 805. Consequently, the outgoing supervisory relay in repeater 9R—1 corresponding to relay 816 of the repeater OR—1 is not disconnected.

The trunk circuit B—TC1 operates as explained in connection with trunk circuit A—TC1 of Fig. 7 to signal the operator by lighting the associated call lamp responsive to the above-mentioned splash-ring operation.

O8. Giving answered supervision

When the operator responds, by inserting the plug of a cord circuit into the jack J1, the associated call lamp is extinguished and the conductors of trunk line B—T1 are bridged, causing operations in repeater 9R—1 as explained hereinbefore in connection with repeater OR—1. One of these operations is the actuation of the outgoing supervisory relay in repeater 9R—1 corresponding to relay 816 (the associated detector relay corresponding to 813 not having been op-

erated as described). Consequently, the current flow in the tip and ring conductors of the calling line multiple #221 is reversed, whereupon polarized relay 806 in repeater OR—1 is operated by its right hand 40-ohm winding to close its contacts 850. When this occurs, incoming supervisory relay 803 operates to reverse the current flow over the conductors of the associated trunk line. Relay 702 is thereupon operated through its right-hand winding to operate supervisory relay 701. Relay 701 closes its inner contacts to give the calling operator answered supervision. The two operators may now converse with each other as described, and the operator at exchange B may make any desired extension of the connection.

O9. Recalling the called operator

In the event that the calling operator at exchange A desires to recall the called operator at exchange B during the continuance of the extended connection, she may do so by momentarily withdrawing her plug from the jack J3 one or more times to flash the supervisory light in the cord circuit not shown in exchange B. When the plug is withdrawn from the jack J3, the opening of contacts 707 disconnects the associated low-resistance bridge including the low-resistance right-hand winding of relay 702, leaving the high-resistance left-hand winding of this relay bridged across the associated tip and ring conductors through the middle upper contacts of the operated supervisory relay 701, whereby relay 702 remains operated to maintain relay 701 operated.

When the low-resistance bridge is thus opened at contacts 707, line relay 804 restores. Series relay 807 remains unoperated at this time, having been disconnected by incoming supervisory relay 803 for this purpose.

The restoration of line relay 804 is followed shortly by the restoration of release relay 805. At its middle contacts, relay 805 removes the ground potential formerly maintained on the extended sleeve lead through the lower armature and front contact of sleeve-control relay 809, and the inner upper armature of the operated incoming transfer relay 808. The sleeve conductor, however, remains grounded at this time in the repeater 9R—1, through the lower winding of the relay therein corresponding to detector relay 813 of repeater OR—1. The established connection is, therefore, maintained, and sleeve-control relay 809 remains operated. Incoming transfer relay 808 remains operated by its connection with the grounded sleeve conductor through the inner lower contacts of auxiliary relay 812 and the lower armature and front contact of sleeve-control relay 809.

At its upper contacts, incoming line relay 804 opens the low-resistance bridge including resistor 825 and the right-hand winding of relay 806, leaving the front contacts of armatures 822 and 823 bridged through the inner upper contacts of the operated supervisory relay 803, the 30,000-ohm left-hand winding of polarized relay 806, and the low-resistance right-hand winding of this relay. Relay 806 is, therefore, maintained operated at this time to maintain relay 803 operated, and the latter relay maintains the current flow in trunk line A—T1 reversed to maintain relay 702 operated in exchange A.

Responsive to the opening of the associated low-resistance bridge at the upper contacts of line relay 804, the line relay in repeater 9R—1 (corresponding to line relay 810 of the repeater OR—1) restores to permit the associated incoming supervisory relay (corresponding to relay 803) to restore and reverse the current flow over the trunk line BT—1 back to normal direction, the trunk circuit B—TC1 operating to bring about the lighting of the supervisory lamp in the cord circuit at exchange B.

When the plug of the cord circuit is reinserted (at the end of an interval too short to permit the operator in exchange B to interpret the lighted lamp as a disconnect signal) contacts 707 reestablish the low-resistance bridge across the associated trunk line conductors, whereupon line relay 804 reoperates, accompanied by the reoperation of relay 805. Relay 805, at its middle contacts, reapplies ground potential to the associated sleeve conductor through contacts of the operated relays 809 and 810.

At its upper contacts, line relay 804 reestablishes the low-resistance bridge through the right-hand winding of relay 806, whereupon the outgoing line relay in repeater 9R—1 reoperates, followed by the operation of the associated incoming supervisory relay to again reverse the current flow over the conductors of the associated interexchange trunk line, causing the trunk circuit B—TC1 to bring about the extinguishment of the momentarily lighted supervisory lamp in the operator's cord circuit.

Upon each momentary withdrawal operation of the plug from the jack J3, the supervisory lamp is momentarily lighted in the called manual exchange as above described.

O10. Recalling the calling operator

If the operator in exchange B desires to recall the calling operator in exchange A during the continuance of the established connection, she may do so by momentarily withdrawing her plug from the jack J7 a desired number of times, to cause the usual supervisory lamp in the cord circuit in use in exchange A to flash.

When the plug is withdrawn from jack J7, operations occur as just described in connection with trunk circuit A—TC1 and repeater OR—1 to cause the incoming line relay in repeater 9R—1 corresponding to line relay 804 to restore. Upon restoring, such line relay open-circuits and restores the associated release relay (such as 805), as well as open-circuiting and restoring the associated outgoing supervisory relay (corresponding to relay 816). When this occurs, the current flow over the tip and ring conductors of the associated line multiple #221 is reversed back to normal direction, thereby restoring polarized relay 806 in the repeater OR—1. Incoming supervisory relay 803 is thereupon restored, reversing the current flow in the associated interexchange trunk line to normal direction. Thereupon, relay 702 restores, followed by the restoration of relay 701. At its inner contacts, relay 701 unbridges the tip and ring conductors of the jack J3 causing the operator's supervisory lamp to become lighted.

When the plug is reinserted into the jack J7 at the end of the momentary withdrawal, the preceding operations are reversed causing the supervisory lamp in the cord circuit in use in exchange A to become extinguished.

O11. Clearing out the connection

When the conversation over the extended connection has been completed and the two operators have withdrawn their plugs from the jacks

J7 and J3, the result is that ground potential is removed at both points from the sleeve conductor of the connection, whereupon the connection is cleared out as before described.

P. Manual-exchange calls to tandem exchange C

The way in which connections are completed to local lines of tandem exchange C from either of the manual exchanges A and B will now be described. For this purpose, it will be assumed that the manual operator in exchange A receives a call which is intended for a local subscriber of tandem exchange C, the subscriber at substation #2024 on the four-party line #202, for example.

P1. Taking an idle interexchange trunk line for use

It may be assumed that the trunk line A—T1 is idle at this time as indicated by the unlighted condition of busy lamp 705 and that the operator takes this trunk line for use by inserting the plug of her cord circuit into the jack J3. The trunk line A—T1 is thereby bridged in trunk circuit A—TC1 by the closure of contacts 707.

In exchange C, incoming line relay 804 operates in response to the bridging of the trunk line A—T1 in the calling manual exchange, followed by the hereinbefore described operation of incoming release relay 805 and of incoming transfer relay 803. The tip and ring conductors of the associated line multiple #211 are thereby bridged at armatures 822 and 823 through the upper contacts of line relay 804 and the low-resistance right-hand winding of supervisory relay 806.

P2. Seizing an idle connector

Line relay 818 of the associated line circuit LC—211 now operates to ground the associated T and U mark conductors to cause an idle finder to make connection with the calling line multiple #211. It may be assumed that the finder F1 of Fig. 11 is the one thereupon operated, in which case the calling multiple #211 is extended to the connector C1, Fig. 13, by way of conductors of the link L1.

The connector C1 is now prepared for operation responsive to the energization of line relays 1305 and 1306 over the tip and ring conductors of multiple #211, through the previously noted bridge in the calling repeater OR—1. The operation of relays 1305 and 1306 is followed by the operation of release relay 1307, sleeve relay 1309 and dial-tone relay 1324, completing the preparation for operation of the connector C1 and sending back a dial-tone signal to the calling operator.

P3. Grounding the sleeve conductor to identify the manual-exchange call

The grounding of the sleeve conductor S of the link L1 at this time at the upper armature of release relay 1307 results in the closure of a circuit over the sleeve conductor of the calling multiple to operate cutoff and lockout relays 820 and 819 of line circuit LC—211, whereupon line relay 818 restores to terminate the calling condition of the line circuit. A further result of the grounding of the sleeve conductor of this multiple is the closure of a circuit through the inner upper armature and front contact of relay 808 for sleeve-control relay 802. Relay 802 thereupon operates to apply ground potential in the repeater OR—1 to the sleeve conductor of the multiple at the lower contacts of relay 809, through the middle contacts of incoming release relay 805. The ground potential thus applied serves to identify the call as from a manual exchange.

P4. Dialing the desired number

Upon hearing the dial-tone signal returned as above noted, the calling operator actuates the dial key K to associate calling device CD with the conductors of trunk line A—T1, whereupon she actuates the calling device CD in accordance with the digits 2, 0, 2, and 4 in the desired number, following which she again restores the key K.

Line relay 804 restores responsive to each interruption impulse of each digit, repeating such interruption impulses at its upper contacts into the bridge across the conductors of line multiple #211, causing line relay 1306 of the connector C1 to follow the calling device CD.

As previously noted, series relay 807 operates at the beginning of each received series of impulses and acts to improve the impulse-repeating circuit by partially shunting resistor 825 and the right-hand winding of relay 806, relay 807 restoring at the end of each series of impulses.

P5. Conditioning the connector for toll operation

With one exception, the connector C1 of Fig. 13 operates as hereinbefore described in response to the respective impulse series constituting the digits 2, 0, 2, and 4 in the called number. This exception occurs following the final digit of the number, at which time either busy relay 1320 or switching relay 1319 operates as hereinbefore described, depending on whether the called line is busy or is idle. The operation of either of these relays removes ground potential from local conductor 15 to render the upper or test winding of detector relay 1308 effective as the sole supply of ground potential in the connector C1 to the sleeve lead of the connection. It will be recalled that detector relay 1308 thereupon operates over the sleeve lead when the call is from a local line. In the present example, the call is from a manual-exchange line and the sleeve lead of the calling multiple is now grounded in the repeater OR—1 through contacts of relays 805, 809, and 808, as previously noted. The upper winding of detector relay 1308 is thereby shunted, preventing the relay from operating. The failure of detector relay 808 to operate responsive to the operation of either busy relay 1320 or switching relay 1319 conditions the connector C1 for operation as a toll connector.

P6. Busy verification

If the called line is busy, a busy-tone signal is returned at the upper contacts of busy relay 1320 to inform the calling operator of the busy condition of the called line.

When the operator desires to verify the busy condition of a busy called line, she may do so by again temporarily associating the calling device CD with the calling trunk line and dialing the digit 1.

With busy relay 1320 operated, and with detector relay 1308 not operated, the momentary restoration of line relay 1306 in response to the dialing of the vertification digit 1 results in the closure of a circuit over conductor 11, through the inner upper armature and front contact of busy relay 1320, conductor 14, middle upper armature and back contact of detector relay 1308, and over conductor 13, for the lower winding of busy-verification relay 1311. Busy-verification relay 1311 thereupon operates and prepares a holding circuit for itself at its inner contacts.

When line relay 1306 reoperates, it opens the initial circuit of relay 1311 at its back contact, while at its front contact it closes a holding circuit over conductor 12, through the inner contacts of relay 1311, the upper winding of relay 1311, and through the winding of ring-trip relay 1315, to battery. Relay 1311 remains operated in this holding circuit and relay 1315 operates, whereupon ring-cutoff relay 1313 is operated and locks itself to conductor 17.

At contacts 79 of ring-cutoff relay 1313, a circuit is closed for switching relay 1319, whereupon relay 1319 completes the talking circuit to the called line at armatures 84 and 85. No ringing current is applied at this time because of the above-described operation of ring-cutoff relay 1315 prior to the operation of switching relay 1319.

The busy-tone signaling circuit is opened at contacts 75 of busy-verification relay 1311, while at armatures 73 and 74 back-bridge relay 1312 is disconnected to prevent a disturbance of the supply of transmitter current to the called line, as well as to prevent an undesired operation of supervisory relay 1304 at this time.

The talking circuit having been completed to the called line as above noted, the operator is now able to determine whether or not the called line is really in use, as distinct from an abnormal condition resulting in the giving of a busy signal. One such abnormal condition is when the called line may be out of order and therefore locked out of service as previously discussed. If the operator finds the called line to be out of order, she may call this to the attention of the attendant at exchange C, if such exchange is attended at the time, or she may cause an attendant to be sent to exchange C, if the exchange is at such time unattended.

Assuming that the called line is not out of order but is regularly busy in a local call (as distinguished from a toll call), the operator may request the subscribers to replace their receivers and permit the local connection between their lines to clear out. The operator may take down the connection at her switchboard to permit the connection which she has set up to the called line to clear out whereupon she again takes an idle trunk line for use and calls the number over again to make connection with the called line in the usual way.

P7. Incoming toll conversations not timed in automatic exchange

Let it be assumed now that the desired line is idle when called as described, in which case switching relay 1319 operates as previously described to complete connection thereto, and ringing current is applied. The ringing operation is terminated when the called subscriber responds, relays 1315, 1313, 1312, and 1304 responding. The conversation is not timed at the automatic exchange in this case, however, because the call is a toll call, and conversation-timing lead P2 remains disconnected at contacts of the unoperated detector relay 1308. The operator is expected to time and ticket the call in the usual manner.

P8. Answered supervision

When supervisory relay 1304 operates and reverses the current flow in the associated tip and ring conductors, polarized supervisory relay 806 (Fig. 8) thereupon responds, causing incoming supervisory relay 803 to reverse the current flow over trunk line A—T1 followed by the successive operation of relays 702 and 701 in trunk circuit A—TC1 to give the operator answered supervision as previously discussed.

P9. Disconnect supervision

When the ensuing conversation is terminated and the called subscriber replaces his receiver, the operator is given disconnect supervision as follows:

Back-bridge relay 1312 of the connector restores, followed by the restoration of supervisory relay 1304, to reverse the direction of the current flow in the associated talking conductors to normal.

In the repeater OR—1 polarized supervisory relay 806 now restores followed by the restoration of incoming supervisory relay 803 to reverse the current flow over trunk line A—T1 to normal direction, causing relays 702 and 701 to restore successively, the latter relay opening its inner contacts to give the operator disconnect supervision as previously discussed.

P10. Clearing out

When the operator removes the plug from the jack J3, the established connection is cleared out as hereinbefore described.

Q. Permanent timing at the repeater OR—1

When the repeater OR—1 is seized in automatic exchange C, timing operations occur to bring about a release of the established connection within from two to four minutes if the operator has not answered during this time, as will now be described.

It will be recalled that the outgoing line and release relays 810 and 811 operate successively upon the seizure of the repeater OR—1 as an outgoing repeater, followed by the operation of auxiliary relay 812 to place a holding ground potential on the associated sleeve lead through the lower winding of detector relay 813, which holding ground potential is effective to maintain a connector such as C1, Fig. 13, operated to maintain the connection established.

At armature 829, relay 812 applies ground potential to start conductor 1356 (extending to timer T, Fig. 13, part 6), to start the timer into operation if it is not already operating. Lead P1 of the timer T is now connected, through contacts of release-timer relay 817, lower armature and back contact of incoming release relay 805, front contact of the lower armature of outgoing release relay 811 and the said armature, and contacts 823 of auxiliary relay 812, to relay 817. As a result of this connection, relay 817 operates when lead P1 is next momentarily grounded, provided the operator has not in the meantime answered to cause incoming release relay 805 to operate. Upon operating, relay 817 closes a self-locking circuit at its lower armature disconnecting itself from lead P1. At its upper armature and associated contacts, release-timer relay 817 substitutes ground potential over hold lead H1 for the local ground connection to the lower winding of detector relay 813.

If the operator has not responded and caused incoming release relay 805 to operate by the time hold conductor H1 next becomes ungrounded (approximately two minutes following the operation of relay 817), such next ungrounding of lead H1 results in the removal of ground potential from the lower winding of detector relay 813 and consequently from the associated sleeve lead. The connection established in the automatic exchange to the repeater OR—1 is thereupon

cleared out as previously described, and the calling line circuit is brought into lockout condition. The repeater OR—1 now clears out, relays 810, 811, and 812 restoring, with the resultant restoration of the other operated relays of the repeater (801, 802, 814, 815, and 817).

Q1. Permanent timing at OR—1 following conversation

Let it be assumed now that the call through repeater OR—1 to the manual exchange is answered before the connection is cleared out by the previously described permanent-timing operation. In this event, when incoming release relay 805 responds to the operation of line relay 804 over the trunk line A—T1, it open-circuits and restores release-timer relay 817 (if operated) at its lower contacts. No conversation timing is effected at this time in the automatic exchange, as the called manual-exchange operator has the responsibility of timing such calls as pass through her switchboard. The permanent timing operation is resumed, however, when either the manual operator or the calling subscriber disconnects.

Q1a. Permanent timing at OR—1 when the called operator fails to disconnect

When the calling subscriber replaces his receiver at the end of the conversation and thereby brings about the restoration of line and release relays 810 and 811, incoming supervisory relay 803 restores to cause disconnect supervision to be given to the manual-exchange operator, but auxiliary relay 812 remains operated in a holding circuit through the middle contacts of incoming release relay 805 and its own inner lower armature until the operator has disconnected. In this event, a new circuit for release-timer relay 817 is established, through the back contact of the lower armature of the restored outgoing release relay 811, and the front contact of the lower armature of the operated incoming release relay 805. The permanent-timing operation thereupon proceeds as previously described to release the connection in the automatic exchange at the conclusion thereof, whereby the calling line is freed from the connection instead of being withheld indefinitely from service while awaiting disconnection at the manual switchboard. The repeater OR—1, however, is not thereby rendered available for use in the automatic exchange, for auxiliary relay 812 at its lower contacts maintains the associated allotter conductors 931 separated, whereby allotter relay 911 cannot become reoperated to again allot the associated trunk line A—T1 until the operator disconnects.

Q1b. Permanent timing at OR—1 when the Calling subscriber fails to disconnect

Let it be assumed now that the calling subscriber in the call under consideration fails to replace his receiver after conversation, and that the connection is taken down in the called manual exchange.

When the connection is taken down in the called manual exchange, incoming line and release relays 804 and 805 restore, relays 810 to 812 remaining operated. A release-timer circuit is thereupon closed for relay 817 through the lower armature and back contact of incoming release relay 805, including the front contact of the lower armature of outgoing release relay 811 and the said armature. As a result, the previously described release-timer operation proceeds to its conclusion, whereupon the connection is cleared out as previously described, and the line circuit associated with the calling line is brought into lockout condition.

R. Operation of the trunk allotters

Referring particularly to trunk allotters TA—8 and TA—9 of Fig. 4 and TA—0 of Fig. 9, the operation of these trunk allotters will be explained more fully. The three allotters are all similar in basic wiring, differing only in the number of trunk lines respectively associated therewith. Seven trunk lines are associated with the trunk allotter TA—0, terminal pairs 931 to 937 being wired respectively to the associated two-way manual-to-automatic repeaters. Only one of these repeaters is shown, being the repeater OR—1, Fig. 8. Allotter conductors 931 associated with the repeater OR—1 are maintained disconnected at the lower contacts of auxiliary relay 812 at all times when the repeater is in use pursuant to an outgoing call to the manual exchange, and they are maintained disconnected at the lower contacts of incoming-transfer relay 808 at all times during an incoming call through repeater OR—1. On the other hand, when the repeater OR—1 (and the associated trunk line A—T1) is idle, neither of the relays 808 and 812 is operated, and conductors 931 are joined together in the repeater to indicate the idle condition to the trunk allotter TA—0.

R1. The first trunk line associated with TA—0 is allotted

The trunk allotter TA—0 is illustrated with all seven of the active allotter relays 911 to 917 in operated condition, each of said allotter relays being held locked operated over its associated one of the conductor pairs 931 to 937. Under this condition, the first of the associated trunk lines (A—T1) is allotted by the allotter TA—0, because the local marking conductor 941 is maintained grounded at this time by relay 911.

R2. Allotting the succeeding trunk lines

With the trunk allotter TA—0 in its illustrated condition, when the next call is made to manual exchange A, the allotter operates as previously described to cause a marking potential to be placed on conductor M1 of cable 1300 upon the described operation of connecting relay 953, causing the connection to be completed to the repeater OR—1. The consequent operation of auxiliary relay 812 separates conductors 931, whereupon relay 911 restores and opens another point in its previously established circuit, preparing a circuit for itself through the lower contacts of reset relay 921. At its middle armature, relay 911 disconnects ground potential from the local marking conductor 941 and applies ground potential to conductor 942, through the corresponding armature of the operated relay 912.

The second associated trunk line is now allotted and will be used for the next call to manual exchange A, unless in the meantime it is restored because the second trunk line is taken for use in the manual exchange to thereby cause the associated conductors 932 to be separated (at the contacts of the relay in the second repeater corresponding to the lower contacts of relay 808 of repeater OR—1). In either event, when the trunk line A—T1 is taken for use in either exchange, relay 912 restores, whereupon the third conductor 943 becomes grounded to transfer the marking to the third trunk line of the group, provided relay

913 has not been restored by a seizure of the associated trunk line in the manual exchange.

In a similar way, the marking is transferred successively as the operated relays of the allotter TA—0 are restored.

R2a. Allotting trunk lines succeeding the fifth

When the first five relays of the allotter TA—0 are in restored condition and at least one of the remaining relays is in operated condition, the units-switching mark conductor 946 is grounded through contacts of the restored relays 911 to 915 to prepare for the operation of the units-switching relay in any one of the connectors (relay U6C, Fig. 13, part 5, in the connector C1). At the same time, one or another of the conductors 941 to 945 is grounded, depending on which relay of the last five in the allotter is the first one operated following the fifth relay 915 in the chain. The trunk line associated with such operated relay is thereby allotted.

R3. The allotter action is progressive

Since each of the allotter relays, on restoring, opens its locking circuit, the allotter relays do not reoperate automatically when the associated trunk line again becomes idle, the allotter being what is termed a progressive allotter. The progressive allotter causes the connections made to the trunk lines through the automatic switching equipment to be divided more or less evenly over the group. One benefit of this arrangement is that a subscriber calling and obtaining connection with a defective trunk line in the group obtains connection with some other trunk line when he discovers the defective condition of the trunk line in use; replaces his receiver; and calls again.

R4. Resetting allotter TA—0

When all of the trunk lines associated with the allotter TA—0 have been used once for a call in either direction, all of the relays of the allotter are then in restored condition, and all marking is removed from conductors 941 to 945. At this time, a chain circuit is closed through contacts of all of the allotter relays 911 to 920 for reset relay 921. Reset relay 921 thereupon operates, to ground the illustrated common reset conductor at its inner lower contacts, thereby reoperating each of the restored relays of the allotter whose associated trunk line is idle, as indicated by the closed condition of the associated one of the conductor pairs 931 to 937. Each reoperated relay closes a self-locking circuit over its associated conductor pair and disconnects itself from the reset conductor.

The chain circuit for reset relay 921 is opened upon the operation of one or more of the allotter relays. Relay 921 restores after a slight interval (being a slow-acting relay as indicated), thereby ungrounding the associated reset conductor to permit the progressive operation of the allotter hereinbefore described to proceed.

Busy relay 953 is also operated temporarily upon each operation of reset relay 921, but ordinarily restores almost immediately, when reset relay 921 restores upon the successful operation of one or more of the associated allotter relays.

R5. An all-trunks-busy condition at allotter TA—0

If all of the trunk lines with which the trunk allotter TA—0 is associated are in use when reset relay 921 operates, none of the allotter relays responds, and relay 921 remains operated until at least one of the associated trunk lines becomes idle to permit its associated allotter relay to reoperate and open the chain circuit of reset relay 921. Under this condition, busy relay 953 is maintained operated by reset relay 921 to prepare for the grounding of busy lead B—1 in the cable 1300, and for the closing of a circuit for the associated counting device (or meter) 956 in the event that connecting relay 953 operates pursuant to an attempt to seize one of the trunk lines of the group while all of them are in use. If exchange A is now called, and assuming connector C1 (Fig. 13) is the calling connector, busy relay 1320 therein is operated over the following circuit: from ground through contacts of relays 921, 953, and 954, lead B—1 in cable 1300, contacts of relay CN—1, conductor 21, and through relay 1320 to battery.

On operating, relay 1321 returns busy signal at its upper contacts, while at the front contact of its middle lower armature, it operates relay 1326 through contacts of restored relay 1324 to prepare the local holding circuit of busy relay 1320 at its lower contacts. At its inner lower contacts, relay 1320 operates relay 1322 to complete the local holding circuit of busy relay 1320 at contacts 89.

At its inner lower contacts, relay 1322 grounds conductor 49, thereby operating hundreds-transfer relay 1327 through contacts of relays 1328 and 1329. At its lower contacts, relay 1327 disconnects conductor 46 permitting relay CH—1 to restore, followed by the restoration of relay CN—1 to free the common allotter equipment from the connector C1.

S. Local calls from tandem exchange C to terminating exchange D

The handling of local calls from subscriber lines of tandem exchange C to lines of terminating exchange D will now be described. For this purpose, it may be assumed that a subscriber at pay station #2031 (Fig. 2, part 2, and Fig. 10) desires to converse with the subscriber at substation #2012 on party line #201;301 of exchange D (Fig. 2, part 3).

S1. Seizing an idle connector

It may be assumed that when the receiver is removed at pay station #2031 (Fig. 10), operations as hereinbefore described occur, extending the connection from the calling line through finder F1 (Fig. 11) to the connector C1 (Fig. 13) and the preparation for operation of the connector C1.

S2. Dialing the single-digit number of exchange D

Since the calling subscriber is calling a line of another exchange, he first dials the single-digit number assigned to such other exchange (the digit 8 in the assumed example), after which he waits for dial-tone from the called exchange before calling the number (2012) of the desired subscriber in the called exchange.

When the digit 8 is dialed into the seized connector C1 as the initial digit, the #8 counting relay 1340 is operated to prepare a circuit over conductor 22 of cable 1366, and this circuit is completed when the slow-acting series relay 1321 restores at the end of the digit and brings about the hereinbefore described grounding of hundreds conductors 38 and 39. The circuit is from ground on conductor 39, through contacts of relay 1340, conductor 23 of cable 1366, and through the winding of tens relay T23C, to battery. Relay T23C operates to connect up the associated tens group of line multiples represented by the conductors in cable CA—23, and also brings about the operation of relays CH—1 and CN—1 as hereinbefore described in connection with the calling

of the single-digit numbers *0* and *9* assigned to the manual exchanges A and B.

S3. Selecting and seizing repeater 8R—1

When relay CN—1 operates, at its inner contacts, it grounds conductor 9 in cable 1300, through contacts of the operated tens relay T22C, thereby closing a circuit for connecting relay 441 of trunk allotter TA—3 associated with the trunk lines interconnecting exchanges C and D. It may be assumed that the first trunk line of this group is allotted at this time (trunk line C—T1, interconnecting repeaters 8R—1 of Fig. 5 and R1 of Fig. 6). Under this condition, conductor 421 of the allotter is in grounded condition, causing ground potential to be applied through contacts of relay 441 to conductor M1 of cable 1300. A circuit is thereby closed for operating units relay U1C of connector C1, causing the first trunk line of the called group to be seized over line multiple #231, to which line circuit LC—231 (Fig. 5) and repeater 8R—1 are connected. This seizure is accomplished by the hereinbefore described operation of switch-through relay 1301.

When the line multiple #231 is seized, cutoff and lockout relays 516 and 517 operate over the associated sleeve conductor from the ground potential applied momentarily from the seizing connector. Relay 516 disconnects line relay 518.

S4. Preparing repeater 8R—1 for outgoing local operation

In the seized repeater 8R—1, outgoing line relay 504 is connected between ground and the tip conductor of line multiple #231, through contacts 521, and the upper left-hand winding of repeating coil 500, while retard coil 505 is connected between the free pole of the exchange battery and the ring conductor of the seized multiple, through contacts 522, and the lower left-hand winding of the repeating coil. Line relay 504 accordingly now operates over the calling line. Outgoing release relay 506 next operates through contacts of line relay 504, and operates outgoing transfer relay 509. At its inner upper contacts, outgoing transfer relay 509 applies ground potential to the associated sleeve conductor through the winding of detector relay 503 to maintain the connection established after slow-acting release relay 1307 of connector C1 restores.

S4a. Operating detector relay 503

Upon restoration of release relay 1307 of the connector C1, the connection is held by the ground potential supplied through the winding of detector relay 503 through contacts of the operated outgoing transfer relay 509. Detector relay 503 accordingly operates (the call under consideration being one coming from a subscriber line instead of from an operator) to open its contacts to prevent the transmission of a signal to exchange D indicative of a call from a manual exchange.

S4b. Bridging the trunk-line conductors

At armatures 523 and 524, relay 509 disconnects incoming line relay 514 and substitutes a bridge controlled by the upper contacts of the now-operated outgoing line relay 504. This bridge may be traced from the front contact of armature 523, through the upper contacts of outgoing line relay 504, the low-resistance left-hand winding of polarized relay 508, and through resistor 533, to the front contact of armature 524.

S5. Preparing repeater R1 for incoming operation

In exchange D, retard coil 60 is connected between ground and the tip conductor of trunk line C—T1, through contacts 625 and the upper left-hand winding of repeating coil 600, while incoming line relay 605 is connected between the free pole of the exchange battery and the ring conductor of the trunk line, through contacts 626 and the lower left-hand repeating-coil winding. As a result, line relay 605 operates over the trunk line C—T1 when it is bridged as described in the repeater 8R—1. Incoming release relay 606 next operates through contacts of line relay 605, and operates incoming transfer relay 610.

Differential detector relay 603, whose windings are connected in series respectively with retard coil 602 and incoming line relay 605, is not operated at this time because the current flow is balanced in its two windings. Detector relay 603 is not operated at any time during a call of the class under consideration because of the operated condition of detector relay 503 in repeater 8R—1, which maintains its contacts open to avoid an unbalancing of the interexchange trunk-line conductors at the end of each dialing operation, as will be explained hereinafter.

S6. Bridging the talking conductors of the line multiple

At armatures 627 and 628, incoming transfer relay 610 disconnects retard coil 612 and outgoing line relay 613, and substitutes a bridge across the tip and ring conductors of the associated line multiple #211. This bridge may be traced from the front contact of armature 627, through the upper contacts of incoming line relay 605, the low-resistance left-hand winding of polarized relay 609, and resistor 633, to the front contact of armature 628.

S7. Seizing a connector in exchange D

In line circuit LC—211', line relay 622 now operates over the bridge established in repeater R1, and applies ground potential to the associated T and U marking conductors so as to cause the distributor DR—1' (Fig. 2, part 3) to operate an idle one of the associated finders to link a connector with the associated calling line multiple #211. It may be assumed that the finder F1' is idle and is accordingly operated by the distributor DR' to link the connector C1' with the calling line multiple #211 through the finder-connector link L1'. This operation is as described hereinbefore in connection with the corresponding apparatus of exchange C shown in Figs. 11 to 13.

When the connector C1' has been taken for use and prepared for operation, it returns a dial-tone signal over the established connection as explained hereinbefore for the connector C1 of Fig. 13. Upon hearing the dial-tone signal, the calling subscriber at pay station #2031 (Fig. 10) in exchange C dials the digits 2, 0, 1, and 2 in the desired exchange-D number.

S8. Repeating the digit impulses from exchange C to exchange D

Each time a digit of the desired number is called, line relay 504 of repeater 8R—1 (Fig. 5) is restored momentarily a corresponding number of times. Slow-restoring series relay 512 is operated through contacts of the slow-restoring outgoing release relay 506 upon the first restoration of line relay 504 and remains operated throughout the series of impulses. Auxiliary-series relay 511 responds to the operation of relay 512, and restores shortly after relay 512 restores at the end of the series of impulses. At its upper

contacts, series relay 513 shunts resistor 532 across resistor 633 and the left-hand winding of polarized relay 508 so as to improve the impulsing circuit to repeater R1.

Upon each momentary restoration of line relay 504, the previously described bridge across the conductors of trunk line C—T1 is opened at its upper contacts, producing a momentary restoration of incoming line relay 605 of the repeater R1.

In the repeater R1, upon the first restoration of incoming line relay 605 of any series, a circuit is closed through contacts of slow-restoring release relay 606 for slow-restoring series relay 607. Relay 607 accordingly operates and remains operated throughout the series of impulses. At the upper contacts of series relay 607, resistor 632 is shunted around resistor 633 and the left-hand winding of relay 609 to improve the impulsing circuit to the connector in use.

Upon each momentary restoration of line relay 605, the bridge across the conductors of the associated line multiple #211 are opened at the upper contacts thereof, thus effectively repeating the dialed impulses to the connector C1' (Fig. 2, part 3).

S9. Completing the connection by local-connector operation in exchange D

The connector C1' responds (as hereinbefore described for the connector C1, Fig. 13) to the digits repeated thereto at the repeater R1 to complete connection to the called substation #2012 on party line #201;301. Assuming that this line is idle, the connection is made and ringing current is applied. In the call under consideration, detector relay 603 of repeater R1 not having operated, sleeve-control relay 602 is consequently not operated, and no ground potential therefore is applied by repeater R1 to the sleeve conductor of the associated multiple #211. As a result, the connector in use (connector C1', Fig. 2, part 3) changes over from toll operation to local operation as hereinbefore described for the connector C1, Fig. 13.

S10. Answered supervision

When the called subscriber answers, connector C1' operates to cause the current flow to be reversed over its incoming conductors, whereby the current flow in the tip and ring conductors of line multiple #211 associated with the repeater R1 is reversed. When this occurs, polarized supervisory relay 609 in the repeater R1 operates, whereupon incoming supervisory relay 601 is operated through contacts of incoming transfer relay 610 to reverse the conductors of the trunk line C—T1.

In repeater 8R—1, polarized supervisory relay 550 now operates, whereupon outgoing supervisory relay 501 operates through contacts of outgoing transfer relay 509 to reverse the tip and ring conductors of the associated line multiple #231. The current flow in the calling pay-station line of Fig. 10 is thereby reversed, rendering the pay-station instrument inoperative as previously described until the subscriber deposits the requisite coin to thereby again render it operative for conversation purposes.

S11. Disconnect supervision

If the called subscriber replaces his receiver first, the current flow is reversed back to normal direction in the connector in use in exchange B, whereupon relays 609 and 601 in repeater R1 restore, causing the restoration of relays 508 and 501 of the repeater 8R—1, the current flow in the calling line being reversed to normal direction by the restoration of relay 501.

S12. Clearing out

When the receiver is replaced at the calling substation, the established connection clears out as will now be explained.

S12a. Clearing out in the calling exchange C

Line relay 504 restores when the receiver is replaced at the calling substation. At its upper contacts, it open-circuits and restores the distant line relay 605, while at its lower contacts it open-circuits release relay 506. Release relay 506 restores after a slight interval, followed by the restoration of outgoing-transfer relay 509. Relays 512 and 511 incidentally operate at this time, but clear out responsive to the resortation of relay 506. At the inner upper contacts of outgoing-transfer relay 509, ground potential is removed from the sleeve conductor of the associated line multiple #231, whereupon line circuit LC—231 returns to normal condition and the connection established through the connector C1 and finder F1 in Figs. 13 and 11 is cleared out as previously described.

S12b. Clearing out in the called exchange D

In exchange D, when line relay 605 is open-circuited at the upper contacts of line relay 504 as above mentioned, it unbridges the tip and ring conductors of the associated line multiple #211 at its upper contacts to permit the connector in use to clear out, while at its lower contacts it open-circuits incoming release relay 606. Release relay 606 restores a moment later, permitting incoming transfer relay 610 to restore. Series relay 607 operates incidentally at this time, but clears out following the restoration of relay 606.

The remaining portion of the connection, including the connector in use, is cleared out as hereinbefore described in connection with the connector C1 (Fig. 13). When this occurs, cut-off and lockout relays 624 and 623 of line circuit LC—211' restore, returning the line circuit to its illustrated normal condition.

T. Manual-exchange calls through tandem exchange C to terminating exchange D

The handling of manual-exchange calls through tandem exchange C to lines of terminating exchange D will now be described. For this purpose, it may be assumed that the operator at exchange A receives a call for a subscriber of terminating exchange D. It may be assumed that the trunk line A—T1 (Figs. 7 and 8), associated with trunk circuit A—TC1 and repeater OR—1, is used for this call.

T1. Seizing and preparing a connector in tandem exchange C

When a cord-circuit plug is inserted into the jack J3 (Fig. 7), operations as hereinbefore described occur, causing line relay 820 of line circuit LC—211 to operate. It may be assumed that finder F1 of Fig. 11 responds at this time to extend the call over the associated link L1 to the connector C1 of Fig. 13. The connector C1 is thereupon prepared for operation as described and returns a dial-tone signal to the calling manual exchange.

T2. Dialing the single-digit number of exchange D

The calling operator now dials the digit 8 assigned to the terminating exchange, causing the connector C1 to be operated to take an idle one of the concerned trunk lines for use as hereinbefore described.

T3. Seizing repeater 8R—1

It may be assumed that the trunk line C—T1 in Figs. 5 and 6 is idle and allotted at this time, in which case the connection is extended through line multiple #231 to the repeater 8R—1, Fig. 5, relays 516 and 517 of line circuit LC—231 operating.

T4. Preparing repeater 8R—1 for outgoing toll operation

The seized repeater 8R—1 is now prepared for outgoing toll operation by the energization of line relay 504, release relay 506, and outgoing transfer relay 509, as hereinbefore described. Detector relay 503 does not operate at this time responsive to the closure of the inner upper contacts of outgoing transfer relay 509 because the sleeve lead of the connection established through tandem exchange A from the calling manual-to-automatic repeater OR—1 (Fig. 8) is grounded in the repeater OR—1 as hereinbefore described. This ground connection to the sleeve conductor in repeater OR—1 includes the middle contacts of release relay 805, lower contacts of operated sleeve-control relay 809, and contacts of incoming transfer relay 808. The repeater 8R—1 is now prepared to condition repeater R1 subsequently for toll operation, as will be described hereinafter.

T5. Preparing repeater R1 for incoming operation

In exchange D, the repeater R1 is prepared for incoming operation as hereinbefore described by the operation of line relay 605, release relay 606, and incoming transfer relay 610. The line circuit LC–211 now operates as described to cause an idle connector to be linked to the associated line multiple #211, whereupon dial-tone signal is transmitted back over the connection to the calling operator to inform her that she may dial the listed directory number of the desired subscriber in terminating exchange D.

T6. Repeating the digit impulses through tandem exchange C to terminating exchange D

The impulse series constituting the digits in the desired number, which are generated by the calling device CD, Fig. 7, are repeated by repeater OR—1, Fig. 8, (at the upper contacts of line relay 804) to the repeater 8R—1. At its upper contacts, line relay 504 of the repeater 8R—1 repeats the received impulses to line relay 605 of the repeater R1, which in turn repeats them at its upper contacts to the connector in use in exchange D.

T7. Relaying the grounded-sleeve, toll-call indication from exchange C to exchange D

It will be recalled that series relay 512 in repeater 8R—1 operates at the beginning of each series of impulses and restores at the end thereof, and that series-auxiliary relay 511 responds to each operation of relay 512 and restores a short interval after the restoration of relay 512.

At the end of the first digit repeated by repeater 8R—1 in the present call (in which detector relay 503 is in restored condition as described to indicate a toll call), the current flow in the conductors of trunk line C—T1 is unbalanced momentarily by a ground connection made thereto in the interval required for relay 511 to restore after series relay 512 restores. With relay 512 restored and with slow-restoring relay 511 still operated for a moment, a circuit connection exists from ground, through the inner armature and back contact of relay 512, contacts of the operated relay 511, contacts 525 of relay 509, contacts of detector relay 503, front contact of armature 523 and the said armature, and through the upper right-hand winding of repeating coil 500, to the tip conductor of the trunk line C—T1. By this ground connection, retard coil 604 and the upper winding of detector relay 603 in the repeater R1 are shunted, thus unbalancing the current flow in the two windings of differential-detector relay 603.

T7a. Conditioning repeater R1 for toll operation

In the exchange D, detector relay 603 of repeater R1 now operates to close a circuit for sleeve-control relay 602 from ground on the sleeve conductor of the associated line multiple #211, through the inner upper contacts of the operated incoming transfer relay 610 and contacts of detector relay 603. Sleeve-control relay 602 now operates. At its upper contacts, it locks itself to the associated sleeve conductor, independent of the contacts of detector relay 603. At its lower contacts, relay 602 completes a ground connection to the sleeve conductor of the associated line multiple #211 as follows: from ground through the inner lower contacts of the operated incoming release relay 606, through the lower contacts of sleeve-control relay 602, the upper contacts of relay 602, and through contacts of relay 610 to the said sleeve conductor. The ground potential is thus applied to the sleeve conductor of line multiple #211 to mark the call as one coming from a manual exchange.

When the above-described temporary unbalanced condition is terminated (by the restoration of relay 511), detector relay 603 restores, but sleeve-control relay 602 remains operated thereafter through its own contacts independent of the contacts of detector relay 603.

The unbalancing operation is repeated at the end of each dialed digit, but is of no particular effect after sleeve-control relay 602 has operated and locked as above noted.

It is to be particularly noted that the unbalancing connection made to the trunk line C—T1 does not interfere with the impulse-repeating circuit from 8R—1 to R1 in the event that slow-restoring series-auxiliary relay 511 occasionally fails to restore between closely spaced successive impulse series, since the ring conductor of trunk line C—T1 is left free for controlling line relay 605 of repeater R1, and line relay 605 is not directly affected by the fact that the ring conductor of the trunk line is grounded at both ends, for such line relay remains under the free control of the upper contacts of line relay 504.

T8. Conditioning the connector in use in exchange D for toll operation

When the complete number has been dialed and the connector in use in exchange D tests the called line and operates either its busy relay or its switching relay, the test winding of the detector relay therein corresponding to detector relay 1308 of the connector C1 is cut into circuit, but

such detector relay is prevented from operating at this time by the ground potential maintained on the sleeve conductor of the connection in exchange D by the above-mentioned ground connection to the sleeve conductor S of the calling line multiple #211 associated with the repeater R1. Accordingly, the connector in use in exchange D is conditioned for toll operation by the failure of the above-mentioned detector relay to operate.

T9. Answered supervision

Assuming that the called line is idle and that the called subscriber responds, the consequent reversal of current flow brought about by the connector in use causes supervisory relays 609 and 601 in the repeater R1 to respond to reverse the current flow over trunk line C—T1, as previously described, whereupon supervisory relays 508 and 501 in repeater 8R—1 respond to reverse the current flow in the connection in exchange C. Relays 806 and 803 in the repeater OR—1 thereupon respond as hereinbefore described, and the latter relay reverses current flow to the trunk circuit A—TC1. When this occurs, relays 702 and 701 respond and the latter relay causes the calling operator to be given answered supervision.

T10. Disconnect and recall supervision

The above-mentioned supervisory operations are reversed when the called subscriber replaces his receiver. The called subscriber can, of course, signal the operator by manipulating his hookswitch as desired, the hookswitch signaling being repeated from repeater R1 to repeater 8R—1 (Figs. 6 and 5), and from the repeater 8R—1 to the repeater OR—1 (Fig. 8) and from the repeater OR—1 to the trunk circuit A—TC1 (Fig. 7).

T11. Clearing out

When the operator at exchange A removes her plug from the jack J3, the resulting open-circuit condition is relayed by the repeater OR—1 (Fig. 8) to the repeater 8R—1 (Fig. 5), thereby to the repeater R1 (Fig. 6), and thereby to connector in use in the terminating exchange D. The connection in tandem exchange A is cleared out responsive to the removal of ground potential from the sleeve conductor of line multiple #211 associated with repeater OR—1 or to the removal of ground potential from the sleeve conductor of line multiple #231 associated with the repeater 8R—1, whichever occurs last.

In the exchange D, the connector in use removes ground potential at one point from the sleeve lead of line multiple #211, Fig. 6, part 2, when it clears out. Incoming release relay 606 of repeater R1 restores as a result of the deenergization of incoming line relay 605. When it does so, it removes ground potential at one point from the sleeve conductor of the associated line multiple #211. Responsive to whichever of these operations occurs last, line circuit LC—211' clears out, and relays 602 and 610 restore.

U. Local call from terminating exchange D to tandem exchange C

The way in which subscribers of terminating exchange D are given service on calls to subscriber lines of tandem exchange C will now be described. For this purpose, it may be assumed that a subscriber at pay station #2021 (Fig. 2, part 2) on line #202 of exchange D desires to converse with a subscriber of tandem exchange C.

U1. Seizing a connector in exchange D

When the receiver is removed at the calling pay station, a finder such as F1' (Fig. 2, part 3) is caused to operate to link a connector such as C1' with the calling line, whereupon such connector is prepared for operation and a dial-tone signal is given to the calling subscriber.

U2. Dialing the single-digit number of exchange C

The calling subscriber may now dial the digit 0 assigned to tandem exchange C from the standpoint of terminating exchange D, with the result that the connector in use is operated as hereinbefore described for connector C1 (Fig. 13) to make connection with an idle one of the trunk lines interconnecting exchanges C and D. It may be assumed that the trunk line C—T1 interconnecting the repeaters 8R—1 and R1 of Figs. 5 and 6 is idle and allotted at this time, in which case it is taken for use by way of line multiple L. M. #211 (Fig. 6, part 2).

U3. Clearing the line circuit LC—211'

When the connector in use in exchange D seizes line multiple #211 therein, associated with repeater R1, Fig. 6, it thereby extends as the conductors of the calling line to the tip and ring conductors T and R of the seized line multiple, and extends the still-grounded sleeve conductor of the connection to the sleeve conductor S of the line multiple. Cutoff and lockout relays 624 and 623 are thereupon operated over the associated sleeve conductors to clear the line circuit LC—211'.

U4. Preparing repeater R1 for outgoing operation

In the repeater R1, retard coil 612 is normally connected between the free pole of the exchange battery and the ring conductor of the associated line multiple through contacts 628 of incoming transfer relay 610 and the lower left-hand winding of repeating coil 600, while outgoing line relay 613 is normally connected between ground and the tip conductor of the line multiple through contacts 627 and the upper right-hand winding of the repeating coil. Consequently, outgoing line relay 613 is energized over the calling line when the associated line multiple #211 is seized. Relay 613 thereupon operates causing the successive operation of outgoing release relay 611 and outgoing transfer relay 608. Outgoing transfer relay 608 applies a holding ground potential to the sleeve conductor of the associated line multiple as follows: from ground, through normally closed contacts controlled by inner armature of release-timer relay 615, the lower winding of transformer 616, and through the inner upper contacts of outgoing transfer relay 608, to the associated sleeve conductor.

With outgoing release relay 611 operated class-tone relay 617 operates through contacts of outgoing supervisory-control relay 614, followed by the operation of class-tone relay 618, to prepare for the giving of a class-tone signal when the call is answered, which signal is important only when a manual exchange is being called.

At armatures 625 and 626, outgoing transfer relay 608 disconnects the conductors of trunk line C—T1 from retard coil 602 and incoming line relay 605 and transfers them to a bridge controlled by the upper contacts of outgoing line relay 613. This bridge may be traced from the front contact of armature 625, through the upper contacts of outgoing line relay 613, the low resistance left-hand winding of polarized supervisory relay 609, and through resistor 633, to the front contact of armature 626.

U5. Preparing repeater 8R—1 for incoming operation

In the repeater 8R—1 in exchange C, incoming line relay 514 is normally connected to the conductors of trunk line C—T1 through the repeating-coil windings and back contacts of armatures 523 and 524. Line relay 514, accordingly, now operates over the trunk line C—T1 through the above-traced bridge across the conductors thereof in the repeater R1, including the upper contacts of outgoing line relay 613. Incoming release relay 513 and incoming transfer relay 507 operate successively responsive to the operation of relay 514. Relay 513 prepares an impulse circuit to series relay 512, while incoming transfer relay 507, at its inner upper contacts, connects the lower winding of sleeve-control relay 510 to the associated sleeve conductor, but without any particular effect at this time because the associated sleeve conductor is not grounded for the moment.

U6. Seizing a connector in exchange C

At armatures 521 and 522, relay 507 disconnects the tip and ring conductors of the associated line multiple #231 from line relay 504 and retard coil 505, and transfers them to a bridge including the upper contacts of line relay 514. This bridge may be traced from the front contact of armature 521, through the upper contacts of line relay 514, the low-resistance left-hand winding of polarized supervisory relay 508, and resistor 633, to the front contact of armature 522. Line relay 518, of line circuit LC—231 now operates through the above-traced bridge to ground the associated T and U mark conductors to cause a finder to link an idle connector with the associated line multiple #231. When this has been done (as by the operation of the finder F1, Fig. 11, to link the connector C1 of Fig. 13), ground potential is placed on the sleeve conductor by the connector, operating cutoff and lockout relays 516 and 517, whereupon line relay 518 is disconnected and restored.

U7. Grounding the sleeve in repeater 8R—1

In the repeater 8R—1, the grounding of the sleeve conductor of the associated multiple closes an operating circuit through contacts of relays 507 and 511 for the lower winding of sleeve-control relay 510. Sleeve-control relay 510 is retarded in operation by the normally short-circuited upper winding thereof. It operates after a slight interval to open-circuit its upper winding to render it fast-releasing, and it makes a circuit connection: from ground at the inner contacts of release relay 513, through the lower contacts of sleeve-control relay 510, and the inner upper contacts of incoming transfer relay 507, to the sleeve conductor of the associated line multiple #231. This application of ground potential has no purpose except in calls from one or the other of the manual exchanges, its purpose then being to shunt out and maintain restored the detector relay of the concerned repeater such as OR—1, Fig. 8, to permit reverse battery supervision to be relayed back therefrom as will be described hereinafter. Special provisions are associated with sleeve-control relay 510 to secure the removal of ground potential in the repeater 8R—1 from the associated sleeve conductor at the time when the detector relay of the connector in use is rendered effective to determine whether the connector is to be conditioned as a toll connector or is to be conditioned as a local connector, as will be described subsequently.

The usual dial-tone signal is sent back by the seized connector in exchange C through the repeaters 8R—1 and R1 of Figs. 5 and 6 to the calling line in terminating exchange D to inform the calling pay-station subscriber that he may now dial the directory number of the desired subscriber in the called tandem exchange C.

U8. Repeating the digit impulses

Upon the dialing of each of the four digits in the directory number of the called line in exchange C, outgoing line relay 613 of repeater R1 is momentarily restored a number of times corresponding to the value of the digit. Each time it restores, it opens the above-traced bridge across the conductors of trunk line C—T1 at its upper contacts, whereby incoming line relay 514 in repeater 8R—1 in exchange C is caused to follow the calling device in exchange D.

Each time incoming line relay 514 momentarily restores, it opens the bridge across the tip and ring conductors of the associated line multiple #231 at its upper contacts, whereby the calling-device impulses are repeated to the seized connector, causing such connector to operate as hereinbefore described to set up the desired connection.

In the repeater R1, each monetary restoration of outgoing line relay 613 closes a circuit for series relay 607 through contacts of outgoing supervisory relay 514 and contacts of the operated outgoing release relay 511. Relay 607 accordingly operates and remains operated throughout the series of impulses. At its inner upper contacts, it shunts resistor 631 around the winding of retard coil 612 to improve the response of line relay 613, while at its upper contacts it shunts resistor 632 across resistor 633 and the left-hand winding of relay 609, to improve the response of incoming line relay 514 of the repeater 8R—1.

U9. Counting the number of digits to determine destination of the call

Arrangements are provided in the repeater R1 to count the number of digits dialed by a calling exchange-D subscriber after seizure of the repeater to determine thereby whether the call is being made to one of the manual exchanges (in which case only a single digit, 9 or 0, is dialed) or is for a local line of exchange C (in which case four digits are dialed). The purpose of the determination is to enable reverse battery supervision received by the repeater R1 when the call is answered to be relayed back to the calling line if the call is to a subscriber line of exchange C, but to be withheld in the repeater R1 if the call is to one of the manual exchanges, whereby calling pay-station subscribers of exchange D are permitted to make free calls to the manual exchanges, but are required to deposit a coin before being permitted to converse with called subscribers of exchange C.

U9a. Disconnecting the outgoing supervisory relay when the first digit is counted

The digit-counting operation is accomplished by digit-counter relays 619 and 620 under the control of series relay 607.

When relay 607 operates as described in response to the first repeated digit, it closes a circuit for the lower winding of digit-counter relay 620, as follows: from ground through the inner

lower contacts of the operated outgoing release relay 611, lower armature and front contact of series relay 607, upper armature and back contact of digit-counter relay 619, and thence to battery through the lower winding of relay 620. Relay 620 operates when this circuit is closed. At its lower contacts, it disconnects outgoing supervisory relay 621 so as to prevent the relaying back of reverse battery supervision unless relay 620 is subsequently restored. At its upper contacts, relay 620 prepares a restoring circuit for its upper winding, and at its inner lower contacts it closes a self-locking circuit, as follows: from ground through the lower contacts of relay 611, the inner lower contacts of relay 620, the lower winding of relay 619, and through the lower winding of relay 620 to battery. The lower winding of relay 619 is not energized in this locking circuit for the time being, for it is short-circuited by the initial circuit closed for the lower winding of relay 620.

When slow-restoring series relay 607 falls back at the end of the first digit dialed following the seizure of the repeater R, it opens the initial circuit above traced for the lower winding of relay 620. Relay 620 remains operated in its above traced locking circuit and relay 619 operates therein. Upon operating, relay 619 closes a locking circuit for its upper winding, to ground through the inner lower contacts of release relay 611, whereby it is maintained operated independent of the contacts of relay 620 until the connection is cleared out.

At its upper armature, relay 619 opens a further point in the previously established initial circuit for the lower winding of relay 620 and prepares a restoring circuit for the upper winding of relay 620.

On calls to the manual exchange, the single digit dialed after the seizure of the repeater R suffices to fully extend the connection, and relay 620 is, therefore, not restored by further dialing. On such calls, outgoing supervisory relay 621 remains disconnected. In the present example, however, the call is for a subscriber line of the tandem exchange and three additional digits are dialed, causing relay 620 to restore, as will be described, to again connect up outgoing supervisory relay 621.

U9b. Reconnecting the supervisory relay when more than one digit is counted

When the second digit in the desired number is dialed, series relay 607 is again operated and remains operated throughout the digit. At its lower armature and front contact, it closes a circuit through the inner contacts of the operated relays 619 and 620 for the upper winding of relay 620. Relay 620 is a differential relay, as indicated. As a result, relay 620 is deenergized by the current flow in its upper winding, and it accordingly restores. Upon restoring, relay 620 again connects up outgoing supervisory relay 621 at its lower contacts; it disconnects its upper winding at its upper contacts; and at its inner lower contacts, it opens the locking circuit through the lower windings of relays 619 and 620. Relay 619, however, remains operated through its own lower contacts and upper winding.

With relay 619 locked operated, and with relay 620 again restored, these relays are not affected by the further operations of series relay 607 during the dialing of the remaining two digits in the number.

In the repeater 8R—1 in exchange C, each time incoming line relay 514 restores momentarily pursuant to the repeating of the digit impulses, it closes a circuit for slow-restoring series relay 512. Relay 512 accordingly operates at the beginning of each digit series of impulses and remains operated until the end thereof. At its upper contacts, relay 512 shunts resistor 532 around resistor 533 and the left-hand winding of relay 508 to improve the impulse-repeating circuit to the connector in use in exchange C.

U10. Temporary sleeve-ground removal for local-call identification

Each time a digit is dialed, relay 512 operates slow-restoring series-auxiliary relay 511. Relay 511 disconnects the lower winding of sleeve-control relay 510 at its inner contacts, whereupon sleeve-control relay 510 immediately restores, removing ground potential in the repeater from the sleeve conductor of line multiple #231, leaving the sleeve conductor of the connection in exchange C grounded only in the connector in use.

At the end of the first series of impulses, series relay 512 restores and opens the circuit of series-auxiliary relay 511. Slow-restoring relay 511 falls back after a slight interval and reconnects sleeve-control relay 510. Relay 510 does not reoperate immediately because of its normally short-circuited upper winding, but it reoperates after a slight interval to reapply ground potential to the associated sleeve conductor.

The above operations of relays 512, 511, and 510 are repeated on the dialing of each subsequent digit in the desired number. Accordingly, at the end of the final digit in the desired number, relays 512 and 511 are in operated condition and relay 510 is restored and ground potential is temporarily removed at the repeater from the associated sleeve conductor. This ground potential is not replaced for a substantial interval, the time required for the successive restoration of the slow-restoring relays 512 and 511 and the operation of the slow-operating relay 510. By the time this has occurred, the series relay (such as 1321) of the connector in use has restored at the end of the final digit and has brought about the operation of one or another of the associated switching and busy relays (such as 1319 and 1320), to remove the normally existing shunt from around the upper winding of the associated detector relay (such as 1306) to allow this detector relay to operate and condition the connector in use for local operation. After this has been accomplished, the subsequent replacing of ground potential on the sleeve conductor in the repeater 8R—1 at the lower contacts of relay 510 does no harm, for the detector relay (such as 1308) locks itself operated at its lower contacts and shunts out its test winding at its inner upper contacts, besides changing over the connector to local operation as hereinbefore described.

U11. Answered supervision.

When the called subscriber responds, the supervisory relay (such as 1304) in the connector in exchange C reverses the connection between the associated incoming tip and ring conductors and the line relays (such as 1305 and 1306), thereby causing the current flow to be reversed in line multiple #231 (Fig. 5) and consequently in the bridge across these conductors in repeater 8R—1, including the left-hand winding of polarized supervisory relay 508. Relay 508 thereupon operates and closes a circuit, through contacts of incoming transfer relay 507, for incoming super-

visory relay 515. Incoming supervisory relay 515 thereupon reverses the conductors of trunk line C—T1, reversing the current flow through the left-hand winding of polarized relay 609 in the repeater R1. Relay 609 thereupon operates its armature 650, closing a circuit, through contacts of outgoing transfer relay 608, and contacts of the restored digit-counter relay 620, for outgoing supervisory relay 621. Relay 621 operates to reverse the current flow over the tip and ring conductors of the associated line multiple #211, thereby reversing current flow over the calling pay-station line #202 (Fig. 2, part 3). The calling pay-station #2021 is thereupon disabled by the operation of the polarized pay-station magnet as described hereinbefore in connection with pay station #2031 (Figs. 2 and 10). The calling pay-station subscriber is thus required to deposit a coin to recondition the pay station for conversation.

U12. Disconnect supervision

Assuming that the called subscriber is the first to replace his receiver after conversation, the above described supervisory operations are reversed, returning the current flow in the line multiple #231 associated with repeater 8R—1, in trunk line C—T1 and in the calling line in exchange D to normal direction.

U13. Clearing out

When the receiver is replaced at the calling substation, the resulting open-circuit condition is relayed by repeater R1 of Fig. 6 to repeater 8R—1 of Figs. 5 and 6, and thence to the connector in use in exchange C, permitting such connector to clear out as hereinbefore described. The repeater 8R—1 is cleared out by the restoration of relays 513 and 507 in succession, following the restoration of incoming line relay 514. Relays 512 and 511 are incidentally operated at this time and relay 511 disconnects and restores sleeve-control relay 510 immediately, relays 512 and 511 restoring successively responsive to the restoration of relay 513.

In the calling exchange D, outgoing release relay 611 restores a slight interval after the restoration of outgoing line relay 613. At its inner contacts, relay 611 open-circuits and restores outgoing transfer relay 633 and digit-counter relay 619. Outgoing transfer relay 633, at its inner contacts, removes ground potential from the associated sleeve conductor, thereby permitting the line circuit LC—211' to clear out along with the connector in use and the calling line circuit. Series relay 607 is operated momentarily upon the restoration of line relay 612 but clears out responsive to the restoration of release relay 611 without producing any particular result at this time.

V. Handling calls from terminating exchange D to manual exchanges A and B

The handling of calls from terminating exchange D, through tandem exchange C, to manual exchanges A and B will now be described. For this purpose, it may be assumed that a subscriber at pay station #2021 (Fig. 2, part 3) desires to make a call to or through one of the manual exchanges A and B, manual exchange A, for example.

V1. Calling tandem exchange C

When the receiver is removed at pay station #2021, an idle one of the connectors C1' to CX' is linked to the calling line #202 by operation of the associated one of the finders F1' to FX' under the control of the distributor DR' as hereinbefore described. Such connector thereupon returns a dial-tone signal to the calling pay station line, and it responds to the digit 0, when dialed, to extend connection to tandem exchange C over an idle one of the interexchange trunk lines C—T1 to C—T6. It may be assumed that trunk line C—T1 is idle and allotted at this time and is therefore seized, by way of repeater R1 of Figs. 2 and 6.

When the repeater R1 is seized in the terminating exchange D, it is prepared for outgoing operation as hereinbefore described, its relays 613, 611, 608, 617, and 618 operating.

The repeater 8R—1 (Fig. 5) in exchange C is now prepared for operation responsive to the bridging of the associated trunk line C—T1 in the repeater R1 as hereinbefore described, its relays 514, 513, and 507 operating.

The line circuit LC—231 now responds (by its line relay 518) to cause an idle connector in tandem exchange C to be linked to the associated line multiple #231 by finder operation. It may be assumed that the finder F1, Fig. 11, operates to link the connector C1 to the calling multiple #231. The connector C1 is thereupon prepared for operation, and grounds the associated sleeve conductor, and consequently the sleeve conductor of multiple #231, whereupon relays 516 and 517 operate and relay 518 restores.

V1a. Sleeve grounding for supervisory identification

In the repeater 8R—1, sleeve-control relay 510 now operates from the grounded associated sleeve conductor, through contacts of incoming transfer relay 507 and contacts of series-auxiliary relay 511. At its lower contacts, relay 510 places ground potential, controlled by incoming release relay 513, on the associated sleeve conductor, through contacts of relay 507, to identify the call as one over which supervision should be given from the called manual exchange.

V2. Calling manual exchange A

When the calling subscriber in exchange D, on hearing the dial-tone signal now sent back from the connector C1 in exchange C, dials the digit 0 assigned to the manual exchange A from the standpoint of exchange C, the ten momentary interruption impulses constituting such digit are repeated by the repeater R1 of Fig. 6 to the repeater 8R—1 of Fig. 5, and are thereat repeated to the connector C1 of Fig. 13. As a result, the connector C1 operates as previously described to cause connection to be made with the called manual exchange A, by way of the trunk line A—T1 for example, Figs. 7 and 8. This connection is made by way of line multiple #211 and the repeater OR—1 of Fig. 8, upon the hereinbefore described switching-through operation of the connector C1.

When the last-named line multiple #211 is seized by the connector C1, the ground potential extended to the sleeve conductor thereof by the seizing connector, brings about the operation of relays 820 and 819 in line circuit LC—211. The repeater OR—1 is prepared for operation as hereinbefore described, relays 810 to 812, 814, 815 operating. Detector relay 813 does not operate at this time because of the ground connection made to the sleeve conductor at repeater 8R—1 by sleeve-control relay 510. Splash-ring relays 801 and 802 operate to project ringing current momentarily over the trunk line A—T1 to signal the operator in exchange A.

V3. Answered supervision

When the operator in manual exchange A answers (having been signaled by call lamp 706), the consequent bridging at the trunk circuit A—T1 of the conductors of trunk line A—T1 causes incoming line relay 804 in repeater OR—1 to operate, followed by the operation of incoming release relay 805.

Class-tone relays 814 and 815 restore successively as previously described responsive to the operation of incoming line relay 804, but no class-tone is thereby impressed on the talking circuit because of the absence of class-tone connections to the sleeve conductors of the concerned line multiplies #211 and #231.

With detector relay 813 in restored condition as previously mentioned, a circuit is closed through contacts of relays 804 and 805, armature 827 and its right-hand front contact, and contacts of detector relay 813, for outgoing supervisory relay 816. Relay 816 thereupon operates to reverse the current flow in the associated line multiple #211 and consequently in the connected line multiple #231 associated with repeater 8R—1, Fig. 5.

In the repeater 8R—1, polarized relay 550 responds to the above-mentioned current-flow reversal, occasioned by the operation of outgoing supervisory relay 816 of the repeater OR—1. At its contacts 550, relay 508 operates incoming supervisory relay 515. At its inner lower contacts, relay 515 disconnects series relay 512 to prevent operation of the latter relay in response to any restoration of line relay 514 which may occur, while the established connection is in the state of answered supervision. At its inner upper contacts, relay 515 closes a parallel, high-resistance bridge across the tip and ring conductors of the associated line multiple #231 through the 30,000-ohm right-hand winding of supervisory relay 508, for a purpose to be discussed subsequently.

Incoming supervisory relay 515 also reverses the direction of current flow over the trunk line, to relay answered supervision to the repeater R1 in exchange D.

In the repeater R1, polarized supervisory relay 609 now responds and operates outgoing supervisory-control relay 614.

V3a. Barring current reversal at repeater R1

Outgoing supervisory relay 621 is not operated at this time because it is maintained disconnected at the lower contacts of the operated digit-counter relay 620, relay 620 not having been restored in the present call, because only a single digit was dialed, following the seizure of the repeater R1, to extend connection to the called manual exchange. The current flow is, therefore, not reversed in the calling pay-station line, wherefore the calling pay-station subscriber is able to carry on a conversation with the operator in the manual exchange without first depositing a coin, as he is obliged to do before conversing when a subscriber of either of the automatic exchanges is called.

Upon operating as above noted, outgoing supervisory-control relay 614 disconnects series relay 607 at its middle lower contacts; at its upper contacts, it closes a parallel bridge across the conductors of trunk line C—T1 including the 30,000-ohm right-hand winding of polarized supervisory relay 609, for a purpose to be subsequently brought out; and at the back contact of its inner lower armature, it disconnects class-tone relay 617.

V3b. Class-tone signaling at repeater R1

Class-tone relays 617 and 618, both of which are slow-restoring relays as indicated, now restore successively. During the time required for relay 618 to restore after relay 617 restores, the upper winding of transformer 616 is bridged across the talking circuit in series with condenser 630, to relay to the talking circuit any tone signal which may be impressed on the sleeve conductor of the calling line. Such sleeve conductor is now extended, through the finder connector link in use to the sleeve conductor S of the associated line multiple #211, and this conductor is extended to ground through the lower winding of transformer 616. The sleeve conductor of the line multiple associated with the calling pay-station line #202 (Fig. 2, part 3) may have a class-tone connection made thereto from a common class-tone lead through an individual condenser, as illustrated in Fig. 10 in connection with line multiple #203 associated with pay station #2931 of tandem exchange C. The pay-station tone is thus received at the lower winding of transformer 616 and is induced in the upper winding thereof and impressed across the conductors of the talking circuit through condenser 630 and the contacts of relays 617 and 618 during the short interval in which relay 618 remains operated after relay 617 restores. The pay-station tone signal is thus sent back over the talking circuit to the called manual exchange to be heard by the answering operator. The operator is thereby informed that the call is from a pay station, as previously discussed in connection with a call to exchange A from the pay station shown in Fig. 10.

The calling pay-station subscriber may now converse with the operator as desired, not having to first deposit a coin, as previously discussed.

V4. Recalling the called manual-exchange operator

While the established connection is in a state of answered supervision (that is, after the operator answers and before she disconnects), the calling pay-station subscriber may recall the operator by momentarily depressing his hookswitch one or more times to cause operations to occur resulting in a flashing of the answering supervisory lamp in the cord circuit in the manual exchange. The previously discussed closing of high-resistance holding bridges in the repeater R1 of Fig. 6 and 8R—1 of Fig. 5 enables such recalling to be accomplished without causing the connection to be released, as will now be described.

When the hookswitch is depressed at the calling substation in terminating exchange D, outgoing line relay 613 of the repeater R1 restores. Series relay 607 does not operate at this time as it is disconnected at contacts of outgoing supervisory-control relay 614, whereby the setting of digit-counter relays 619 and 620 is not interfered with.

Outgoing release relay 611 restores a short interval following the restoration of outgoing line relay 613, but outgoing transfer relay 608 remains operated nevertheless, through the inner lower armature and front contact of outgoing supervisory-control relay 614. As a result, outgoing transfer relay 608 maintains the associated sleeve conductor grounded at its inner upper contacts to maintain the connection established in the local exchange. At its upper contacts, line relay 613 opens the previously traced low-resistance

bridge across the conductors of trunk line C—T1 through the left-hand winding of polarized supervisory relay 609, but relay 609 remains operated at this time in a high-resistance bridge including both windings of relay 609 in series, and the upper contacts of outgoing supervisory-control relay 614. Contacts 650 are thereby maintained closed to maintain relay 614 operated.

In tandem exchange C, line relay 514 of the repeater 8R—1 restores when the upper contacts of line relay 613 of the repeater R1 open, as it is unable to remain operated over the high-resistance bridge maintained through the upper contacts of relay 614. At its upper contacts, relay 514 opens the low-resistance control bridge, leaving the high-resistance holding bridge closed through the upper contacts of relay 515 to maintain relay 508 operated.

Relays 512, 511, and 510 are prevented from responding to the restoration of relay 514 because series relay 512 has been disconnected at the lower contacts of incoming supervisory relay 515.

Incoming release relay 513 restores a slight interval after line relay 514 restores. When it does so, it removes, at its inner lower contacts, the ground potential applied locally to the sleeve conductor S of the associated line multiple #231, but incoming transfer relay 507 and sleeve-control relay 510 are maintained operated thereafter, over the said associated sleeve conductor which is grounded by virtue of the connection which has been extended to the repeater OR—1 (Fig. 8).

In the repeater OR—1, the ground connection to the associated sleeve conductor is through contacts of the operated auxiliary relay 812 and the lower winding of detector relay 813. Detector relay 813 operates when it is thus made the sole supply of ground connection to the sleeve conductor, but the associated outgoing supervisory relay 816 is not thereby restored, as it is maintained operated in a locking circuit including its lower contacts in shunt of the contacts of the detector relay.

Outgoing line relay 810 restores responsive to the opening of the upper contacts of incoming line relay 514 of the repeater 8R—1, as it is unable to remain operated in the high-resistance bridge in the latter repeater. The restoration of relay 810 is followed a moment later by the restoration of outgoing release relay 811, but auxiliary relay 812 remains operated at this time in a circuit from ground, through the middle contacts of incoming release relay 805, and the inner armature and front contact of relay 812, whereby ground potential is maintained on the associated sleeve conductor through the upper contacts of relay 812 to maintain the connection established in the tandem exchange.

The lower contacts of line relay 810 open-circuit and restore incoming supervisory relay 803, whereby the current flow over trunk line A—T1 is reversed to normal direction to cause relays 702 and 701 to restore successively, whereby the operator's cord-circuit lamp becomes lighted as previously described.

When the calling subscriber in exchange D again releases the hookswitch and permits the contacts thereof to close, the above-described operations are reversed, resulting in the extinguishment of the supervisory lamp in the called manual exchange. The act of depressing the hookswitch momentarily may be repeated as many times as desired, causing the operator's supervisory lamp to flash to call her attention to the fact that the calling subscriber desires to converse with her again.

V5. Clearing out

When the calling subscriber has replaced his receiver and the operator has taken down the connection in the manual exchange, the entire connection is cleared out. The clearing out of the connection occurs in either of two ways, depending upon whether the operator disconnects first or the calling subscriber replaces his receiver first. The more usual operation is for the calling subscriber to replace his receiver first, and the clearing-out operations will be described under this assumption.

When the receiver is replaced at the calling substation, operations as hereinbefore described in connection with the temporary depression of the hookswitch contacts occur to cause the supervisory lamp to become lighted in the manual exchange, being lighted steadily at this time as a disconnect signal. When the operator responds to the disconnect signal by removing her plug from the jack J3 (Fig. 7), incoming line relay 804 of repeater OR—1 restores responsive to the opening of the jack contacts 707, open-circuiting and restoring outgoing supervisory relay 816. The current flow is thus reversed back to normal direction in the connection between repeater OR—1 and the repeater 8R—1 of Fig. 5.

After a slight interval, incoming release relay 805 restores, followed by the restoration of auxiliary relay 812 to remove ground potential from the associated sleeve conductor of line multiple #211, permitting the connection in tandem exchange C to clear out.

In the repeater 8R—1, Fig. 5, supervisory relay 508 restores when the current flow through its two windings in series, by way of upper contacts of incoming supervisory relay 515, is reversed back to normal direction by the above restoration of outgoing supervisory relay 816. When this occurs, incoming supervisory relay 515 restores and reverses the current flow over trunk line C—T1 to normal direction.

A moment later, when the connection in the tandem exchange is cleared out as above noted, and ground potential is consequently removed from the sleeve lead of the associated line multiple, sleeve-control and incoming transfer relays 510 and 507 restore, along with cutoff and lockout relays 516 and 517 of the line circuit LC—231, returning this repeater and line circuit to their illustrated normal condition.

In the calling exchange D, polarized supervisory relay 609 of repeater R1 (which was being held operated in a high-resistance bridge including both its windings and the upper contacts of relay 614) restores when the current flow over trunk line C—T1 is reversed back to normal direction by the restoration of incoming supervisory relay 515. Upon restoring, relay 609 open-circuits and restores outgoing supervisory-control relay 614. At the front contact of its inner lower armature, relay 614 open-circuits and restores digit-counter relay 619 and outgoing transfer relay 608. Relay 608 thereupon ungrounds the associated sleeve lead at its inner upper contacts, returning the repeater R1 and associated line circuit LC—211' to normal condition and clearing out the portion of the connection in exchange D between the calling line and the repeater R1.

W. Permanent timing at the repeater 8R—1

Leads H1, P1, and 1356 of the two-minute timer T (Fig. 13, part 6) are extended to the repeater

8R—1 to permit so-called permanent-timing operations to occur in the repeater 8R—1 during outgoing operation thereof, release-timer relay 502 and associated circuit arrangements being provided for this purpose.

When repeater 8R—1 is seized, in exchange C, for outgoing operation, the consequent operation of outgoing release relay 506 results in the application of ground potential to the common start conductor 1356. At the same time, pickup lead P1 is extended through contacts of release-timer relay 502, lower contacts of series-auxiliary relay 511, contacts of outgoing release relay 506, and contacts of outgoing supervisory relay 501, to the winding of release-timer relay 502. This circuit connection is broken temporarily during the dialing of each digit when series-auxiliary relay 511 responds to the operation of series relay 512, and it is also broken when the call is answered and outgoing supervisory relay 501 operates.

If, at the time lead P1 is next grounded momentarily, neither of the relays 511 and 501 is in operated condition, release-timer relay 502 operates over lead P1 and locks itself operated through contacts of relays 511, 506, and 501, disconnecting its winding from lead P1. At its inner armature and associated contacts, relay 502 transfers the associated sleeve conductor to the normally grounded hold lead H1.

If no further dialing occurs during the next two-minute interval, and the call is not answered during this time to operate outgoing supervisory relay 501, then release-timer relay 502 remains operated and the maintenance of ground potential on the associated sleeve lead is dependent upon the continued grounded condition of hold lead H1. Under this condition, when hold lead H1 is next momentarily ungrounded by the common timer, the associated sleeve lead is consequently ungrounded, permitting the connection established to the repeater 8R—1 to clear out, whereupon the line circuit associated with the calling line is brought into lockout condition.

W1. Permanent timing at 8R—1 following conversation

If, in a call through repeater 8R—1 to terminating exchange D, the calling subscriber in tandem exchange C fails to replace his receiver after the conversation has ended, and outgoing supervisory relay 501 has restored as previously described, the pickup circuit for release-timer relay 502 to lead P1 is reëstablished at the lower contacts of relay 501, with the result that the connection is subsequently cleared out by timer action as previously described if the calling subscriber does not in the meantime replace his receiver to permit the connection to clear out.

X. Permanent timing at the repeater R1

Repeater R1 (Fig. 6) is provided with release-timer relay 615 and has associated therewith common start lead 1356', common pickup lead P1', and common hold lead H1', associated with the two-minute timer in terminating exchange D similar to the timer T (Fig. 13, part 6) in exchange C.

When the repeater R1 is seized in exchange D on a call outgoing to exchange C, outgoing release relay 611 completes a circuit connection at its lower armature and front contact between pickup lead P1 and the winding of release-timer relay 615.

If the call has not been answered, to thereby cause outgoing supervisory relay 614 to operate, before lead P1 is next grounded, release-timer relay 615 operates over lead P1 and locks itself at its lower armature to ground through contacts of series relay 607 and the inner contacts of outgoing release relay 611.

If no dialing occurs during the next two-minute interval (to operate series relay 607), and if the call is not answered during this interval (to operate outgoing supervisory-control relay 614), relay 615 remains operated, and the associated sleeve conductor remains dependent upon the continued application of ground potential to the common hold lead H1'. Under this condition, when hold lead H1' is next ungrounded the associated sleeve lead is consequently ungrounded, permitting the connection to clear out and causing the calling line circuit to be placed in lockout condition.

The connection is similarly released following conversation (and the consequent restoration of relay 614) if the calling subscriber does not replace his receiver in the meantime.

Y. Allotter control at repeaters 8R—1 and R1

The repeater 8R—1 controls the #1 allotter relay in the associated trunk allotter TA—8 (Fig. 4) over the allotter conductors 401 as explained hereinbefore in connection with the repeater OR—1 of Fig. 8 and trunk allotter TA—0 of Fig. 9. When the repeater 8R—1 is in use as an incoming repeater, conductors 401 are separated at the lower contacts of incoming transfer relay 507. When the repeater is in use as an outgoing repeater, conductors 401 are separated at the lower contacts of outgoing transfer relay 509. Conductors 401 are thus maintained separated at any time when the repeater 8R—1 (and consequently the associated interexchange trunk line C—T1) is in use, being joined together at all other times to indicate an idle condition of the trunk line to the associated allotter.

Similarly, the corresponding relays (608 and 610) of the repeater R1 control the associated allotter conductors 641 to indicate to the associated trunk allotter (not shown) in exchange D the busy or idle condition of trunk line C—T1.

I claim:

1. In a telephone switching system, multi-level automatic switches having access to lines, said lines being divided into groups corresponding to the levels of said switches, each of said switches being provided with means for selecting all the lines of any level, and being further provided with means for selecting any one line of the selected level, the last-named means including units relays each operable to select a pair of lines and a units-switching relay operable to select a line of the pair selected by the operation of a units relay, an allotter associated with the lines reached by way of one level of said switches, means effective when any one of said switches is operated to select the last-named level for temporarily rendering said allotter exclusive to such switch and for making temporary connections between the switch and the allotter, said temporary connections comprising conductors corresponding respectively to said units relays and said units-switching relay, said allotter including allotter relays corresponding respectively to lines reached through the associated level of said switches, said allotter relays being individually controllable each in accordance with the busy or idle condition of the associated line, said allotter relays being arranged by pairs to energize the conductors associated with the units relays of a switch, and

a chain circuit path for energizing the conductor associated with said units-switching relay including contacts controlled by one relay of each of said pairs.

2. In a telephone system, a first exchange and a second exchange, a two-conductor trunk line extending from the first exchange to the second and having a three-conductor extension in each exchange, each such extension including a sleeve conductor, a repeater in the first exchange interposed between said trunk line and its local extension, means in the first exchange for extending connections of two classes to said repeater over the associated local extension, means included in connections of one class but not in connections of the other class for maintaining energized the sleeve conductor of said local extension, a detector relay in said repeater controlled by said energization of the sleeve conductor, said repeater being effective following seizure to repeat series of digit impulses over the trunk line to the second exchange by intermittent balanced current flow over the two conductors thereof, means controlled by said detector relay in accordance with whether or not said energization of the associated sleeve conductor is being maintained for temporarily establishing an unbalanced current flow over said trunk line following the repeating of a series of digit impulses, and means in the second exchange controlled by such unbalanced current flow for energizing the said sleeve conductor in the second exchange when the connection is of one class but not when the connection is of the other class.

3. In a telephone system, a first exchange and a second exchange, a two-conductor trunk line extending from the first exchange to the second and having a three-conductor extension in each exchange, each such extension including a sleeve conductor, a repeater in the first exchange interposed between said trunk line and its local extension, means in the first exchange for extending connections of two classes to said repeater over the associated local extension, means included in connections of one class but not in connections of the other class for maintaining energized the sleeve conductor of said local extension, a detector relay in said repeater controlled by said energization of the sleeve conductor, said repeater being responsive to seizure to set up a balanced current flow over the trunk-line conductors, said repeater being effective following seizure to repeat series of digit impulses over the trunk line to the second exchange by series of interruptions of said balanced current flow, means controlled by said detector relay in accordance with whether or not said energization of the associated sleeve conductor is being maintained for temporarily unbalancing said current flow following the repeating of a series of digit impulses, means in the second exchange controlled by such unbalanced current flow for energizing the said sleeve conductor in the second exchange when the connection is of one class but not when the connection is of the other class.

4. In a telephone system, a first exchange and a second exchange, a two-conductor trunk line extending from the first exchange to the second and having a three-conductor extension in each exchange, each such extension including a sleeve conductor, a repeater in the first exchange interposed between said trunk line and its local extension, means in the first exchange for extending connections of two classes to said repeater over the associated local extension, means included in connections of one class but not in connections of the other class for maintaining energized the sleeve conductor of said local extension, said repeater being effective following seizure to repeat digit information over the trunk line to the second exchange, said digit information being represented by successive series of digit impulses repeated by said repeater, means controlled by said repeater in accordance with the energized or unenergized condition of the associated sleeve conductor for transmitting or failing to transmit other information over said trunk line at a time when said digit information is not being repeated, and means in the second exchange responsive to said other information for determining whether or not the associated sleeve conductor in the second exchange is to be energized, the last-named sleeve conductor being thereby energized when the connection is of the one class but not when the connection is of the other class.

5. In a telephone system, a first exchange and a second exchange, a two-conductor trunk line extending from the first exchange to the second, means for extending a connection to said trunk line in the first exchange, and for setting up a balanced current flow over the two conductors thereof in series, contacts in the first exchange for producing series of interruptions in said balanced current flow to transmit digit information to the second exchange, means for transmitting other information from the first exchange to the second exchange by unbalancing the said current flow, means in the second exchange responsive to the current flow when unbalanced to signal the arrival of said other information, said unbalancing operation in the first exchange consisting in connecting a shunt around one of the conductors of the trunk line, said contacts in the first exchange being located between said shunt connection and the other trunk line conductor, and a digit-impulse responding relay in the second exchange connected in circuit with said other conductor and controlled thereover independent of the current flow in the shunted conductor to enable the said transmission of digit information to proceed effectively while said other information is being transmitted.

6. In a telephone system, a manual exchange, a tandem automatic exchange, and a terminating automatic exchange, trunk lines interconnecting said tandem exchange with each of the other said exchanges, automatic switches in said tandem exchange effective to extend connections from any line thereof to subscriber lines of the tandem exchange and to said trunk lines, each such connection including a pair of talking conductors and a sleeve conductor, means effective when one of the automatic switches is completing a connection from the manual exchange and controlled over its incoming sleeve conductor for conditioning the circuits associated with the automatic switch for toll operation, such conditioning being responsive to an energizing connection to the sleeve conductor of the calling line, there being no such energizing connection on a call from a subscriber line, the said trunk lines extending from the tandem exchange to the manual exchange being arranged to cause answered supervision to be relayed back toward the calling line only responsive to an energizing connection made to the sleeve conductor associated with the calling line, whereby answered supervision is not relayed back to calling local lines of the tandem exchange when calls are answered in the manual exchange, means associated with the sleeve con-

ductors in the tandem exchange of the trunk lines between the tandem and terminating exchanges for applying energizing potential thereto when calls are made from the terminating exchange to or through the tandem exchange, whereby answered supervision is relayed back to the concerned trunk line between the terminating and tandem exchanges when the call is through the tandem exchange to the manual exchange, the determination of whether one of the automatic switches in the tandem exchange is to operate as a local switch or as a toll switch being made immediately following the dialing of one of the digits in the desired number, and means in the tandem exchange associated with the trunk lines between the terminating exchange and the tandem exchange for temporarily removing the sleeve-energizing connection for a sufficient interval following the dialing of such digit to cause the automatic switch in use in the tandem exchange to be conditioned to operate as a local switch rather than as a toll switch.

7. In a telephone system, including a terminating automatic exchange, a tandem automatic exchange, and a manual exchange, said exchanges being interconnected by trunk lines extending from the terminating and manual exchanges to said tandem exchange, automatic switching equipment in said terminating and tandem exchanges controllable over lines of the terminating exchange to extend connections from lines of the terminating exchange through said tandem exchange to the manual exchange, means including repeaters in the tandem and terminating exchanges for relaying answered supervision from the manual exchange back to the terminating exchange, each of the connections through the terminating exchange including a pair of talking conductors and a sleeve conductor, each of certain of the lines of the terminating exchange having a class-tone signal impressed on its sleeve conductors, means in the terminating exchange responsive to answered supervision relayed back from the manual exchange for temporarily coupling the sleeve conductor inductively with the talking conductors to enable the operator to hear any class-tone signal that may be impressed on the sleeve conductor of the calling line, the connections through the terminating exchange to the trunk lines between the terminating and tandem exchanges being subject to being held by a potential applied to the sleeve conductor to enable recall of the manual-exchange operator to be effected by hookswitch operation, and means in the terminating exchange for applying a holding potential to the associated sleeve lead responsive simply to the receipt of said answered supervision.

8. In a telephone system including a terminating automatic exchange, a tandem automatic exchange, and a manual exchange, said exchanges being interconnected by trunk lines extending from the terminating and manual exchanges to said tandem exchange, automatic switching equipment in said terminating and tandem exchanges controllable over lines of the terminating exchange to extend connections from lines of the terminating exchange through said tandem exchange to the manual exchange, means including repeaters in the tandem and terminating exchanges for relaying answered supervision from the manual exchange back to the terminating exchange, each of the connections through the terminating exchange including a pair of talking conductors and a sleeve conductor, the connections through the terminating exchange to the trunk lines between the terminating and tandem exchanges being subject to being held by a potential applied to the sleeve conductor to enable recall of the manual-exchange operator to be effected by hookswitch operation, and means in the terminating exchange for applying a holding potential to the associated sleeve lead responsive simply to the receipt of said answered supervision.

PIER BAKKER.

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